SHUTTLE LAUNCH COMMIT CRITERIA AND BACKGROUND

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FOR

NSTS 16007 - Shuttle Launch Commit Criteria and Background Document

REVISION H

Change No. 097

Program Requirements Control Board Directive No. S072380LK/(1-1), dated 10/2/08.(1)

October 6, 2008

Kathleen E. Kaminski
Secretary, Program Requirements
Control Board

CHANGE INSTRUCTIONS

1. Replace the following SSIDs unless otherwise noted.

SSID	PRCBD No.	Starting Page No.
CS-01	N/A	00b-01.1
LOC-05	N/A	00e-05.1
EPDC-00	N/A	26-00.1
EPDC-08	S072380LK	26-08.1

2. Sign and date this page in the space provided below to show that the changes have been incorporated.

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Signature of Person Incorporating Changes Date

NOTICE

Any questions in reference to the technical content of this document should be directed to the LCC Document Manager, Jim Draus (321) 867-8515.

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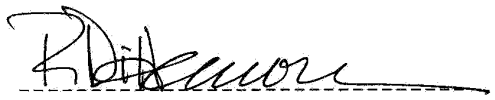
FOREWORD

This is the Space Shuttle Program (SSP) baseline document that provides the launch support system and the launch team with the Shuttle launch commit criteria and background information. The launch commit criteria outline preplanned decisions designed to minimize the amount of realtime rationalization required when non-nominal situations occur. A violation of redline limits established for these criteria is a constraint to launch.

All elements of the SSP must adhere to these baselined requirements. All changes to this document shall be processed on an LCC Change Notice (LCN) and dispositioned by a Space Shuttle Program Requirements Control Board Directive.



Ronald D. Dittemore
Manager, Space Shuttle Program

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2	IMPL	KSC GENERAL LAUNCH COMMIT CRITERIA IMPLEMENTATION
3	CREW	LAUNCH/LANDING WINDOW AND CREW RESTRICTIONS
4	WEA	WEATHER RULES
5	ETR	RANGE SAFETY CRITERIA
6	SAFE	KSC FLIGHT CREW AND PAD PERSONNEL SAFETY
7	HOLD	HOLD/CUTOFF GUIDELINES
8	SEQ	SPACE SHUTTLE VEHICLE FUNCTIONAL SEQUENCE
9		RESERVED
10	SRM	SOLID ROCKET MOTOR
11	BTVC	BOOSTER THRUST VECTOR CONTROL SUBSYSTEM
12	BRSS	BOOSTER RANGE SAFETY SYSTEM
13	BEI	BOOSTER ELECTRICAL AND INSTRUMENTATION
14	BSEP	BOOSTER SEPARATION SUBSYSTEM
15	BREC	BOOSTER RECOVERY SUBSYSTEM
16		RESERVED
17	ET	EXTERNAL TANK SUBSYSTEMS
18	TRSS	EXTERNAL TANK RANGE SAFETY SUBSYSTEM
19		RESERVED
20	SSME	SPACE SHUTTLE MAIN ENGINE
21	MPS	MAIN PROPULSION SYSTEM
22	RCS	REACTION CONTROL SUBSYSTEM
23	OMS	ORBITAL MANEUVERING SYSTEM

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24	PRSD	POWER REACTANT SUPPLY AND DISTRIBUTION
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27	APU	AUXILIARY POWER UNIT
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29	AFM	MECHANICAL SYSTEMS
30	ECL	ENVIRONMENTAL CONTROL AND LIFE SUPPORT
31	DPS	DATA PROCESSING SYSTEM
32	CT	COMMUNICATIONS AND TRACKING
33	INS	OPERATIONAL INSTRUMENTATION
34	GNC	GUIDANCE, NAVIGATION AND CONTROL
35	BFS	BACKUP FLIGHT CONTROL SYSTEM
36	RSLS	REDUNDANT SET LAUNCH SEQUENCER
37	PAY	PAYLOADS
38	SL	SPACELAB
39	GSE	GROUND SUPPORT EQUIPMENT
40	HAZ	HAZARDOUS GAS DETECTION SYSTEM
41	LPS	LAUNCH PROCESSING SYSTEM
42	COM	COMMUNICATIONS
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A	AA	ABBREVIATIONS AND ACRONYMS
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D	REF	REFERENCES
E	FSUM	FAULT SUMMARY MESSAGE AND CAUTION AND WARNING LISTINGS
F	ICE	ICE LAUNCH COMMIT CRITERIA
G		RESERVED
H	MEL	MINIMUM EQUIPMENT LIST
I	MIL	MANDATORY INSTRUMENTATION LIST
J	WAIV	WAIVERS/DEVIATIONS

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LIST OF CHANGES

REV LTR	AMEND NO.	DESCRIPTION	DATE
		BASELINE ISSUE	
	001	PRCBD S05967	
	002	PRCBD S05999	
	003	PRCBDs S13149 and S13150.	
	004	PRCBDs S13089 and S13152.	
	005	PRCBD S13055	
	006	PRCBDs S13154, S13538 and S13538A.	
	007	PRCBD S13156	
	008	PRCBD S13162	
	009	PRCBD S13153	
	010	PRCBDs S13158, S13160 and S13160A.	
	011	PRCBD S13162A	
	012	PRCBD S13161	
	013	PRCBD S13155	
A		Baseline plus baseline amendments 001 - 013 plus PRCBDs S14399 and S14476.	
	001	PRCBDs S05873B, S14507 and S14399.	
	002	PRCBDs S13155A, S13158, S13160B, S14399A, S14399C, S14399D, S14711, S14580, S14857, S14858, S14924, S14926, S14938, S14975, S14976, S15002, S15017, S15017R1, S15024, S15025, S15026, S15027, S15029, S15032, S15033, S15034, S15034R1, S32877U, S15047, S15048, S15049 and S15050.	

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REV LTR	AMEND NO.	DESCRIPTION	DATE
	003	PRCBD S42877	
	004	PRCBDs S13151B, H13158C, S14399D, S14399E, S14926, S15120D, S15135, S15178, S15191, S15192B, S15197, S15204, S15213, S15272, H15903, H15903A, H15913, H15918, H15919, H15926 and H15938.	
B		Revision A plus Revision A amendments 001 - 004 plus PRCBDs S15326A, S15326, S15294 and S15327.	
	001	PRCBDs S15670, S15720A, S15633, S15719A, S15644, S57634E, S15731, S15734 and S15326.	
	002	PRCBDs S20000, S15734A, S15871, S20028A, S20029A, S67030A, S20065 and EDITORIAL.	
	003	PRCBDs H20063, H20106, H20137, H20195, H20197, H20209, H20210, H20211, H20213, H20216, H20217 and H20220.	
	004	PRCBDs S15794A, S20490 and S20495.	
	005	PRCBDs S20558, S20558A, S20558B, S20558C, S20601, S20676, S20698, S20764, S20028 and S15326.	
	006	PRCBDs S20109, S20558B and EDITORIAL.	
	007	PRCBDs H15940, H15941, H20946, S20558E, H20558F, H20063B, H20972, S20558D and H20981.	
	008	PRCBDs S13158E, S21078, S21079, S21088, S21089, S21128, S21212, S21213, S21290, S21291, S21318 and EDITORIAL.	
	009	PRCBDs S21357, S21425, S21427, H21452, H21453, H21463, H21484B and S21496.	
	010	PRCBD S22081	

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REV LTR	AMEND NO.	DESCRIPTION	DATE
	011	PRCBD H22143	
C		Revision B plus revision B amendments 001 - 011 plus PRCBDs S22192 and S22191.	
	001	PRCBDs S20281J, S21692, S21692A, S22321, S22343, S22344, S22345, S22350, S22357, S22378 and S22395.	
	002	PRCBDs S22473 and S22636.	
	003	PRCBDs TBD	
	004	PRCBDs S23045, S23055 and S23292.	
	005	PRCBDs S13158F, S23366, S23375, S23379, S23471, S23475, S23551 and S23564.	
	006	PRCBDs S87809A, S23627 and S23564.	
	007	PRCBDs S23475, S23601, S23691 and S23708.	
	008	PRCBD S23888	
	009	PRCBDs S30011, S30048 and S30212.	
	010	PRCBDs S30332, S23417C, S30264, S30262 and S30440.	
	011	PRCBDs S30503, S30521, S30556 and S30541.	
	012	PRCBDs S30580, S30581, S30647 and S30751.	
	013	PRCBDs S30878, S30885, S30886, S30929 and S30945.	
	014	PRCBDs S31021 and S31217.	
	015	PRCBD S31539	
	016	PRCBDs S30048A, S31600A, S31600B, S31658 and S31800.	

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REV LTR	AMEND NO.	DESCRIPTION	DATE
	017	PRCBDs S32029 and S31209.	
	018	PRCBDs S21804A, S32106, S32186, S32247 and EDITORIAL.	
	019	PRCBDs S32390 and S32415.	
	020	PRCBDs S32562, S32564, S32677 and S32584.	
	021	PRCBDs S30885, S32975, S32816 and S33064.	
	022	PRCBDs S33186, S33225, S33233, S33234 and S33236.	
	023	PRCBDs S33808, S40129, S40725, S40727, S40749, S60006A, S60006B, S66846, S66846B, and S66846D.	
	024	PRCBD S66846C	
	025	PRCBDs S66846ER1 and S33363.	
	026	PRCBDs S66846A, S66846F(partial), S66846FR1 (partial), and S92398(partial).	
	027	PRCBD S66846G	
	028	PRCBDs S66846FA (partial), S66846H, S66846HR1, S66846J and S66846JR1.	
	029	PRCBD S66846K	
	030	PRCBDs S40726A, S92398, S92398R1 (partial), S92398A, S92398AR1, S92398AR2, S92398B, S92398BR1, S92398C, S92398D, S92398DR1, S92398E, S92398ER1, S92398F and S92398FR1.	
	031	PRCBDs S40978 and S40979.	
	032	PRCBD S66846L	
	033	PRCBDs S40749R2 and S66846CR1.	

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	034	PRCBD's S40727A, S40727B, S66846CR1 (partial), S66846CR2, S66846FR2, S66846FR3, S92398DR2 and S92398ER2.	
	035	PRCBDs S41272, S66846CR3, S66846HR2, S66846KR1, S66846P, S66846T, S66846V and S76053R1.	
D		Issuing authority S41304P incorporates Revision C plus Revision C amendments 001-035 plus PRCBDs S41222, S41243, S41304, S41304B, S41304D, S41304P, S40725B, S40726AR1, S66846Z, S76053B, S92398H, S92398J, S92398K and S94516.	07/01/88
	01	PRCBD's S41304L (Partial), S41304W, S41304Z (Partial), S52877N, and S61304 (Partial).	07/22/88
	02	PRCBD's S40726C, S61304 (Partial), and S94962.	07/22/88
	03	PRCBD's S41304C, S41304F, S41304G, S41304H, S41304L (Partial), S41304M, S41304N, S41304Q, S41304T, S41304U, S41304V, S41304Z (Partial), S61304 (Partial), and S66846U.	07/22/88
	04	PRCBD S41304A and Errata (Pages 7-01, 01A, 01B)	08/26/88
	05	PRCBD's S40725C, S40726D, S40726E, S53042M, S61304A, S61304C, S61304D, S61304E, S61304F, S93570, S94185, S94271, S94984, and Errata (Pages 2.2-04, G-101, and I-4.7).	09/02/88
	06	PRCBD's S41243A, S61304B, S61304H, S61304M, S61304N, S61304Q, S61304T, S61304U, S61304V, S61304Y, S90005, S94962B, S95055 and Errata (Page 5.2-10).	09/20/88
	07	PRCBD's S41304E, S41304QR1, S60055R2, S61304P, S61304Z, S71304, S71304B, S71304C, S76266, S91171, S98015, and Errata (Pages 6.9.6-01B, 6.9.10-24, 24A, 24B, 7-01B, and 7-01.1).	09/23/88

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	08	PRCBD's S40725D, S41502B, S41544, S41546, S61304G, S61304J, S71304D, S71304J, S71304K, S71304L, S71304M, S71304N, S71304P, S71304Q, S71304T, S76322, S76337, S94185D, S98154, S98156 and S98157.	11/11/88
	09	PRCBD's S41304BR1, S71304E, S71304H, S71304MR1, S71304U, S71304V, S71304Z, S81304A (Errata), S81304B, S81304C, S81304D, S81304E AND S81304F.	12/15/88
D	10	PRCBD's S40749A, S41243C, S81304J, S81304K, S81304M, S81304N, S81304P, S81304U, S81304V, S81304W, S81304Y, S94516, S98154A, and S98157A.	02/15/89
D	11	PRCBD's S40725E, S40749B, S41757, S41757A, S41757C, S81304H, S81304T, and S81304UR1.	02/24/89
D	12	PRCBD's S41546R1, S41757B, S41757D, S41757H, S41757J, S41757K, S81304Q, and Errata (Pages 3.1-31A, 5.1-iii, 6.2.1-iv, -v, 6.7.1-iii, -iv, 7-iii, J-01, and J-02).	04/03/89
D	13	PRCBD's S41757F, S41757M, S41757N, S41757P, S41757Q, and S98044.	04/11/89
D	14	PRCBD's S41757T, S41757U, S41757V, and S98750.	04/25/89
D	15	PRCBD's S41757PR1, S41757TR1, S41757W, S41757Y, S98750R1, and Errata (Pages 3.1-iv and J-01).	06/07/89
D	16	PRCBD's S40749C, S71757, S71757A, S71757M, S71757N, S71757Q, S71757T, S71757U, S71757V, S71757Y, S81757C, S91171C, S94185L and S98790.	07/24/89
D	17	PRCBD's S40749D, S40749F, S81757B, S81757J, S81757P, and Errata (Pages 7-vi and 7-55).	09/19/89

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D	18			PRCBD's S40749G, S81757DR1, S81757M, S81757N, S81757Q, S81757T, S81757U, S81757V, and Errata (Page 6.8.3-iii).	09/29/89
D	19			PRCBD's S95055A and S98750A.	10/04/89
D	20			PRCBD S40749H	10/06/89
D	21			PRCBD's S81757Y and S81757Z	10/09/89
D	22			PRCBD S50957 and Errata (Pages 6.9.3-20B and -20C).	10/12/89
D	23			PRCBD S50957A	10/16/89
D	24			PRCBD's S40749E, S50957B, S50957C, S50957D, S50957E, S50957G, S50957J, S76653, S81757W, and Errata (Pages 6.3-04B, -05C, 6.8.3-02A, 6.9.10-08, -08A, and J-02).	11/16/89
D	25	001	S71757B	All of Sections 4.1, 4.2, 4.3, & 4.4.	11/29/89
D	26	002	S71757D	6.3-iii, iv, 11, 11A, 11B, 12, 12A, 13, 13A, 14, 14A, 15, 15A, 6.7.1-iii, iv, 10, 10A, 10A, 11, 11A, 11.1, 11.1A, 11.2, 11.2A, 14, 14A, 15, 15A, 18.4E, 18.5, 18.5A, 18.5B, and all of Section 6.9.10.	11/30/89
		003	S71757C	All of Section 6.9.3	
D	27	004	S81757A	All of Sections 3.1 and 3.2	12/1/89
		005	S81757G	All of Appendix H.	
		006	S81757H	All of Appendix I.	

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D	28	007	S41757Z	Pages 5.1-iii, -08.2, -08.2A, -08.3, -08.3a, all of Section 6.2.1.	12/5/89
		008	S71757J	All of Section 6.5.2.	
		009	S71757H	All of Section 6.5.1.	
		010	S81757K	All of Section 6.9.6.	
		011	S71757G	All of Section 6.4.	
		012	S71757F	All of Section 6.3.	
D	29	013	S40726AR4	6.2.2-05 and -05A.	01/10/90
			S50957F	H-3.1(32), 3.2(32), -3.3(32), -3.4(32), -3.5(32), and -3.6(32).	
			S50957K	6.9.3-50	
			S50957N	7-01B, -1D, -01E, and -01F.	
			S50957P	6.9.5-04 and -04A.	
			S50957Q	6.2.1-11 and -12.	
			S50957T	6.6-14, -14A, -16, and -16A.	
			S50957V	3.2-11, -12, -13, -14, and -F02.	
			S50957W	3.2-13, -14	
			S50957Y	6.8.3-01A and -01B.	
			S50957Z	6.5.1-06	
			S53127Z	6.8.1-10, -10B, -10C, -10D, and -10E.	
			S83319	2.4-08.2 and -08.2A.	
			S83336A	2.4-06A and -06B.	
			ERRATA	D/26-i	
D	30	014	S81757F	All of Section 6.7.1	02/07/90
		015	S81757	All of Section 5.1	
D	31	016	S40749J	3.2-27, and -28	02/16/90
			S50957U	H-9.7	
			S60957	3.2-23, and -24	
			S60957B	3.2-11, -12, -13, -14, F02, and F03	
			S60957C	2.2-02, and -02A	
			S60957J	6.9.10-038, -039, -044, -045 -064, and -065	
			S71757DR1	6.9.10-42, and -43	
			S71757FR1	6.3-13, and -15	
			S83336B	2.4-06A, and -06B	

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D	32	017	S60957H	6.8.3-01, -01A, -01B, and I-6.6.	02/20/90
D	33	018	S60957G	All of Section 6.7.2	03/13/90
			S60957N	All of Section 6.9.24	
			S60957Q	J-03	
			S60957Y	J-03	
			S60957T	J-03	
			S60957U	J-03	
			ERRATA	D/33-i, and xv	
D	34	019	S71757E	All of Section 6.9.7	03/16/90
			ERRATA	D/34-i, and xv	
D	35	020	S60957D	6.4-14	04/02/90
			S60957V	H-3.1A (31), -3.2A (31), -3.3A (31), -3.4 (31), -3.5 (31), and -3.6 (31).	
			S70957	7-iii, -02, and -03.	
			S83336C	2.4-06A, and -06B.	
			S83838	2.3-07.1 and -07.1A.	
			ERRATA	D/35-i, xiii, xv, and 7-iv.	
D	36	021	S83319A	2.4-08.2 and -08.2A.	04/06/90
			S98792	2.1-01, and -01A.	
			ERRATA	D/36-i, and xv.	
D	37	022	S70957BR1	1.4-02, and -02A	04/11/90
			S70957G	F-2	
			ERRATA	D/37-i, and xvi	
D	38	023	S83856A	2.4-04, and -04A	04/20/90
			ERRATA	D/38-i, and xvi	
D	39	024	S50957M	3.1-04, -50, -51, and F01	04/26/90
			S60957Z	6.9.10-040, 041, -046, -047, -052, -053, -057, -058, -059, -066, -067, and -F01.	
			S70957E	H-3.1A(35), -3.2(35), -3.3A(35), -3.4(35), -3.5(35), -3.6(35), -3.7(35), and -3.8(35).	
			ERRATA	D/39-i, xvi, and H-3.9(35)	

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D	40	025	S70957C	6.9.25-01, -02, -03, -04, -05, -06, and -07.	05/16/90
			S70957K	6.9.3-20, -21, -22, and -26.	
			S70957L	J-03	
			S70957P	6.8.3-01A, and -01B.	
			S70957Q	7-02 through 7-20.	
			S70957T	6.9.3-45, -46, 6.9.25-03, and -06.	
			S83319B	2.4-08.2A	
			S83336D	2.4-06A, and -06B	
			S98949	6.2.2-03, -03A, -05, -05A, -08A, -35.3, -35.3A, -35.5, and -35.5A.	
			S98949R1	6.2.2-35.4, and -35.4A	
			ERRATA	D/40-i, xvi, 6.2.2-iv, 7-iii, and H-4.1.	
D	41	026	S70957J	1.4-02, and -02A	05/24/90
			S70957QR1	7-02	
D	42	027	S40749KR1	4.1-04, -52, and -53.	06/26/90
			S60957AR1	6.9.5-01 thru -F03.	
			S60957PR1	2.1-14, and -14A.	
			S60957WR1	7-01 thru -10.	
			S70957DR1	6.2.1-64, -65, and -65A.	
			S70957FR1	6.9.6-16, and -17.	
			S70957HR1	6.9.6-11, and -12.	

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			S70957NR1	2.3-iii, and -02.	
			S81304ZR1	1.4-04, and -05.	
			S83319C	2.4-08.2, and -08.2A.	
			S83336E	2.4-06, -06A, -06B, and -06C.	
			S98792AR1	2.1-iii, -03, -04, -04A, -10, and -10A.	
			ERRATA	D/42-i, xvii, 2.1-03A, 2.3-02A, 2.4-06D, 6.2.1-65B, and 7-11 thru -29.	
D	43	028	S80957	6.9.3-45, and 6.9.25-06.	06/28/90
			S80957A	6.9.3-60, and -61.	
			Errata	6.9.3-04, -46, and 6.9.25-07.	
D	44	029	S50957L	A-2, -3, and -4.	08/16/90
			S98016R1	All of Sections 2.1, 2.2, 2.3, 2.4, 2.6 and 5.2. Excluding pages 2.4-14 thru -17, and 2.4-23 thru -24B.	

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LIST OF CHANGES

REV LTR	AMEND NO.	CHG NO.	PRCBD NOS.	PAGES AFFECTED	DATE
E		000	S070957V	Incorporate Revision D in its entirety. Complete document replacement post STS-35 launch countdown.	08/21/90
E	01	001	S070957Y	SSID DPS-08	09/14/90
			S080957C	SSID SRM-10.	
			S080957D	All of Section 27 (APU)	
			S080957J	SSID's SSME-TOC, and SSME-40.	
			S080957M	SSID MPS-03.	
			S080957N	SSID LPS-25	
			S080957Q	SSID MEL-13.	
			S080957T	SSID's PAY-TOC, -03, and Page Fig. 27-01	
			S083930	SSID SSME-03.	
			S083930A	SSID SSME-09.	
E	02	002	S040725H	SSID's ET-TOC, -01, ICE-TOC, -01, Fig. 17-04, Fig. 17-05, Fig. F-03, and Fig. F-04.	10/12/90
			S052271A	SSID's HAZ-04 and HAZ-05.	
			S052271D	SSID WAIV-01.	
			S080957DR1	All of Section 27 (APU).	
			S080957E	Fig. 40-04.	
			S083319D	SSID SRM-10.	
E	O3	003	S052271E	This PRCBD makes an errata correction to SSID INS-03 and provides Revision E effectivity for the following PRCBD's: S080957C - SSID SRM-10 S083024 - SSID TRSS-05 S083930 - SSID SSME-03 S083930A - SSID SSME-09 S080957M - SSID MPS-03 S080957W - SSID ECL-40 S080957WR1 - SSID ECL-40 S0709576 - SSID DPS-08 S052271A - SSID HAZ-04, -05 S080957V - SSID HAZ-12 S080957N - SSID LPS-25 S050957L - SSID CHG-01	10/29/90

LIST OF CHANGES

REV LTR	AMEND NO.	CHG NO.	PRCBD NOS.	PAGES AFFECTED	DATE
			S052271F	SSID's GSE-TOC, and -24.	
			S052271H	SSID's APU-08, and -12.	
			S052332	SSID's HYD-TOC, -06, -10, and MEL-09.	
			S080957K	SSID's CT-02, -04, -06, -09, FIGURES 32-01, and 32-02.	
			S080957U	SSID ECL-10	
			S083024A	SSID RCS-02	
			S083024D	SSID's BRSS-TOC, -02, -03, -04, -06, -10, TRSS-TOC, -02, -03, and -07.	
			S083024DR1	SSID's BRSS-07, -08, -11, -12, TRSS-05, and -08.	
			ERRATA	WAIV-01.	
E	O4	004	S052271	SSID's EPDC-13.	12/04/90
			S052271AR1	SSID's HAZ-04 and HAZ-05.	
			S052271R1	SSID's EPDC-13, and DPS-25.	
			S052271Q	SSID FCP-04.	
			S052271T	SSID ECL-40.	
			S052346	SSID's BFS-TOC, and BFS-13.	
			S070957Y	SSID DPS-08.	
			S070957YR1	SSID DPS-08.	
			S080957G	SSID's EPDC-01, -02, -03, -04, -06, -07, -09, and -10.	
			S080957H	SSID's INS-02, -03, -04, and -05.	
			S080957HR1	SSID INS-03.	
			S080957N	SSID DPS-25	
			S083024DR2	SSID's BRSS-07, and TRSS-05.	
			S083024DR3	SSID's BRSS-07, and TRSS-05.	
E	05	005	S040725J	SSID ICE-01.	02/06/91
			S052271M	SSID CT-05.	
			S052346A	SSID's HAZ-05, and -05A	
			S052346L	SSID's ECL-10, and -10A.	
			S083024B	SSID's PRSD-01, -02, -03, -04, -05, -06, -09, FCP-02, and -03.	
			Errata	SSID's CS-01, LOC-01, -02, HAZ-TOC, and CT-05.	

LIST OF CHANGES

REV LTR	AMEND NO.	CHG NO.	PRCBD NOS.	PAGES AFFECTED	DATE
E	06	006	S052271V	SSID's WEA-01, GSE-TOC and GSE-24.	02/20/91
			S052271Z	SSID MEL-13.	
			S052346M	SSID GSE-03.	
			S052346P	SSID's DPS-26, and BFS-14.	
			S052379	SSID MEL-13.	
			S084208	SSID SRM-10.	
			Errata	SSID's CS-01, LOC-02, WEA-01, GSE-03, DPS-TOC, BFS-TOC, and GSE-TOC.	
E	07	007	S052346T	SSID's PAY-01, ROEU-01, -02, and -03.	02/28/91
E	08	008	S052271VR1	SSID's GSE-TOC, GSE-24, and WEA-01.	03/29/91
E	09	009	S040725K	SSID's ET-TOC, -01, -02, -03, -04, -05, -07, -08, and -11.	04/23/91
			S052271W	SSID's OMS-04, -16, and -17.	
			S052346C	SSID FCP-06.	
			S052346Y	SSID BEI-07.	
			S053193B	SSID CHG-01.	
			S070957AR1	SSID's ET-06, and MPS-43.	
			S083024F	SSID BRSS-15.	
			S084223	SSID's BEI-02, -03, BSEP-05, BREC-05, and SRM-09.	
E	10	010	S052271U	DPS-23.	05/10/91
			S052346D	LPS-01 thru -21, -25, and Fig. 41-01.	
			S052346E	COM-01, -02, and -03.	
			S052346F	EGR-02, -04, and -08.	
			S052346G	GSE-TOC, GSE-04 thru -10, and -13 thru -23.	
			S080957P	MEL-13.	
E	11	011	S052379D	SL-TLP, SL-TOC, SL-01 thru -07, SL-10 thru SL-15, and MEL-13.	05/20/91
			S052379DR1	SL-04.	
			S072346	ICE-01.	

LIST OF CHANGES

REV LTR	AMEND NO.	CHG NO.	PRCBD NOS.	PAGES AFFECTED	DATE
E	12	012	S052379A	WAIV-01.	05/31/91
			S052379B	BFS-14.	
			S084208A	SRM-04, -06, -07, -08 and -11.	
E	13	013	S052346B	RCS-02, -06 and -09.	06/19/91
			S052379F	MEL-13.	
			Errata	TLP-01, FWD-01, TOC-01, LOC-01 and LOC-02.	
			Errata	BEI-07 and FG-01.	
E	14	014	S052379FR1	MEL-13.	07/10/91
			S052379K	TDRS-01 thru -30, and TDRS-FG01 thru -FG09.	
			S086056	DPS-06.	
			S086076	RCS-06, -08, and GNC-45.	
			S086080	DPS-03, -07, -26, and -27.	
			Errata	BEI-FG01.	
E	15	015	S052346N	APU-01 thru -06, -08 thru -23, and APU-FG11.	07/19/91
			S052346Z	GNC-56, -58, -59, -61 and -67.	
E	16	016	S052379FR2	MEL-13.	07/19/91
E	17	017	S052271VR2	WEA-01 and GSE-24.	08/20/91
			S052346W	ETR-01.	
			S083024G	HYD-01 and -08.	
			S084223R1	SRM-09, BEI-02, BEI-03, BSEP-05 and BREC-05.	
			S086060	INS-01.	
			Errata	GNC-TOC, -56, -58, -59, -61, -67, -68, and RCS-08.	
E		018	S052379T	MEL-13.	09/05/91
			S052379V	PAY-01, ROEU-01, 02 and 03.	
			S052379W	UARS-01.	
E		019	S052346NR1	APU-TOC, -01, and APU-FG11.	09/16/91
			S052379N	GSE-01 thru -03.	
			S052501	MILA-TOC, -01 thru -03.	
E		020	S052346WR1	ETR-01.	10/01/91

LIST OF CHANGES

REV LTR	AMEND NO.	CHG NO.	PRCBD NOS.	PAGES AFFECTED	DATE
E		021	S052379Z	PAY-TOC, DSP-01, -02 AND -03.	11/08/91
			S052501B	MEL-13.	
			S052501C	WAIV-01.	
			Errata	ETR-01; SRM-TOC, -04 thru -08, -10, -11, -FG01; ET-01 thru -08, -11, -FG02, -FG03, -FG06, -FG14, -FG15; MPS-43; RCS-02, -06, -09; OMS-16, -17; FCP-06, -FG02; APU-01 thru -06, -08 thru -23; HYD-TOC, -01, -08 thru -10, -FG01, -FG02; ECL-10A; DPS-TOC, -06, -23 thru -27, -FG01 thru -FG03; INS-01; GNC-TOC, -56, -58, -59, -61 thru -64, -67; PAY-TOC, -01; UARS-01; ROEU-01 thru -03; TDRS-01 thru -30, -FG01 thru -FG09; GSE-TOC, -01 thru -24, -FG01, -FG02; LPS-TOC, -01 thru -25, -FG01; COM-01 thru -03; EGR-TOC, -02, -04 thru -09; MEL-TOC.	
E		022	S052501G	ECL-11.	11/21/91
			S052501L	BTVC-11, -13	
E		023	S052379G	GNC-TOC, -01, -03, -04, -09, -10, -12 thru -14, -16, -24, -27, -31, -32, -40, -41, -62, -64 thru -66, -73, -79 thru -84, -FG18; FSUM-08; MEL-02 thru MEL-04.	12/18/91
			S083024H	BTVC-TOC, -01 thru -05, -07 thru -11; BRSS-05, -07, -08; BEI-TOC, -01, -04, -06; BSEP-TOC, -01 thru -04; BREC-TOC, -01 thru -04; TRSS-TOC, -04, -05, -09.	
			Errata	BTVC-06, -11 thru -14, -FG01; BEI-05, -07, -FG01; BREC-05, -FG01; TRSS-01, -02, -03, -06 thru -08, -10 thru -13, -FG01; GNC-02, -05, -17, -22, -23, -25, -26, -28 thru -30, -67, -68, -76; DPS-01, -02, -03; MEL-13.	

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REV LTR	AMEND NO.	CHG NO.	PRCBD NOS.	PAGES AFFECTED	DATE
E		024	S052501M	MEL-13.	12/27/91
			S052501P	PRSD-03.	
E		025	S052379U	FRF-TLP, -TOC, -INTRO and -01 thru -32.	01/10/92
E		026	S052501T	SEQ-01.	01/15/92
E		027	S052379P	MILA-01, -02.	02/04/92
			S052379Y	GNC-TOC, -83.	
			S052501-R1	INS-05; MEL-10, -11.	
			S052603	GSE-08, -09, -16.	
			S084223-R2	SRM-09; BEI-02, -03; BSEP-05; BREC-05.	
			Errata	MEL-13.	
E		028	S062379	MEL-TOC, -13.	02/27/92
E		029	S052501J	PRSD-TOC, -01, -04, -06, -07, -08.	02/28/92
			S052501W	WAIV-01.	
			Errata	PRSD-02, -03, -05, -09, -FC01.	
E		030	S062379A	APU-02, -04, -05, -09, -14 thru -19, -22, -23.	03/06/92
			S062379B	HYD-08.	
			S062379C	EPDC-TOC, -14.	
			S062379F	FRF-22, -32.	
			Errata	HYD-07.	
E		031	S062379H	BRSS-07, -08; BEI-03, -04, -06; BSEP-01, -05; BREC-02; TRSS-05, -09; APU-02, -14, -19; AFM-10; INS-05; EGR-06.	03/11/92
			S062379J	BFS-05.	
E		032	S062379K	WEA-01.	03/20/92

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REV LTR	AMEND NO.	CHG NO.	PRCBD NOS.	PAGES AFFECTED	DATE
E		033	S052501U	AFM-30.	03/25/92
			S052501Z	HAZ-TOC, -02, -04, -05, -05A, -07, -08, -10.	
			S062379G	ECL-02.	
			S062379M	DPS-18, RSLS-01.	
			S062379N	INS-04, FRF-23, MEL-11.	
			S062379P	FRF-16.	
			S084744	SSME-05, -15, -19, -23.	
E		034	S062379T	MEL-13.	04/22/92
E		035	S062379U	ECL-05.	04/27/92
			S062379Z	IMPL-01.	

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LIST OF CHANGES

REV LTR	CHG NO.	PRCBD NOS.	PAGES AFFECTED	DATE
F	001	S062379Q	Incorporates Revision E in its entirety. Complete document revision. (Also includes PRCBDs S040725M, S052501H, S052501N, S072379, and S093004E.)	05/01/92
F	002	S050970C	SRM-10.	06/22/92
		S062379L	PRSD-TOC, -04.	
		S072379A	ECL-02.	
		S072379H	MEL-TOC, -13.	
		Errata	ET-11, RCS-02, PRSD-TOC, -04 thru -09, EPDC-13, GNC-FG02, HAZ-02, -04, -05a, -07, -08, -10, FRF-TLP thru -32, MEL-13.	
F	003	S022695J	SRM-03, -05, -09, BEI-TOC, -08, -09, -10.	06/30/92
		S052501Q	AA-TLP, -01.	
		S062379D	BFS-01, -02, -04, -07, -08, -09, -12, -13.	
		S072379E	MEL-TOC, -13.	
		S083029B	TRSS-08.	
		S084802	GSE-24.	
F	004	S052501V	INS-03.	07/06/92
		S062379Q-R1	WAIV-01.	
		S086198	ECL-TOC, -01 thru -48, FG01.	
F	005	S052501Y	CT-05, INS-06.	07/09/92
		S072379J	PAY-TOC, -01, ROEU-01, -02, -03.	
F	006	S072379F	APU-11.	07/14/92
F	007	S072379G	MPS-03.	07/28/92
F	008	S072379C	WAIV-01.	08/11/92
		S072379D	WAIV-01.	
		S072379K	MEL-TOC, -13.	
		S072379L	MEL-TOC, -13.	
F	009	S072379N	SL-01 thru -06, -10 thru -15.	08/31/92

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REV LTR	CHG NO.	PRCBD NOS.	PAGES AFFECTED	DATE
F	010	S052501E	REF-01.	09/16/92
		S062379AB	DPS-17, CT-01, CT-06, -07, -08.	
		S062379E	DPS-26.	
		S062379V	MPS-TOC, -01 thru -42, -44, -45.	
		S086417	FCP-05.	
		Errata	SRM-03, -05, -09, BEI-02, -03, BSEP-05, TRSS-08, PRSD-01, -04, -06 thru -08, APU-17, HYD-08, AFM-03, ECL-01 thru -04, -06 thru -08, -10, -20 thru -23, -30 thru -34, -41 thru -48, CT-05, INS-02 thru -05, GNC-83, BFS-01, -02, -04, -07 thru -10, -12 thru -14, GSE-24, MEL-10, -11, -13.	
F	011	S022695K	BEI-01.	10/13/92
		S062379AA	PRSD-03.	
		S072379U	FCP-FG02.	
		S072379AH	INS-03, MEL-10, MEL-13.	
F	012	S072379Z	WAIV-01.	10/20/92
		S072379AA	WAIV-01.	
		S072379AJ	SSME-TOC, -41.	
		S086517	ECL-40.	
F	013	S052501HR1	CHG-TOC, -01, -FG01, FG02, -FG03, GUID-TOC, -01, -02.	10/28/92
		S072379V	INS-01, -03, -04.	
		S098357	BTVC-01, BRSS-08, BSEP-01.	
F	014	S052778A	BFS-05, -07, -11, -13, FSUM-02, -03, -05.	11/18/92
		S072379Y	GSE-21.	
		S072379AE	CREW-01.	
		S072379AK	MEL-TOC, -13.	
		Errata	SSME-TOC, INS-TOC, -05, -06.	
F	015	S072379AF	MILA-01.	11/30/92
		S072379AL	BTVC-TOC, -15.	
		S072379AM	SSME-08.	
		S072379AU	HAZ-04, -05A, -FG02.	
		S072379AV	MPS-35, -36, -37.	

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REV LTR	CHG NO.	PRCBD NOS.	PAGES AFFECTED	DATE
F	016	S072379AY	GNC-63, -65.	12/17/92
		S072379BA	EPDC-09.	
		S072379BB	MPS-11.	
		S072379BD	GNC-08.	
F	017	S072379AD	PAY-TOC, TDRS-01 thru -30, TDRS-FG01.	12/22/92
		S072379AP	MPS-40.	
		S072379AQ	MPS-24, -25, SEQ-01.	
		S072379AZ	MPS-15, -16, -34, RSLS-01.	
		S072379BC	HAZ-03, -06, -09 thru -12.	
F	018	S072379BF	APU-TOC, -01 thru -06, -08, -09, -10, -12 thru -16, -18 thru -23, -FG01.	01/11/93
		S072379BG	MPS-06.	
		S072379BH	MEL-TOC, -13.	
		S072379BJ	GNC-82.	
		S072379BL	MPS-24.	
		S072379BM	WEA-01.	
		S072379BN	MEL-TOC, -13.	
		S072379BP	MPS-TOC, -03, -46.	
		S072379BQ	INS-03.	
		Errata	APU-11, -17.	
F	019	S072379BE	WAIV-01.	02/18/93
		S072379BV	MEL-TOC, -13.	
		S072379BW	PRSD-03.	
		S072379BZ	ECL-08, -44.	
		S072379CA	GSE-11.	
F	020	S072379BT	MPS-40.	02/26/93
		S072379BU	MPS-34.	
		S072379CB	HYD-01.	
		S072379CC	SSME-24, -29, -30.	
		S072379CE	MPS-01, -02, -04, -05, -07 thru -10, -12, -13, -14, -17 thru -23, -26 thru -33, -38, -39, -41, -42, -44, -45.	
		S072379CH	HAZ-06.	
F	021	S072379CG	BFS-03, -06, -09.	03/11/93
		S072379CT	MEL-13.	
F	022	S072379BY	DPS-18, RSLS-01.	04/01/93
		S072379CK	APU-10.	
		S072379CM	MEL-TOC, MEL-13.	
		S072379CP	MPS-38.	

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REV LTR	CHG NO.	PRCBD NOS.	PAGES AFFECTED	DATE
F	023	S072379CL	DPS-06.	05/03/93
		S072379CQ	GNC-57.	
		S072379CU	OMS-12, -18, PRSD-01, -06, FCP-01 thru -04, -06.	
		S072379DG	MPS-12.	
F	024	S072379CF	EPDC-13.	05/13/93
		S072379CW	CS-01, GEN-01, SAFE-01, SEQ-01, SSME-02, -35, EPDC-07, DPS-23, CT-05, PAY-02, GSE-10, -11, -12, -14, -15, -17, -18, -19, LPS-01, -02, -06, -07, -25.	
		S072379CY	GNC-60, -62, -63, -64.	
		S072379DD	MEL-TOC, -13.	
		S072379DE	APU-11.	
		S072379DN	MPS-12, -34.	
F	025	S072379BWR1	PRSD-03.	05/24/93
		S072379CJ	PAY-01, ROEU-01, -02, -03.	
		S072379CV	DPS-11, GNC-79, -81, -83.	
		S072379DA	WAIV-01.	
		S072379DB	WAIV-01.	
		S072379DC	PAY-TOC, SH-01, -02, -03, TDRS-FG01.	
		S072379DF	DPS-20.	
		S072379DH	WAIV-01.	
		S072379DM	SSME-TOC, -41.	
		S072379DP	INS-03.	
F	026	S072379DJ	WAIV-01.	06/11/93
		S072379DU	ECL-47.	
		S072379DW	PAY-TOC, -03.	
F	027	S072379DK	SL-TOC, -01 thru -05, -15.	06/28/93
		S072379DQ	ETR-01.	
		S072379DTR1	GNC-26, -79.	
		S072379DV	MPS-26, -28, -30.	
		Errata	SL-06, -07, -10 thru -14.	
F	028	S072379DY	MEL-TOC, -13.	07/02/93
		S072379DZ	PAY-TOC, ACTS-01 thru -07, -FG01.	
F	029	S072379EA	WAIV-01.	07/21/93
		S072379EB	BTVC-15.	
		S072379EC	MIL-06.	
		S072379EE	PRSD-03, EPDC-10.	
		S072379DL	AFM-TOC, -01 thru -19, -30.	

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REV LTR	CHG NO.	PRCBD NOS.	PAGES AFFECTED	DATE
F	030	S072379EN	DPS-06.	07/26/93
F	031	S072379ET	DPS-06.	08/09/93
F	032	S072379EM	GNC-32.	08/16/93
		S072379EP	GNC-49, -FG03.	
		Errata	MEL-TOC, -13.	
F	033	S072379ED	BFS-TOC, -15, FSUM-08, MEL-11.	08/24/93
		S072379EQ	MEL-TOC, -13.	
F	034	S072379HA	SSME-29.	09/10/93
		S072379HB	MEL-13.	
		S072379HD	DPS-03, BFS-09.	
F	035	S072379EF	MPS-11.	09/23/93
		S072379EJ	SL-12.	
		S072379EU	BEI-01.	
F	036	S072379CZ	ECL-21.	10/05/93
		S072379EK	SRM-07, -11.	
		S072379EL	SL-14.	
		S072379HC	PAY-TOC, ORF-01, LSLE-01, RAHF-01, TDRS-FG01.	
		S072379HF	SL-11.	
		S072379HJ	SSME-TOC, -29.	
		S072379HK	MEL-13.	
F	037	S072379HE	AFM-TOC, -16, -17, -18.	10/12/93
		S072379HG	WEA-01.	
		S072379HH	SRM-10.	
		S072379HL	PAY-02, SL-02.	
F	038	S072379EG	GSE-21.	11/05/93
		S072379EV	GNC-43, -44.	
		S072379HM	BEI-06.	
		S072379HN	WAIV-01.	
		S072379HP	WAIV-01.	
		Errata	ETR-01, SSME-29, MPS-26, -28, -30, PRSD-03, EPDC-10, -13, APU-11, AFM-01 thru -15, ECL-47, DPS-11, GNC-26, -32, -60, -64, -79, -81, -83, PAY-TOC, -01, -03, ROEU-01, -02, -03, ACTS-01 thru -07, ORF-01, LSLE-01, RAHF-01, TDRS-FG01, SL-01 thru -05, -15, FSUM-08, MEL-11, -13.	

LIST OF CHANGES

REV LTR	CHG NO.	PRCBD NOS.	PAGES AFFECTED	DATE
F	039	S072379HQ	MEL-TOC, -13.	11/19/93
		S072379HU	SSME-29.	
		S072379HV	CHG-FG01.	
		S072379HW	HAZ-07.	
		S072379HY	ECL-05, MIL-06.	
		Errata	ORF-01, LSLE-01, RAHF-01.	
F	040	S072379JC	GNC-24.	11/24/93
F	041	S072379JA	PAY-TOC, SH-01, SH-02, SH-03.	12/17/93
		S072379JB	PAY-TOC, SH-04 thru SH-11, ORF-01, LSLE-01, RAHF-01, TDRS-FG01.	
		S072379JD	WAIV-01.	
F	042	S072379EW	PAY-TOC, -02, -03.	01/26/94
		S072379JE	SH-08.	
		S072379JF	AFM-30.	
		S072379JJ	PAY-01.	
		S072379HZ	MEL-TOC, -13.	
F	043	S072379EH	MPS-15, -16.	02/22/94
		S072379EY	BFS-10, DPS-01, -09.	
		S072379JL	MEL-TOC, -13.	
		S072379JM	CHG-TOC, 01, -FG02, GEN-01.	
		S072379JW	SSME-18, -29, -34.	
		S072379JY	CT-16.	
F	044	S072379JZ	BTVC-15.	03/01/94
F	045	S072379JG	SSME-04.	03/11/94
F	046	S072379JH	PAY-01.	03/25/94
		S072379JK	FCP-TOC, -02, -FG02, -FG03.	
		S072379JQR1	MEL-TOC, -13.	
F	047	S072379KA	WAIV-01.	04/15/94
		Errata	ET-06.	
F	048	S072379FB	SL-TOC, -03, -06, -13, -14, -15.	06/02/94
		S072379JN	MEL-02, -03, -09, -12.	
		S072379JP	MIL-07.	
		S072379JT	SSME-08.	

LIST OF CHANGES

REV LTR	CHG NO.	PRCBD NOS.	PAGES AFFECTED	DATE
F	049	S072379JU	MPS-03, -04, -05, -15, -46.	06/17/94
		S072379KC	GSE-TOC, -25, -FG01, -FG02.	
		S072379KD	GSE-04, -08.	
		S072379KF	ET-06.	
		S072379KG	APU-02, -14, -15, -18, -22.	
		S072379KH	SSME-TOC, -TAB, -27.	
		S072379KL	KYD-10.	
		S072379KM	MEL-TOC, -13.	
		S072379KN	APU-06.	
		Errata	WEA-01, SRM-07, -10, -11, BTVC-15, BEI-01, -06, SSME-04, MPS-11, FCP-02, -FG02, DPS-01, -09, GNC-24, -49, -FG03, BFS-10, PAY-01, ORF-01, LSLE-01, RAHF-01, FG01, -02, SL-14, MEL-13, MIL-06.	
F	050	S072379FA	PAY-TOC, IML-01, -02, TDRS-FG01.	06/23/94
		S072379KP	APU-TOC, -24, -FG01.	
		S072379KU	SL-TOC, -10.	
		Errata	FWD-01, PAY-TOC.	
F	051	S072379KT	MEL-TOC, -13.	08/04/94
		S072379KZ	PAY-TOC, SPI-01, TDRS-FG01.	
F	052	S072379FC	GNC-75.	08/16/94
		S072379KE	HAZ-TOC, -01, -03, -09, -10, -11, -12, -FG01, -FG02, -FG03, -FG04.	
		S072379KQ	PAY-01.	
		S072379KV	BEI-06, -07.	
		S072379KWR1	WEA-01, ET-TOC, ICE-TOC, -01, -02, -03, -FG01, -FG02, -FG03, -FG04.	
F	053	S072379FJ	MEL-TOC, -13	08/30/94
F	054	S072379FL	PRSD-01, -04, -06, -07, -08.	09/15/94
F	055	S072379HT	BFS-TOC, -04, -05.	09/20/94
		S072379LB	APU-24, GSE-04, -08, -25.	
		Errata	HAZ-FG01, -FG02.	
F	056	S072379FM	MPS-04, -05, -07, -08.	09/30/94
F	057	S072379LD	MEL-TOC, -13	10/21/94
		S072379LE	CT-TOC, -06	
		S072379LF	ET-TOC, -01, -FG01	
		S072379LG	SSME-11	

LIST OF CHANGES

REV LTR	CHG NO.	PRCBD NOS.	PAGES AFFECTED	DATE
F	058	S072379LJ	WAIV-01.	12/20/94
		S072379LL	PAY -TOC, SH-01 thru -11.	
F	059	S072379KBR1	GEN-01, IMPL-01.	01/20/95
		S072379LN	MPS-04, -05, -07, -08.	
		S072379LP	SSME-38.	
		S072379LQ	MEL-TOC, -13.	
F	060	S072379LT	GNC-15.	01/30/95
		S072379LV	ETR-01.	
F	061	S072379LK	PRSD-01, -06.	02/23/95
		S072379LM	WAIV-01.	
		S072379LU	DPS-17, CT-TOC, -01, -07, MEL-04.	
		S072379LW	ETR-01.	
		S072379LY	MEL-TOC, -13.	
		S072379LZ	WAIV-01.	
F	062	S072379FD	PAY-TOC, AST-01, TDRS-FG01.	02/24/95
F	063	S072379FF	AST-01.	02/28/95
F	064	S072379FE	WAIV-01.	03/20/95
		S072379FN	WAIV-01.	
F	065	S072379FG	SEQ-01, SSME-10, -27, MPS-03.	04/10/95
F	066	S072379FH	WEA-TLP, -TOC, -01.	05/17/95
		S072379FP	HYD-TOC, -04, -FG01.	
		S072379FT	MPS-TOC, -06, -09, -10, -12, -34, -46, -47.	
		S072379FU	WAIV-01.	
		S072379LH	HAZ-02, HAZ-FG02.	
		Errata	ETR-01, BEI-06, -07, ET-06, MPS-04, -05, -07, -08, -15, -46, PRSD-01, -04, -06, -07, -08, ECL-05, GNC-75, BFS-04, -05, PAY-TOC, IML-01, -02, SPI-01, AST-01, TDRS-FG01, MEL-TOC, -13.	
F	067	S072379FW	PAY-TOC, TDRS-01, -02, -05 THRU -30, -FG01.	05/31/95
		S072379FY	PAY-TOC, IUS-01.	
		S072379FZ	MEL-TOC, -13.	
		S072379GA	MEL-TOC, -13.	
		Errata	MPS-06, -09, -10, -12, -34, -46, SH-10, HAZ-02, -FG02.	

LIST OF CHANGES

REV LTR	CHG NO.	PRCBD NOS.	PAGES AFFECTED	DATE
F	068	S072379FK	INS-03.	06/13/95
		Errata	HAZ-FG02.	
F	069	S072379GD	LPS-TOC, -01 THRU -25.	06/21/95
		S072379GG	ETR-01.	
F	070	S072379GB	BEI-TOC, -04, -06, -07.	07/13/95
F	071	S072379GH	BRSS-07, TRSS-05.	07/26/95
		S072379GJ	SRM-11.	
		S072379GK	MEL-TOC, -13.	
F	072	S072379GF	GEN-01, GUID-TLP, -TOC, -01, -02, -FG01.	08/28/95
		S072379GM	ET-08, HAZ-07.	
		S072379GN	MEL-TOC, -13.	
F	073	S072379GL	SL-11, -12.	09/14/95
		S072379GW	SSME-38.	
		S072379KK	ECL-43.	
F	074	S072379GP	LPS-TOC, -01 THRU -25.	09/25/95
F	075	S072379GQ	WAIV-01.	10/18/95
		S072379MC	DPS-17, CT-01, MEL-04.	
F	076	S072379GQR1	WAIV-01.	10/27/95
		S072379GT	WAIV-01.	
		S072379GU	WAIV-01.	
		S072379MA	SRM-10.	
		S072379MB	MEL-TOC, -13.	
		S072379MD	LPS-TOC, -01 thru -25.	
		S072379ME	GSE-TOC, -24, -25, -FG01, -FG02, -FG03.	
F	077	S072379MF	DPS-17, CT-TOC, -01, MEL-04.	11/01/95
F	078	S072379GV	TOC-01, WAIV-TLP, -01.	12/12/95
		Errata	CT-01, GSE-TOC.	
F	079	S072379MG	SSME-TOC, -03, -10, MPS-03.	12/28/95
		S072379MH	MEL-TOC, -13.	
		S072379MJ	ROEU-01, -02, -03.	
		S072379MK	GSE-FG03.	

LIST OF CHANGES

REV LTR	CHG NO.	PRCBD NOS.	PAGES AFFECTED	DATE
F	080	S072379GC	ECL-48.	02/13/96
		S072379ML	MEL-TOC, -13.	
		S072379MM	DPS-TOC, -08, -26, BFS-14, FSUM-08.	
		S072379MN	APU-TOC, -21.	
		S072379MP	GSE-FG03.	
		Errata	PAY-TOC, TDRS-01, -02, -10 thru -14, -16 thru -26, IUS-01, SEQ-01, SRM-10, BEI-04, -06, -07, ET-08, SSME-27, MPS-06, -09, -10, -12, -34, -46, DPS-17, INS-03, GNC-15, BFS-TOC, ROEU-01 thru -03, SL-11, -12, HAZ-02, -07, -FG02.	
F	081	S072379GZ	SSME-TOC, -12, -13, -14, -24, -25, -42.	02/20/96
F	082	S072379MQ	CHG-FG03.	03/12/96
		S072379MT	GEN-01.	
		S072379MU	MEL-TOC, -13.	
		S072379MV	ET-10.	
		S072379MY	MEL-03, -05.	
		S072379MZ	OMS-TOC, -01, -15, -18.	
		S072379NA	RCS-01, -02, -05, -10.	
		S072379NB	GSE-FG03.	
F	083	S072379MW	EPDC-TOC, -08, -09.	04/18/96
		S072379NC	MEL-TOC, -13.	
		S072379NE	PAY-TOC, SH-01 thru -08.	
		S072379NF	DPS-06, FSUM-08.	
		S072379NG	ECL-09.	
		S072379NH	GNC-74, -75.	
F	084	S072379NJ	SH-04.	05/06/96
		S072379NK	GSE-FG03.	
F	085	S072379NL	MILA-TOC, -03.	05/13/96
F	086	S072379ND	ETR-01.	06/07/96
		S072379NM	MEL-TOC, -13.	
		S072379NN	SL-10, -11, -12.	
F	087	S072379NP	GSE-FG03.	06/14/96
F	088	S072379NQ	CT-02, 09, INS-04, MEL-02, -03, -11, MIL-09	08/16/96
		S072379NT	MEL-TOC, -13	
		S072379NV	SEQ-01	
		S072379NW	PAY-TOC, SH-04, -06, -07	

LIST OF CHANGES

REV LTR	CHG NO.	PRCBD NOS.	PAGES AFFECTED	DATE
F	089	S072379NU	TRSS-TOC, -01, -04, -05, -06, -08 thru -13.	08/38/96
		S072379NY	ETR-01.	
F	090	S072379NZ	GSE-FG03.	09/11/96
F	091	S072379PA	HAZ-TOC, -01 thru -12, -FG02.	10/10/96
		S072379PC	CHG-TOC, -01, -FG02.	
F	092	S072379PD	OMS-13.	10/18/96
		S072379PE	MEL-TOC, -13.	
F	093	S072379PF	GSE-FG03.	11/07/96
		S072379PG	GSE-01, -02, -03.	
F	094	S072379PH	DPS-18.	01/02/97
		S072379PK	MEL-TOC, -13.	
		S072379PL	SSME-10.	
F	095	S072379PN	GSE-FG03.	01/07/97
F	096	S072379PJ	MEL-05, MIL-03, OMS-17.	02/05/97
		S072379PM	AA-TLP, -01.	
		S072379PP	WAIV-01.	
		S072379PQ	ECL-05.	
		S072379PT	RSLS-01.	
		S072379PU	MEL-TOC, -03.	
		S072379PV	FCP-05.	
		S072379PY	MEL-12.	
		S072379QB	GSE-FG03.	
F	097	S072379PW	EPDC-TOC, -09 thru -14.	03/13/97
		S072379PZ	GUID-01.	
		S072379QA	INS-04.	
F	098	S072379QD	MEL-TOC, -13.	03/31/97
		S072379QE	CHG-FG03.	
		S072379QF	GSE-FG03.	
		S072379QG	APU-04.	

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REV LTR	CHG NO.	PRCBD NOS.	PAGES AFFECTED	DATE
F	099	S072379QJ	HAZ-03.	05/12/97
		S072379QL	PAY-TOC, SH-04, -FG05.	
		S072379QM	MEL-TOC, -13.	
		S072379QN	CHG-01.	
		S072379QP	WAIV-01.	
		S072379QQ	GSE-FG03.	
		S072379QT	WEA-01.	
		S072379QU	FCP-03.	
		Errata	WAIV-01.	
F	100	S072379QV	MEL-TOC, -13.	06/24/97
		S072379QW	SSME-10.	
		S072379QY	SSME-09.	
		S072379QZ	GSE-FG03.	
F	101	S072379TA	WAIV-01.	07/25/97
		S072379TB	MEL-TOC, -13.	
		S072379TC	FCP-03.	
		S072379TD	GSE-FG03.	
F	102	S072379TF	MEL-TOC, -13.	09/08/97
F	103	S072379TE	FCP-03.	09/18/97
		S072379TG	HAZ-01 thru -05, -06, -07, -08.	
		S072379TH	SH-FG05.	
		S072379TJ	GSE-FG03.	

LIST OF CHANGES FOR REVISION G

CHG NO.	LCN NO.	PRCBD NOS.	PAGES AFFECTED	DATE
000		S072379QC	Incorporates Revision F in its entirety. Complete document revision. (Also includes CAR S072379QC.)	09/26/97
001	00796	S072379TK	WAIV-01.	11/14/97
	00788	S072379TN	MEL-TOC, -13.	
	00789	S072379TP	GSE-FG03.	
002	00801	S072379TQ	WAIV-01.	01/12/98
	00799R01	S072379TW	MEL-TOC, -13.	
	00800	S072379TY	GSE-24, -FG03.	
003	00772R05	S072379TL	ROEU-01, -02, -03.	02/13/98
	00803	S072379TZ	WAIV-01.	
	00803	S072379UA	WAIV-01.	
	00803	S072379UB	WAIV-01.	
004	00784	S072379TT	CHG-01, GUID-TOC, -01.	03/30/98
	00798	S072379TV	APU-03, -FG01.	
	00804	S072379UC	ET-TOC, -04, -05, -FG03.	
	00808	S072379UD	SSME-02, -09.	
	00806	S072379UE	ETR-01.	
	00807	S072379UF	MEL-TOC, -13.	
	00812	S072379UG	GSE-FG03.	
	00784	Errata	GUID-TOC, -FG01.	
005	00810R02	S072379UH	SL-03 thru -06, -11, -12.	04/06/98
006	00818	S072379UJ	WAIV-01.	04/13/98
	00814R03	S072379UK	SL-TOC, -07, -08.	
	00814R03	Errata	SL-09.	
007	00811R03	S072379UL	SLWT-TOC, -INT, -01 thru -33.	05/11/98
	00816R02	S072379UM	APU-19.	
008	00782R04	S072379TM	CT-08, DPS-17, MEL-04.	05/21/98
	00822R01	S072379UNR1	MEL-TOC, -13.	
	00821	S072379UP	GSE-FG03.	
009	00824R03	S072379UQ	WEA-TOC, -01.	06/11/98
	00828	S072379UT	WAIV-01.	

LIST OF CHANGES FOR REVISION G

CHG NO.	LCN NO.	PRCBD NOS.	PAGES AFFECTED	DATE
010	00820R03	S072379VB	BFS-TOC, -10, -10a, DPS-TOC, -01, -01a, -09, -23, FSUM-08, MEL-04, -05, -10.	07/27/98
	00827	S072379VC	APU-TOC, -19.	
	00829	S072379VD	PRSD-04.	
	00834	S072379UU	WAIV-01.	
	00834	S072379UV	WAIV-01.	
011	00832R02	S072379VE	DPS-TOC, -09, BFS-05.	08/31/98
	00832	S072379VF	ET-04.	
012	00838	S072379VH	HAZ-02.	09/29/98
	00848	Errata	SLWT-TOC, -INT, -01 thru -33.	
013	00831R01	S072379VG	GSE-24.	10/09/98
	00843R01	S072379VN	SSME-42.	
	00844R01	S072379VP	SSME-29.	
	00845	S072379VQ	BREC-TOC, -01.	
014	00846R01	S072379UW	SH-01, -FG05, -07.	10/14/98
	00837R03	S072379VJ	MEL-TOC, -13.	
	00840R02	S072379VK	SSME-TOC, -10, -12, -13, -16 thru -23, -33.	
	00842R02	S072379VM	SSME-43.	
015	00841R03	S072379VL	CT-05, MEL-11.	10/22/98
016	00847R02	S072379UY	GSE-24, -FG03.	10/27/98
	00854	Errata	SSME-23.	
017	00851R02	S072379VT	GSE-TOC, -26, WEA-TOC, -01.	10/28/98
018	00856R01	S072379VU	SSME-43.	11/25/98
	00863	S072379VW	WAIV-01.	
	00860R03	S072379VY	MEL-TOC, -13.	
	00861	S072379VZ	GSE-FG03.	
019	00864	S072379WA	WAIV-02.	01/05/99
020	00858R02	S072379VV	SSME-29.	03/05/99
	00857R01	S072379WB	MPS-02.	

LIST OF CHANGES FOR REVISION G

CHG NO.	LCN NO.	PRCBD NOS.	PAGES AFFECTED	DATE
021	00875	S072379WC	WAIV-01, -02.	04/19/99
	00875	CAR S072379WC	WAIV-01.	
	00874	S072379WD	SSME-29.	
	00868R01	S072379WE	GSE-16, -17.	
	00869	S072379WF	MILA-01, -02, -03.	
022	00883	S072379WH	GSE-FG03.	05/18/99
	00885R01	S072379WJ	SSME-03, -04.	
	00877R02	S072379WK	SEQ-01, ET-10.	
	00876R02	S072379WMR1	MEL-TOC, -13.	
	00888R03	S072379WN	TOC-01, INS-06, FSUM-TLP, -TOC, CW-01, -02.	
	00870R03	S072379WP	HAZ-TOC, -01 thru -08, -FG01, -FG04.	
	00889	S072379WQ	ETR-01.	
023	00867R02	S072379WT	HYD-07.	05/20/99
024	00871R03	S072379WL	APU-TOC, -01 thru -06, -08 thru -16, -18, -20, -22 thru -24.	06/14/99
	00893	S072379WU	WAIV-02.	
025	00879R02	S072379WV	AFM-30.	06/24/99
	00892	S072379WW	PAY-TOC, IUS-01.	
026	00896	S072379WY	GSE-FG03.	07/09/99
	00878	S072379YA	PAY-TOC, -02, -03.	
	00881R01	S072379YB	ECL-22, -23.	
	00897	S072379YD	ICE-01.	
027	00895R02	S072379WZ	ECL-30 thru -33.	07/14/99
	00844R03	S072379YC	MEL-TOC, -13.	
028	00902R02	S072379YE	PAY-TOC, IUS-02.	07/16/99
	00904	S072379YF	AXAF-01.	
029	00911	S072379YG	WAIV-02.	08/10/99
030	00921	S072379YH	WAIV-02.	08/17/99
031	00918R02	S072379YL	SSME-09, -15.	10/08/99
	00917	S072379YM	SSME-TOC, -42.	
	00915	S072379YP	SSME-19, -20, -23.	
	00925R01	S072379YW	EGR-04.	

LIST OF CHANGES FOR REVISION G

CHG NO.	LCN NO.	PRCBD NOS.	PAGES AFFECTED	DATE
032	00906R01	S072379YK	MEL-13.	11/04/99
	00916R03	S072379YNR1	SSME-TOC, -24, -25, -44.	
	00919R04	S072379YU	EGR-03.	
	00909R02	S072379YV	DPS-01, -01a, BFS-10a, MEL-10.	
033	00920R04	S072379YQ	GNC-73 thru -75.	11/22/99
	00914R02	S072379YY	PRSD-03, FCP-02.	
	00934	S072379ZB	WAIV-02.	
	00933	S072379ZC	HAZ-03.	
034	00928	S072379ZA	GSE-FG03.	12/07/99
035	00940	Errata	PRSD-03, FCP-02.	12/15/99
036	00903R01	S072379YJ	MEL-13.	12/22/99
	00941	S072379ZK	WAIV-02.	
037	00927R03	S072379YZ	ETR-01.	01/17/00
	00936	S072379ZJ	GSE-FG03.	
	00943	S072379ZN	WAIV-02.	
038	00923R03	S072379ZL	BTVC-TOC, -16.	01/24/00
039	00944	S072379ZW	SL-TLP, -TOC.	02/29/00
040	00929R02	S072379ZD	HYD-01, -02, MEL-02, MPS-03, -46.	03/09/00
041	00866R07	S072379ZH	ECL-10, MEL-08.	04/07/00
	00951	S072379ZP	GSE-FG03.	
042	00953R01	S072379ZU	MEL-TOC, -13.	04/21/00
043	00954R01	S072379ZZ	HAZ-01 thru -05, -06 thru -08.	06/14/00
	00963	S072380A	WAIV-02.	
044	00960R03	S072380ER1	PRSD-07, -08.	07/06/00
	00972	CAR S072379ZQ	WEA-01, BREC-01, PRSD-03, FCP-02, PAY-TOC, IUS-01, -02, AXAF-01, GSE-TOC, -24, -26, MEL-TOC, -13.	
045	00966R01	S072380B	SSME-02, -09.	07/19/00
	00965	S072380D	SSME-17, -32.	

LIST OF CHANGES FOR REVISION G

CHG NO.	LCN NO.	PRCBD NOS.	PAGES AFFECTED	DATE
046	00971R02	S072380G	GNC-TOC, -73, -74, -75.	08/10/00
	00970	S072380H	FCP-06.	
047	00899R03	S072379ZG	HYD-02.	08/16/00
048	00955R04	S072380	ECL-41.	08/29/00
	00969R01	S072380C	EPDC-TOC, -09 thru -14.	
	00975R01	S072380J	MEL-TOC, -13.	
049	00977R03	S072380K	GSE-TOC, -24, -FG03.	09/06/00
050	00985R01	S072380L	ECL-10.	09/26/00
	00979R04	S072380M	HAZ-01, -03, -FG01, -FG02, -FG04.	
	00981R01	S072380N	MEL-TOC, -13.	
051	00978R02	S072380P	SSME-28.	10/16/00
	00987R01	S072380Q	MEL-TOC, -13.	

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LIST OF CHANGES FOR REVISION H

CHG	LCN NO	AUTHORIZATION	SSIDS AFFECTED	DATE
000		S072380T	Incorporates Revision G in its entirety. Complete document revision.	11/20/00
001	01053R01	S072380W	APU-11	01/09/01
	01054R02	S072380Y	MEL-13(098)	
	01056	S072380U	WAIV-02	
002	01055R02	S072380Z	MEL-13(102)	02/19/01
003	01058R01	S072380AG	MEL-13(100)	03/27/01
004	01061R01	S072380ABR1	SSME-24, SSME-25, SSME-44	04/23/01
005	01066R01	S072380AC	MEL-13(104)	05/18/01
006	01067R01	S072380AD	GSE-24	05/24/01
007	01065R02	S072380AN	ICE-FG01	06/04/01
	01068R01	S072380AP	GNC-28, GNC-31, GNC-74	
008	01060R03	S072380AM	ET-01, ET-07, ET-FG01, ET-FG02	06/29/01
009	01070R05	S072380AK	HAZ-02, MPS-40	07/05/01
010	01071R03	S072380AT	AA-01	07/24/01
	01072	S072380AQ	MEL-13(105)	
011	01057R03	S072380AL	AFM-01, AFM-02, AFM-03, AFM-04, AFM-05, AFM-06, AFM-07, AFM-09, AFM-10, AFM-11, AFM-12, AFM-13, AFM-14, AFM-15, AFM-16, AFM-17, AFM-18, AFM-30, APU-01, APU-02, APU-03, APU-04, APU-05, APU-08, APU-09, APU-10, APU-11, APU-12, APU-13, APU-14, APU-15, APU-20, APU-23, APU-24, BEI-04, BEI-06, BEI-07, BFS-05, BFS-09, BFS-10, BFS-10a, BFS-14, BREC-02, BRSS-01, BRSS-05, BRSS-07, BRSS-08, BRSS-16, BRSS-17, BSEP-01, BTVC-01, BTVC-05, BTVC-16, CT-01, CT-02, CT-04, CT-05, CT-09, DPS-01, DPS-01a, DPS-02, DPS-03, DPS-09, DPS-19, DPS-23, DPS-24, DPS-26, ECL-01, ECL-02, ECL-03, ECL-04, ECL-05, ECL-06, ECL-07, ECL-08, ECL-09,	08/20/01

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CHG	LCN NO	AUTHORIZATION	SSIDS AFFECTED	DATE
011	01057R03	S072380AL	ECL-10, ECL-11, ECL-20, ECL-21, ECL-31, ECL-33, ECL-40, ECL-41, ECL-43, ECL-45, ECL-48, EGR-03, EGR-05, EGR-06, EGR-07, EGR-08, EGR-09, EPDC-01, EPDC-04, EPDC-06, EPDC-08, EPDC-09, EPDC-10, EPDC-14, ET-03, ET-05, FCP-03, FCP-04, FCP-05, FCP-06, GEN-01, GNC-09, GNC-10, GNC-14, GNC-15, GNC-24, GNC-26, GNC-27, GNC-32, GNC-38, GNC-39, GNC-41, GNC-45, GNC-47, GNC-48, GNC-49, GNC-56, GNC-57, GNC-58, GNC-59, GNC-61, GNC-63, GNC-66, GNC-67, GNC-73, GNC-79, GNC-80, GNC-81, GSE-09, GSE-10, GSE-11, GSE-16, GSE-17, GUID-01, HAZ-01, HAZ-03, HAZ-05, HAZ-06, HAZ-08, HYD-03, HYD-04, HYD-08, HYD-10, INS-01, INS-02, INS-03, INS-04, INS-05, INS-06, LPS-17, LPS-18, LPS-19, LPS-20, LPS-21, LPS-25, MPS-04, MPS-05, MPS-07, MPS-08, MPS-34, MPS-35, MPS-36, MPS-37, OMS-01, OMS-02, OMS-03, OMS-06, OMS-07, OMS-09, OMS-10, OMS-11, OMS-13, OMS-16, OMS-17, PAY-01, PRSD-01, PRSD-02, PRSD-03, PRSD-05, PRSD-06, PRSD-09, RCS-01, RCS-02, RCS-03, RCS-04, RCS-05, RCS-06, RCS-08, RCS-10, ROEU-01, ROEU-02, ROEU-03, SSME-01, SSME-07, SSME-09, SSME-29	08/20/01
012	01062R02	S072380AE	GEN-01, GUID-01	08/22/01
013	01059R02	S072380AV	RDM-01, RDM-02, RDM-03, RDM-04, RDM-05, RDM-06, RDM-07, RDM-08, RDM-09, RDM-10, RDM-11, RDM-12, RDM-13, RDM-14, SH-01, SH-02, SH-03, SH-04, SH-06, SH-07, SH-08, SH-09, SH-10, SH-11, SH-12, SH-FG05	09/20/01
014	01073R02 01076R01	S072380AY S072380AW	DPS-24, GNC-85, MEL-04 ET-05	11/01/01
015	01074R04	S072380AU	BFS-12, BFS-15, CT-03, DPS-06,	11/16/01

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CHG	LCN NO	AUTHORIZATION	SSIDS AFFECTED	DATE
015	01074R04	S072380AU	DPS-22, GNC-83, HYD-02	11/16/01
	01079R03	S072380AZ	MEL-13(108)	
	N/A	CAR S072380AZ	MEL-13(098) (Removed)	
	N/A	CAR S072380AZ	MEL-13(100) (Removed)	
	N/A	CAR S072380AZ	MEL-13(102) (Removed)	
	N/A	CAR S072380AZ	MEL-13(104) (Removed)	
	N/A	CAR S072380AZ	MEL-13(105) (Removed)	
016	01069R04	S072380BB	DPS-06, DPS-06a, DPS-07, INS-02, INS-02a, MEL-10, MEL-11	12/20/01
	01086	S072380BC	WAIV-02	
017	01075R04	S072380BD	GNC-73	01/18/02
018	01078R03	S072380BG	HAZ-01, HAZ-02, HAZ-03, HAZ-04, HAZ-05, HAZ-06, HAZ-07, HAZ-08, HAZ-09, HAZ-10, HAZ-11, HAZ-12, HAZ-FG01, HAZ-FG02, HAZ-FG04	02/08/02
	01081R02	S072380BH	EPDC-03	
	01084	S072380BE	ETR-01	
	01087R01	S072380BF	MEL-13(109)	
019	01090R02	S072380BJ	BFS-10a, DPS-01a	03/12/02
	01092	S072380BK	SRM-06	
	N/A	CAR S072380BF	MEL-13(108) (Removed)	
020	01063R03	S072380BL	ECL-10	03/18/02
	01091R01	S072380BM	MEL-13(110)	
	01093R01	S072380BN	DPS-15	
021	01089R01	S072380BP	EPDC-02, GNC-38	03/25/02
022	01098	S072380BQ	WAIV-02	04/16/02
023	01097R02	S072380BT	MEL-13(111)	05/09/02
024	01095R01	S072380BU	HAZ-04, HAZ-09, HAZ-11, HAZ-12, HAZ-FG04	05/14/02
025	01099R03	S072380BW	LPS-17, LPS-18, LPS-19, LPS-20, LPS-21, LPS-25	05/24/02
	N/A	CAR S072380BT	MEL-13(109) (Removed)	
	N/A	CAR S072380BT	MEL-13(110) (Removed)	
026	01096R01	S072380BV	RDM-05, RDM-06, RDM-07, RDM-12, RDM-13, RDM-14, SH-12	06/12/02
027	01085R02	S072380BZ	GNC-22, GNC-25, GNC-26, GNC-28,	06/25/02

LIST OF CHANGES FOR REVISION H

CHG	LCN NO	AUTHORIZATION	SSIDS AFFECTED	DATE
027	01085R02	S072380BZ	HYD-05, SSME-01	06/25/02
	01100R02	S072380CA	MEL-13(107)	
028	01101R03	S072380CB	RDM-01, RDM-06, RDM-08, RDM-11	07/12/02
029	01064R03	S072380CD	EPDC-08, GNC-08, GNC-09, GNC-32, GNC-39, GNC-57	08/19/02
	01104	S072380CE	MEL-13(107)	
030	01094R03	S072380CF	ECL-03	09/19/02
	01105R01	S072380CG	MEL-13(112)	
	01106R01	S072380CH	LPS-17, LPS-18, LPS-19, LPS-20, LPS-21, LPS-25	
031	01107R01	S072380CK	MEL-13(113)	10/21/02
	01108R01	S072380CJ	WAIV-02	
	N/A	CAR S072380CK	MEL-13(111) (Removed)	
	N/A	CAR S072380CK	MEL-13(112) (Removed)	
032	01082R03	S072380CL	APU-01, APU-02, APU-04, APU-05, APU-06, APU-08, APU-09, APU-10, APU-12, APU-13, APU-14, APU-15, APU-16, APU-18, APU-20, APU-22, APU-23, APU-24	12/12/02
	01110R01	S072380CM	FCP-06	
033	01109R01	S072380CN	HAZ-12, ICE-04	12/18/02
034	01112	S072380CQ	ET-10	03/11/03
035	01113R01	S072380CT	CT-01, CT-08, DPS-17, MEL-04	04/15/03
036	01115R01	S072380CVR1	OMS-07, OMS-08, RCS-08	09/04/03
	01118R02	S072380CZ	RCS-04, RCS-06, RCS-07	
037	01117R02	S072380DA	SH-01, SH-06, SH-08, SH-11, SH-12	09/18/03
038	01116R03	S072380BY	CHG-01, CHG-FG01, CHG-FG02, ETR-01, FSUM-01, GEN-01, GUID-01, GUID-FG01, IMPL-01, REF-01	11/07/03
039	01123R02	S072380CY	GSE-10, GSE-11, GSE-12, GSE-13	03/09/04
040	01122R02	S072380DC	EPDC-11	04/02/04
041	01121R02	S072380DB	ET-05	04/26/04
	01126R02	S072380DE	ET-15	

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CHG	LCN NO	AUTHORIZATION	SSIDS AFFECTED	DATE
042	01125R03	S072380DD	ET-12, ET-13, ET-14	06/04/04
043	01129R01	S072380DF	MIL-07	07/12/04
044	01114R05	S072380CU	WEA-01	08/04/04
045	01127R03	S072380DH	DPS-06, DPS-06a, FSUM-08, INS-02, MEL-10	10/06/04
	01131R01	S072380DG	GNC-10, GNC-FG03	
046	01130R02	S072380DJ	DPS#-03, ECL#-43, ECL#-44, INS#-04, SEQ#-01, SSME#-07, TTEST-01, WEA#-01	11/09/04
	01132R02	S072380DK	HAZ-09, HAZ-10, HAZ-11, HAZ-12, HAZ-13, HAZ-FG01, HAZ-FG03	
	01133R01	S072380DL	PRSD-09	
047	01136R02	S072380DM	BTVC-05	01/14/05
048	01144R01	S072380DN	ECL-11	02/21/05
	01146R03	S072380DP	ET-13, ET-14	
049	01149R02	S072380DT	GSE-09	03/01/05
050	01134R02	S072380DU	SSME-02, SSME-09, SSME-10, SSME-17, SSME-24, SSME-27, SSME-28, SSME-44	04/13/05
	01135R02	S072380DV	MPS-03, SSME-11	
	01150R02	S072380DY	MPS-19, MPS-20, MPS-38, MPS-46	
	01151R02	S072380DWR1	AFM-19, AFM-20, AFM-21	
051	01147R02	S072380DZ	ECL-10	04/20/05
	01154R03	S072380ED	LPS-17	
	01156R01	S072380EE	GSE-27	
	01159	S072380EF	TTEST-01	
052	01120R03	S072380EA	MPS-21, MPS-22, MPS-23	04/26/05
	01137R01	S072380EB	ICE-01, ICE-FG01, ICE-FG02, ICE-FG03, ICE-FG04	
053	01138R04	S072380DQ	CT-10, MEL-11, MEL-12	05/18/05
	01145R02	S072380EH	GSE-26	
	01157R02	S072380EJ	EGR-03	
	01163R01	S072380EG	WAIV-02	
	01168R02	S072380EK	ECL#-11, ECL#-40, GNC#-59, TTEST-01	
054	01152R03	S072380ECR1	APU-25, MIL-07	05/25/05

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CHG	LCN NO	AUTHORIZATION	SSIDS AFFECTED	DATE
055	01167R01	S072380EL	ET-16, ET-17	06/03/05
056	01153R03	S072380EN	FCP-01, FCP-FG01, MIL-05	06/28/05
	01160R04	S072380EW	GSE-24	
	01161R04	S072380EQ	MEL-12, MEL-13(114)	
	01166R01	S072380EU	WEA-01	
	01170R02	S072380EY	ET-04, ET-04	
	01171	S072380EM	WAIV-02	
	01172R01	S072380EZ	MPS-25	
	01173R02	S072380FA	ET-16	
057	01158R02	S072380EP	SRM-11, SRM-11	07/07/05
	01165R02	S072380ET	SRM-10, SRM-10	
058	01174R03	S072380FE	BFS-01, BFS-02, BFS-03, BFS-04, BFS-05, BFS-06, BFS-08, BFS-09, BFS-11, BFS-12, BFS-14, BFS-15	11/11/05
059	01124R02	S072380FB	SRM-06	12/02/05
	01175R02	S072380FF	MPS-04, MPS-05, MPS-07, MPS-08	
060	01155R05	S072380FD	PAY-01	03/06/06
	01164R04	S072380FC	SRM-01, SRM-02, SRM-04	
	01180R01	S072380FH	MPS-21, MPS-22, MPS-33, MPS-34	
061	01182R02	S072380FK	MPS-35, MPS-36, MPS-37	03/22/06
062	01080R07	S072380FJ	SRM-07, SRM-07	04/06/06
	01183R01	S072380FL	SRM-06, SRM-06, SRM-10, SRM-10, SRM-11, SRM-11	
063	01179R02	S072380FM	GSE-24	04/18/06
	01181R02	S072380FN	BFS-10, BFS-10a, DPS-01, DPS-01a, DPS-09, DPS-23, FSUM-08, MEL-01, MEL-02, MEL-03, MEL-04, MEL-05, MEL-10, MIL-02	
064	01178R04	S072380FGR1	CREW-01, GUID-01, HOLD-01, SEQ-01	05/04/06
065	01148R06	S072380FP	BFS-16	06/09/06
	01176R02	S072380FV	GSE-13, GSE-13	
	01186R02	S072380FQ	HAZ-04, HAZ-07	
	01187R01	S072380FT	HAZ-10	
	01188R02	S072380FU	MPS-48, MPS-49, MPS-50, MPS-51, MPS-52	
	01190	S072380FW	ET-10	
066	01177R02	S072380GA	EGR-05, EGR-06, EGR-07, EGR-08,	06/14/06

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CHG	LCN NO	AUTHORIZATION	SSIDS AFFECTED	DATE
066	01177R02	S072380GA	EGR-09, SAFE-01	06/14/06
	01191R04	S072380FY	MPS-22	
	01196R02	S072380GB	AFM-30	
067	01194R01	S072380GD	AA-01	06/20/06
	01195R02	S072380FZ	MEL-13(121)	
	01197R02	S072380GC	ECL-07	
068	01199R02	S072380GM	ECL-08, ECL-09	08/16/06
	01200	S072380GL	WAIV-02	
	01202R02	S072380GP	PRSD-01, PRSD-06	
069	01201R01	S072380GN	MEL-13(115)	08/21/06
070	01198R03	S072380GY	GSE-21, MPS-48	11/14/06
	01203R02	S072380GW	GNC-08	
	01205	S072380GU	WAIV-02	
	01210	S072380GZ	ET-04, GSE-13, SRM-06, SRM-07, SRM-10, SRM-11	
	N/A	CAR S072380GZ	DPS#-03 (Removed)	
	N/A	CAR S072380GZ	ECL#-11 (Removed)	
	N/A	CAR S072380GZ	ECL#-40 (Removed)	
	N/A	CAR S072380GZ	ECL#-43 (Removed)	
	N/A	CAR S072380GZ	ECL#-44 (Removed)	
	N/A	CAR S072380GZ	GNC#-59 (Removed)	
	N/A	CAR S072380GZ	INS#-04 (Removed)	
	N/A	CAR S072380GZ	RDM-01 (Removed)	
	N/A	CAR S072380GZ	RDM-02 (Removed)	
	N/A	CAR S072380GZ	RDM-03 (Removed)	
	N/A	CAR S072380GZ	RDM-04 (Removed)	
	N/A	CAR S072380GZ	RDM-05 (Removed)	
	N/A	CAR S072380GZ	RDM-06 (Removed)	
	N/A	CAR S072380GZ	RDM-07 (Removed)	
	N/A	CAR S072380GZ	RDM-08 (Removed)	
	N/A	CAR S072380GZ	RDM-09 (Removed)	
	N/A	CAR S072380GZ	RDM-10 (Removed)	
	N/A	CAR S072380GZ	RDM-11 (Removed)	
	N/A	CAR S072380GZ	RDM-12 (Removed)	
	N/A	CAR S072380GZ	RDM-13 (Removed)	
	N/A	CAR S072380GZ	RDM-14 (Removed)	
	N/A	CAR S072380GZ	SEQ#-01 (Removed)	
	N/A	CAR S072380GZ	SSME#-07 (Removed)	
	N/A	CAR S072380GZ	TTEST-01 (Removed)	
	N/A	CAR S072380GZ	WEA#-01 (Removed)	
071	01206	S072380GV	ET-10	11/22/06
	01207	S072380HC	AA-01	
	01209R01	S072380HA	MPS-22	

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CHG	LCN NO	AUTHORIZATION	SSIDS AFFECTED	DATE
072	01208R02	S072380HD	MEL-13(116)	12/05/06
	N/A	CAR S072380HD	MEL-13(107) (Removed)	
	N/A	CAR S072380HD	MEL-13(113) (Removed)	
	N/A	CAR S072380HD	MEL-13(114) (Removed)	
	N/A	CAR S072380HD	MEL-13(115) (Removed)	
	N/A	CAR S072380HD	MEL-13(121) (Removed)	
073	01212	S072380HG	WAIV-02	02/15/07
074	N/A	CAR S072380HH	MEL-13(116) (Removed)	02/22/07
075	01213	S072380HH	MEL-13(117)	02/28/07
076	01217R02	S072380HL	GNC-74	05/23/07
077	01218R01	S072380HM	GNC-64	05/30/07
078	01192R05	S072380HJ	BRSS-01, BRSS-05, BRSS-07, BRSS-08, BRSS-09, BRSS-11, BRSS-12, BRSS-13, BRSS-14, BRSS-15, BRSS-16, BRSS-17	06/29/07
	01216R02	S072380HK	CT-01, CT-11, DPS-17, DPS-28, FSUM-08, MEL-04, MIL-02	
	01221	S072380HP	WAIV-02	
079	01214R02	S072380HN	MEL-13(118)	07/26/07
	01219R04	S072380HQR1	MPS-53	
	01222R02	S072380HU	GSE-24	
	01223R01	S072380HV	ECL-11	
	01224	S072380HW	AA-01	
080	01225R01	S072380JA	BRSS-01, BRSS-05, BRSS-07, BRSS-08, BRSS-09, BRSS-11, BRSS-12, BRSS-13, BRSS-14, BRSS-15, BRSS-16	09/27/07
	01232	S072380JE	WAIV-02	
081	01215R01	S072380JC	ECL-04, ECL-05	10/11/07
	01226R01	S072380JD	MEL-13(120)	
	01229	S072380JG	MPS-53	
	01230R01	S072380JF	ET-10, SEQ-01	
	01231R02	S072380JK	OMS-07	
	01234R01	S072380JJ	ECL-10	
082	01233R02	S072380JL	CT-01	11/12/07
	01236R01	S072380JT	MEL-13(122)	
083	01237	S072380JU	MPS-53	11/27/07

LIST OF CHANGES FOR REVISION H

CHG	LCN NO	AUTHORIZATION	SSIDS AFFECTED	DATE
084	01235R03	S072380JV	PRSD-01, PRSD-06	12/03/07
085	01238	S072380KA	WAIV-02	01/22/08
	01241	S072380JZ	MEL-13(123)	
	N/A	CAR S072380JZ	MEL-13(117) (Removed)	
	N/A	CAR S072380JZ	MEL-13(118) (Removed)	
	N/A	CAR S072380JZ	MEL-13(120) (Removed)	
086	01211R02	S072380JB	BTVC-01, BTVC-02	02/14/08
	01239R03	S072380JW	ET-03	
087	01227R01	S072380KE	IMPL-01	02/18/08
	01228R03	S072380KC	GSE-22	
	01240R02	S072380KB	ET-04	
	01243R01	S072380KD	BFS-10a, DPS-01a, MEL-10	
088	01244	S072380KG	GNC-64	02/27/08
	01245	S072380KF	MPS-53	
	01248	S072380KH	AA-01	
089	01247	S072380JY	WAIV-02	03/05/08
	01249	S072380KJ	MPS-53	
090	01246R01	S072380KM	MEL-13(124)	04/14/08
	01251	S072380KK	WAIV-02	
	N/A	CAR S072380KM	MEL-13(122) (Removed)	
	N/A	CAR S072380KM	MEL-13(123) (Removed)	
091	01250R01	S072380KQ	CHG-01, GEN-01	05/05/08
	01252	S072380KN	INS-01	
	01253R01	S072380KP	GSE-10	
092	01256R03	S072380KU	APU-24	05/13/08
	01257R01	S072380KW	AFM-10	
093	01254R03	S072380KV	SSME-05	06/09/08
094	01255R02	S072380KT	IMPL-01	08/12/08
	01259R01	S072380KZ	ECL-08, ECL-09	
	01262	S072380LC	SSME-09	
	01264	S072380LE	CREW-01, CW-01, FSUM-01, GSE-24, HAZ-FG04, MPS-49, MPS-50, MPS-51, MPS-52, REF-01	
095	01258R02	S072380KY	ECL-10	08/26/08
	01260R02	S072380LA	MPS-53	
	01261R02	S072380LB	GSE-01, GSE-02, GSE-03	
	01263R03	S072380LD	DPS-29, INS-01, LPS-18, LPS-19	

LIST OF CHANGES FOR REVISION H

CHG	LCN NO	AUTHORIZATION	SSIDS AFFECTED	DATE
096	01265R02	S072380LF	MEL-13(125)	09/25/08
	01266R02	S072380LG	MEL-13(400)	
	01267R01	S072380LH	MEL-13(126)	
097	01269R01	S072380LK	EPDC-08	10/06/08

SECTION 01

INTRODUCTION AND GENERAL CRITERIA

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GENERAL

1.0 INTRODUCTION AND GENERAL CRITERIA.

1.1 PURPOSE. This document provides the launch support system and launch team with the Shuttle Launch Commit Criteria (LCC) and background information. It provides detailed performance criteria for committing the Vehicle and ground systems for launch and minimizes real-time rationalization of those requirements.

1.2 SCOPE. Launch Commit Criteria are developed for all Shuttle missions and are applicable to all operations and support elements involved in the launch countdown from External Tank (ET) Cryogenic Loading, T-6 hours, through Reusable Solid Rocket Motor (RSRM) ignition, T-0.

1.3 PHILOSOPHY. The overall philosophy for LCC is to launch a configuration that supports mission objectives while maintaining Vehicle and Crew safety, concurrent with maximizing launch probability. In support of this philosophy, violation of any Launch Commit Criteria shall be considered a constraint to launch that can only be cleared through specific methods (Ref. LCC Violation definition, Appendix C, GUID-01 paragraph 1.4).

1.4 REQUIREMENTS. Launch Commit Criteria consistent with the philosophy in Paragraph 1.3 shall be developed to assure that flight and ground systems are configured and performing as required to support Vehicle, Crew safety, mission success and Solid Rocket Booster (SRB) recovery prior to launching the Space Shuttle. The criteria will specify the conditions to be satisfied for the "commit to launch" countdown milestones as specified in Paragraph 1.4.D and will be in accordance with the following guidelines. Exceptions to the guidelines will be addressed on a case specific basis and will consider overall risks, effects on Crew procedures and training, the relationship to Flight Rules, or other basis for an exception.

A. The requirements for fault tolerance will be based on the program experience and likelihood of failure as defined in NSTS 07700-10-MVP-01, Paragraph 3.7.3. A consistent assignment of likelihood is to be used for the Master Verification Plan (MVP), Operations and Maintenance Requirements and Specifications Document (OMRSD), Flight Rules and LCC. When fault tolerance is based on unlike redundant functions, the likelihood of failure of the lowest confidence function will be used as the basis of the requirement.

   Criticality 1 functions, when verifiable, will be specified as required for launch.

   Criticality 1R functions will specify fault tolerance based on the overall risks and will avoid launching a configuration that would require a shortened mission or an ascent abort. Criticality 2 and 2R functional fault tolerance will be based on mission success risks and, as a minimum, will be capable of performing the primary mission objectives. SRB recovery functions will be specified to protect SRB recovery capability.

Loss of available fault tolerance, down to the minimum required, is acceptable if the failure is isolated and the remaining functional redundancy or fault tolerance of the system has not been affected by the failure.

Element specific guidelines:

Orbiter:

For Orbiter systems, LCC should allow launch after sustaining a pre-launch problem when there is no indication the problem may be generic and the mission can be safely and successfully completed if a problem occurs after committing the system for launch. The system pass/fail criteria (redlines) should accept verifiable conditions that indicate degraded but acceptable system performance.

LCC that accept a credible pre-launch problem should include any conditions or actions necessary to sufficiently understand the problem and determine that the remaining redundancy or fault tolerance of the system is not affected. LCC should constrain launch if a subsequent problem could result in Crew or Vehicle loss, abort, or pre-MDF (Minimum Duration Flight) mission termination (ELS (Emergency Landing Site) or PLS (Primary Landing Site) as established in Flight Rules (NSTS 12820)) unless an assessment of subsequent problem likelihood and specific effects determines the condition is acceptable. If a flight problem could only result in mission termination after achieving MDF, LCC acceptance of the prelaunch problem should be based on assessment of flight problem likelihood and specific effects including mission objective impacts.

SSME:

Intent of Space Shuttle Main Engine (SSME) LCCs:
Preclude/minimize probability of Crit-1 shutdown, post lift-off engine shutdown, post lift-off engine control lockup.

SSME LCC Guidelines:

(1) Sensors needed for redlines and control parameters after start must be qualified prestart.
(2) LCC limits-set based on flight data base experience.
(3) Incorporated changes per Failure Mode Effects Analysis/Critical Items List (FMEA/CIL) retention rationale.
(4) All qualified sensors must satisfy launch criteria (trust function versus a failed sensor).
(5) Engine controller to provide monitor for all LCCs where possible.

General SSME LCC Philosophy:

(1) Minimize need for LCCs through engine design and operational tolerance.
(2) Maximize utilization of instrumentation redundancy to minimize launch scrub situations.
(3) Consider probability of situation occurrence with implementation of a new or revised LCC.
(4) Utilize ground test and flight experience to open up LCC limits to enhance launch probability.

RSRB:

SRB Hardware:

For SRB , analysis of requirements for fault tolerance shall not be done for systems which are designed to be less than two fault tolerant or for systems which fail redundancy screen 3 (not subject to multiple failure from a common environment or cause) as documented in the SRB FMEA.

Items which are not eliminated by the analysis criteria listed above shall be considered for fault tolerance requirements. Cost and launch probability benefits of launching with a failure present in such systems shall be considered. For those systems determined to represent reasonable potential for program benefits in cost or launch probability if launch with failure can be implemented, analysis of failure probability will be done per NSTS-07700-MVP-01, Paragraph 3.7.3. If a second failure is determined to be less than "probable," launch-with-failure would be implemented unless a cost/risk analysis providing rationale for prohibiting launch-with-failure is approved by the Program.

RSRM Hardware:

Analysis Criteria:

Analysis of RSRM fault tolerance requirements shall be conducted for all RSRM systems that are designed to be fault tolerant and for RSRM systems that pass redundancy screen C (not subject to multiple failures from a single credible cause) as documented in the RSRM FMEA.

Guidelines Application:

Items which are identified by the criteria defined above shall be evaluated with respect to Crew/Vehicle safety, cost and possible launch probability improvement, based on launching with failures present.

Items which could improve launch probability, if launched with a single failure present, shall be analyzed for the possibility of additional failure per NSTS-07700-MVP-01, Paragraph 3.7.3.

If the fault tolerance analysis indicates the possibility of additional failure is less than "probable", the LCC shall allow the launch countdown to continue.

If the possibility of additional failure is "probable", or a cost/risk analysis providing rationale to prohibit the launch is approved by the Program, then the LCC shall not allow the launch countdown to continue.

External Tank:

Verifiable Criticality 1 functions (zero fault tolerant) will be specified as required for launch commit. (CIL waiver rationale supports zero fault tolerant operations.) Ascent critical 1R functions will specify single fault tolerance for a likelihood of failure of remote or improbable. A specific risk assessment will be required for program experience that would result in a likelihood of infrequent.

Launch and Landing:

When establishing or changing LCC, Kennedy Space Center (KSC) ground support equipment and launch support hardware will be assessed to ensure that a failed component will not jeopardize the safety of the Crew or the orderly continuation of the countdown or possible launch abort. Loss of redundancy and the subsequent likelihood of component failure based on the total program experience will be considered. Also, time period and signature of failure will play a major role in establishing a realtime commit to launch.

When assessing an anomaly, redundancy and reliability will be primary considerations for management risk analysis as the launch team approaches the three primary milestones of committing to ET Cryo Tanking, clearing personnel to a loaded Vehicle and committing the launch team to a launch (launch abort/scrub). Insurance of single fault tolerance is a primary goal and a plan for next failure will be developed.

Mission Operations Directorate:

Fault tolerance for critical Mission Control Center (MCC) functions/capabilities for launch commit shall reflect protection to a level of .995 for all functions (command, telemetry, voice and trajectory) taken together and to a level of .9995 for each function taken alone. The MCC critical functions required for launch commit are reflected in the Flight Rules and the specific minimum acceptable levels of redundancy specified therein with supporting risk-based rationale. Reporting of violations shall be via the Flight Director.

Payloads:

LCC Documentation Requirements
- All payload parameters utilized for safety monitoring during the count and criteria used for calling safety related Holds.
- Specific actions and payload commanding initiated by the customer after pad clearing which, if unsuccessful, could cause a launch Hold.

- Orbiter payload interface services (i.e., Payload Data Interleaver (PDI), power, etc.) and ground operations support decisions (i.e., Payload Operations Control Center (POCC), communications lines, aircraft, etc.) which represent Go/No Go decisions.

B. Launch Commit Criteria will be developed to monitor instrumentation for measurements that are mandatory for in-flight operations or are used by the systems software to perform critical functions.

C. Launch Commit Criteria will be established only for those system level functional elements for which integrity can be verified during the effective period and, as a goal, will be based on measurements for which integrity can be verified.

D. The LCC will become effective at the start of ET Cryogenic Tanking and will terminate at RSRM ignition. Specific monitoring time periods will be identified for each Subsystem Identifier (SSID), providing milestones at which the required flight and/or ground systems will be committed for launch. The appropriate milestones will be in accordance with the following:

(1) Flight or ground systems that have been configured, serviced, pressurized or activated during the launch countdown and are functionally stable, will be committed for launch prior to "Go for GLS auto-sequence start (T-9 minutes)". Exceptions to this criteria requires a risk trade analysis approved by the Program.

(2) Flight or ground systems that are activated or reconfigured after Ground Launch Sequencer (GLS) auto-sequence start (T-9 minutes and counting) and are in the launch configuration and operating within limits will be committed for launch prior to "Go for RSLS start (T-31 seconds)". Exceptions to this criteria requires a risk trade analysis approved by the Program.

(3) Flight or ground systems that are activated or reconfigured after Redundant Set Launch Sequencer (RSLS) start (T-31 seconds and counting) will be committed for launch following system verification in the launch configuration. Exceptions to this criteria requires a risk trade analysis approved by the Program.

(4) Criticality 1 functions (zero fault tolerant) which would result in a loss of the Vehicle or Crew if the launch were to proceed will be committed to launch as close to RSRM ignition (T-0) as possible.

(5) Some elements/subsystems require only Discrete Interlock (DI) checks rather than Continuous Interlock (CI) monitoring. For these systems, the word "verify" is used to identify the milestone or desired time at which the element or subsystem is to be committed for launch.

SSID parameters will be monitored and verified until the specified launch countdown milestone or event. For parameters which are not automated in GLS or RSLS and which do not have redundant monitoring implemented, the launch countdown event or condition at which the system/function is configured, verified, stable and not effected by the remainder of the countdown will be noted. Unplanned and unrecoverable loss of monitoring will not constrain launch for parameters meeting these conditions that were verified and within limits at the time of loss of monitoring. This is not applicable to zero fault tolerant functions which must be monitored to the specified time effectivity.

E. The redline limits identified in the LCC will take precedence over all other limits (e.g., OMRSD, Shuttle Operational Data Book (SODB), etc.) and will be established based on expected systems dispersions and/or safe operating limits. Detailed guidelines are defined in Appendix C, paragraph 1.1.

F. Preplanned contingency procedures to verify LCC compliance will be developed, when practical, to ensure timely problem resolution during the launch countdown. Preplanned contingency procedures are particularly important for SSIDs effective late in the countdown. Fault isolation, when required to assure failures affecting the fault tolerance of critical system functions are isolated, or procedures that confirm the critical function and remaining fault tolerance features are unaffected by a failure, shall be documented in preplanned contingency procedures. Detailed guidelines are defined in Appendix C, paragraph 1.2.

G. Launch Commit Criteria will be developed for those items, other than flight or ground systems, such as weather or range safety required to assure safe operations.

H. Systems/functions not meeting these criteria will be configured and verified to OMRSD requirements.

1.5 CHANGES. Changes in this document shall be made in accordance with the procedures in Appendix B and are controlled by the Space Shuttle Program Requirements Control Board (PRCB). Changes will be made as page additions, deletions, or replacements. Pages that are changed will be identified with a change number in the lower right-hand corner of the page.

1.6 AUTHORITY GUIDELINES. The following guidelines are established to define the authority of the launch team:

A. During the countdown, the Shuttle Commander and Launch Director may take any action required to protect the Flight Crew, Vehicle, ground personnel, and facility safety.

B. The Flight Crew, Launch Director (LD), NASA Test Director (NTD), Test Conductor(s), Flight Control Officer (FCO), or Flight Director (FD) may request a Hold for conditions within their respective areas of responsibility.

C. During the countdown, the Mission Management Team (MMT) provides management decisions and directions directly to the Launch Director. The MMT Chair is the authority to approve LCC Waivers, Deviations, or scrub a launch attempt.

D. Concurrence to downgrade a range safety item must be received from the Eastern Range (ER) Commander prior to Waiver/Deviation approval.

E. The failure of an item will be reported to the MMT by the KSC Launch Director, the Flight Director, or the appropriate Project Manager.

F. The NASA Test Director will be responsible for all actions in the event of launch site emergencies from start of count to RSRM ignition.

G. Complete control of the Space Shuttle Vehicle passes from KSC to Johnson Space Center (JSC) when RSRM ignition occurs.

H. Whenever possible, the launch site and MCC will verify telemetry readout discrepancies occurring prior to lift-off. If the MCC loses a parameter, but the launch site has a valid readout, the MCC will continue on the launch site readout. This is true except for those parameters (listed in the LCC) for which Flight Rule action is taken. In this case, a Hold may be called to evaluate the problem.

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SECTION 02

KSC GENERAL LAUNCH COMMIT CRITERIA IMPLEMENTATION

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1.0 KSC GENERAL LAUNCH COMMIT CRITERIA. Detailed guidelines and procedures for the development and implementation of Launch Commit Criteria by responsible organizations are established for the KSC launch site in this document.

1.1 LAUNCH COMMIT CRITERIA (LCC) MONITORING GUIDELINES. Launch Commit Criteria measurements, and/or functions which the measurements represent, are committed for launch at the end of the Time Period effectivity indicated.

Unless specified in the LCC, the methods of monitoring or verifying all measurements/functions will be determined by the launch team responsible systems engineers. These will be implemented in approved KSC procedures and software. Periodic and/or manual monitoring is acceptable unless the LCC requires continuous or automatic implementation. Automated Hold or Recycle capability will not be implemented after the end of the effectivity period.

If a later than T-31 seconds effectivity is designated that results in an automated Hold or Recycle, the item will be implemented in flight or ground software.

If a parameter makes an excursion out of its limits, it will not be considered an LCC violation for launch if either of the following situations apply:

a. the excursion is the result of a failed or manipulated flight or ground system supporting its function,
b. if the excursion is the result of a temporary condition that is expected or understood and is not an unacceptable hazard to the Crew or Vehicle.

This determination will be made by the MMT. The function must be restored to LCC limits after isolating and/or repairing the failed support system or after the temporary condition has passed. Functional integrity of the system in question must be verified prior to launch to ensure it did not violate design certification criteria and a determination made that the safe operating limits were not violated. Failure of redundant items or instrumentation does not constitute an LCC violation as long as the LCC allows for the failure (i.e., 1 of 2).

1.2 REPORTING AND OPERATING GUIDELINES.

A. LCC VIOLATIONS DURING TIME PERIOD EFFECTIVITY

All LCC violations will be reported along with one of the following recommendations:

- Hold (at the appropriate milestone as determined by the Launch Director (LD))
- Continue (with MMT approval)

For a known violation which cannot be corrected, a dispositioned and approved Waiver is required to continue the countdown beyond T-5 minutes.

LCC violations first detected after T-5 minutes and counting for flight hardware or software or safety critical ground systems, as identified in this document, will require a Recycle.

An LCC violation detected prior to T-5 minutes may be waived down to T-31 seconds, if more time is needed and the violation is potentially correctable before the end of the available Hold at T-31 seconds.

When time does not permit formal documentation, an LCC Waiver may be verbally approved by the MMT on a recorded Operational Intercom System (OIS) net with documentation to follow post launch or post scrub.

B. LCC MONITORING/REPORTING OUTSIDE OF TIME PERIOD EFFECTIVITY

Monitoring of LCC related parameters outside of the associated LCC time period effectivity is not required. If a LCC related measurement is exceeded after the LCC time period effectivity has ended the exceedance does not constitute an LCC violation. These anomalies will be reported to T-9 minutes and counting with the following recommendation:

- Continue (with LD concurrence)

C. LCC VOTING LOGIC ANOMALIES (Does not violate LCC Requirement)

LCC parameter voting logic anomalies that do not violate LCC requirements will be reported to T-9 minutes and counting. Standard reporting protocol will be used including identifying the exceedance as being related to voting logic only and rationale for acceptance with the following recommendation:

- Continue (With LD concurrence)

D. FLIGHT AND GROUND SYSTEMS FAILURES (Non LCC functions)

All flight or ground systems failures will be reported prior to T-9 minutes and counting with one of the following recommendations:

- Hold
- Continue (With LD concurrence)

E. CONFIRMED SAFETY CRITICAL ITEMS FOR LAUNCH OR ABORT

At any time, systems engineers are expected and authorized to call a Hold for any confirmed safety critical item. Safety critical describes items, events, or damage that, if launch countdown proceeded, could result in injuries, loss of vehicle, an on pad or ascent abort, or an unsafe condition for pad abort.

1.3 AUTOMATICALLY SEQUENCED FUNCTIONS. All functions on an automatic sequencer are mandatory by design and the launch team has the authority to Hold and correct such functions if they fail prior to start of the automatic sequence. Thus, any function that is interlocked on an automatic sequencing device and will effect an automatic shutdown or will prevent lift-off in the event of a malfunction is defined as mandatory by design. These are included in the Launch Commit Criteria. There are three automatic sequencing functions: the Redundant Set Launch Sequencer (RSLS), the Space Shuttle Main Engine Controller (SSMEC), and the Ground Launch Sequencer (GLS). The capability exists within the GLS to mask or bypass any of the automated GLS functions. The capability also exists to allow for real-time changes to limits of mandatory items being monitored. Masks, bypasses and limit changes may be predetermined or real-time and will be implemented as approved by the Projects and the Space Shuttle Program.

1.4 HOLD/RECYCLE. Prior to resuming the countdown following a prolonged Hold or Recycle, all items that failed or exceeded redline values after their specified effectivity period, or that were waived during the previous countdown attempt, will be reassessed in light of the new countdown attempt.

1.5 LAUNCH COMMIT CRITERIA/FLIGHT RULES INTERFACE. For certain operational support elements (required to be operational at lift-off) for which KSC, ER and Goddard Space Flight Center (GSFC) are operationally responsible, redundant entries may be contained in both the LCC and Flight Rules. The LCC will contain rules concerning only those operational support elements for which the Launch Director or appropriate elements of the Launch Team organization would call a Hold or Recycle in the event of malfunctions.

1.6 KSC/MER/HOSC INTERFACE. All prelaunch failures or LCC violations will be coordinated between the KSC Launch Team and the JSC Mission Evaluation Room (MER) and the Marshall Space Flight Center (MSFC) Huntsville Operations Support Center (HOSC) launch site representatives, as applicable, through the KSC Integration Console. The JSC MER or the MSFC HOSC will assist the KSC Launch Team in the evaluation of prelaunch failures or LCC violations.

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SECTION 03

LAUNCH/LANDING WINDOW AND CREW RESTRICTIONS

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1.0 LAUNCH WINDOW AND CREW RESTRICTIONS

1.1 WINDOW RESTRICTIONS

All launch windows will be determined by the "Flight Requirement Document", JSC 17462-(mission number), published a minimum of 30 days prior to launch.

1.2 CREW RESTRICTIONS

A. The maximum Crew awake period for flight day one is eighteen (18) hours.

RATIONALE: Abnormally long days will result in Crew fatigue and increase the potential for procedural errors that could affect safety or compromise mission success. Without a Waiver, Crew awake time on launch day will not be premission scheduled for greater than 16 hours. Since the Crew is awake about 4 hours 55 minutes before launch, this allows for up to 11 hours 5 minutes of on-orbit activities before the start of the sleep period. If there is a launch Hold or Orbiter/Payload contingencies require the use of backup timelines for deploy opportunities or off-nominal operations, these adjustments will be accommodated as long as the maximum Crew day of 18 hours is not exceeded.

B. The maximum time for any member of the Crew to remain in the launch seat posture is five (5) hours and fifteen (15) minutes.

RATIONALE: It is impractical to keep the Crew in the launch-seat posture for an extended period of time due to the inconvenience caused by the Crew worn equipment. The Crew enters the vehicle about 2 hours 45 minutes before launch, thus a 2.5 hour launch window is preserved.

1.3 POST TANKING FLIGHT/GROUND CREW DEPLOYMENT WEATHER CONSIDERATION

Weather conditions will be considered in reaching a decision for Flight/Ground Crew deployment to the pad after the start of ET Load. Consideration must be given to adequately support Pad Emergency Egress, Triage and Medevac Operations. The Launch Director is responsible for determining satisfactory weather conditions for Flight/Ground Crew deployment to the pad after the start of ET Load.

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SECTION 04

WEATHER RULES

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1.0 Weather Rules.

This section contains the weather conditions that are a constraint to launching the Space Shuttle Vehicle (SSV). The weather constraints stated in this section shall not be waived. The time effectivity of the constraints contained herein is as follows unless otherwise specified within the section text:

- Ambient Temperature Criteria (section 1.1) – from Start of ET Cryo Tanking (T-6 hours) to Go for APU Start (T-5 minutes)

- Precipitation Criteria (section 1.2) - from Start of ET Cryo Tanking (T-6 hours) to Go for APU Start (T-5 minutes)

- Ground Wind Criteria (section 1.3) - reference GSE-24

- Lightning Criteria (section 1.4) - from Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds)

The Orbiter landing site criteria are contained in the Space Shuttle Operational Flight Rules document.

1.1 Ambient Temperature Restriction at the Space Shuttle Vehicle.

Ambient temperature, relative humidity and wind speed measurements are 5 minute averages supplied by the Launch Weather Officer (LWO) for the launch pad in use.

A. Prior to External Tank (ET) Cryogenic Loading.

1. Propellant loading of the ET shall not be initiated if the average temperature for the 24 hours prior to tanking is below 41.3 degrees Fahrenheit (F).

2. Propellant loading of the ET shall not be initiated if the temperature anytime during the 24 hours prior to tanking drops below 33 degrees F.

Neither of the above minimum temperature requirements is based on a particular piece of flight hardware violating a specific temperature constraint. A typical diurnal profile for a day averaging 41.3 degrees F at Kennedy Space Center (KSC) reflects a minimum ambient temperature at, or above, 32.9 degrees F. This is intended to minimize the potential for ice formation on or inside the SSV flight hardware and on the launch pad. This is also consistent with the statistical 1% cold day at the KSC launch site that is used for SSV Element design assessments per NSTS 07700 Volume X. The 33 degree F minimum temperature requirement (32 degree baseline plus 1 degree for instrumentation error) was added as protection for non-typical days that may meet the 41.3 degrees average requirement but still exhibit minimum temperatures at or below 32 degrees F. By accepting these minimum temperature requirements, the Space Shuttle Program (SSP) maintains a conservative approach and does not require any SSV Project Element to perform real time thermal analysis prior to ET loading.

B. From Start of ET Cryogenic Loading to Exiting the Last Hold Prior to Auxiliary Power Unit (APU) Start.

1. The countdown shall not be continued nor the SSV launched if the ambient temperature during this time period exceeds 99 degrees F for more than 30 consecutive minutes.

2. The SSV shall not be launched if the ambient temperature (Tamb) is lower than the minimum temperature limit (Tmin) (Table 1.1A), for more than 30 consecutive minutes unless the Preplanned Contingency Procedure (PCP) indicates recovery from the low temperature excursions that caused the Launch Commit Criteria (LCC) violation. The minimum temperature limits are specified in Table 1.1A as a function of wind speed and relative humidity. The 0-64% column of Table 1.1A shall be used to specify minimum ambient temperature limits if relative humidity instrumentation is non-functional.

	Minimum Ambient Temperature (Deg F), Tmin				
Wind Speed	Relative Humidity				
(knots)	0-64%	65-74%	75-79%	80-89%	90-100%
0-1	48	47	46	45	44
2	47	46	45	44	43
3	41	41	41	40	39
4	39	39	39	39	38
5-7	38	38	38	38	38
8-14	37	37	37	37	37
>14	36	36	36	36	36

Table 1.1A

Rationale: The ambient temperature restriction protects temperature limits specified in NSTS 07700, Volume X. Temperature constraints are based on temperature depression and measurement uncertainties.

PCP for Minimum Ambient Temperature Violations:

The following Recovery Temperature Algorithm (RTA) shall be initiated upon violation of the minimum ambient temperature LCC limit. The RTA balances energy levels for ambient air temperature deviations below the LCC versus the effect of air temperature returning above the limit. The RTA integrates a convective cooling energy term for the time the ambient air temperature is below the limit and offsets it with a convective heating term plus a diffuse solar heating term when the ambient air temperature is back above the limit. When the total energy is greater than zero, the SSV system has recovered from convective cooling excursions.

Nomenclature:

Delta t= Time interval for summing (units of 5 minutes)

X= Switch for summing energy terms
X=1 for Tamb > or = Tmin
X=0 for Tamb < Tmin

Tamb= Average measured ambient air temperature in the time interval (units of degrees F)

Tmin= Minimum ambient air temperature limit specified in Table 1.1A at the measured wind speed in the time interval (units of degree F)

Qsol= Diffuse solar flux from Table 1.1B (units of British Thermal Unit (Btu)/Square Foot per Hour (ft2-hr))

Esum= Running energy sum of convective cooling, convective heating solar energy (Btu-minutes/ft2-hr)

V= 5 minute averaged wind speed in knots

Hc= the maximum of: Hc=4.0(V/5.0)**0.5 or, Hc=1.0. The lower limit of 1.0 is a natural convection value and for winds greater than zero, a forced value is calculated as a function of wind speed in knots (units of Btu/ft2-hr-F)

sigma= summation

System RTA:

Esum (Btu-minutes/ft2-hr) =
.5(Btu/ft2-hr-F) sigma ((Tamb-Tmin)(F) (Delta t)(minutes) (X))
+ 0.2 sigma ((Qsol)(Btu/ft2-hr)(Delta t)(minutes)(X))
- sigma Hc(Btu/ft2-hr-F) ((Tmin-Tamb)(F) (Delta t)(minutes) (1-X))

where Hc is the greater of Hc = 4.0(V/5.0)**0.5 (Btu/ft2-hr-F) or Hc = 1.0 (Btu/ft2-hr-F)

Diffuse Solar Table (Table 1.1B):

The values for diffuse solar are the minimum that can be expected on the launch pad and are valid for any time of year and any amount of cloud cover.

Solar Time	Eastern Standard Time	Qsol (Btu/ft2-hr)
0:00	0:20	0.00
6:40	7:00	0.00
7:00	7:20	0.04
7:20	7:40	4.54
7:40	8:00	8.79

Table 1.1B (Continued)

Solar Time	Eastern Standard Time	Qsol (Btu/ft2-hr)
8:00	8:20	11.43
8:20	8:40	13.14
8:40	9:00	14.32
9:00	9:20	15.16
9:20	9:40	15.79
9:40	10:00	16.26
10:00	10:20	16.62
10:20	10:40	16.90
10:40	11:00	17.11
11:00	11:20	17.26
11:20	11:40	17.36
11:40	12:00	17.42
12:00	12:20	17.44
12:20	12:40	17.42
12:40	13:00	17.36
13:00	13:20	17.26
13:20	13:40	17.11
13:40	14:00	16.90
14:00	14:20	16.62
14:20	14:40	16.26
14:40	15:00	15.79
15:00	15:20	15.16
15:20	15:40	14.32
15:40	16:00	13.14
16:00	16:20	11.43
16:20	16:40	8.79

Table 1.1B (Continued)

16:40	17:00	4.54
17:00	17:20	0.04
17:20	17:40	0.00
24:00	0:20	0.00

Table 1.1B (Concluded)

Rules for Use of the RTA:

1. The time interval for summing is 5 minutes consistent with the 5 minute average temperature values supplied by the LWO.

2. The RTA must sum Esum for the time period when the first 5 minute average minimum temperature excursion (Tamb < Tmin) occurs continuous through the time period where recovery occurs (Esum greater than 0).

3. Re-zero Esum if it is positive and a subsequent low temperature excursion is encountered.

4. When Esum is positive, the SSV has recovered and the LCC violation is cleared.

1.2 Precipitation Constraint.

The SSV will not be launched if precipitation (visible rain, virga, or minimum discernible weather radar echo) exists in the flight path of the SSV.

1.3 Surface Wind Limits. Surface wind limits for launch (Measured at 60 feet above natural grade).

Surface wind criteria are specified in LCC GSE-24.

1.4 Natural and Triggered Lightning Constraints.

Notice: Any changes to this section will require coordination with the 45th Space Wing Range Safety Office (RSO).

Natural and Triggered Lightning LCC

The Launch Weather Team (LWT) must have clear and convincing evidence that the following hazard avoidance criteria are not violated.

Even when these criteria are not violated, if any other hazardous condition exists, the LWT will report the threat to the Launch Director (LD). The LD may Hold at any time based on the instability of the weather.

A. Lightning

1. Do not launch for 30 minutes after any type of lightning occurs in a thunderstorm if the flight path will carry the SSV within 10 Nautical Miles (NM) of that thunderstorm.

2. Do not launch for 30 minutes after any type of lightning occurs within 10 NM of the flight path unless:

   a. The cloud that produced the lightning is not within 10 NM of flight path;

   -and-

   b. There is at least one working field mill within 5 NM of each such lightning flash;

   -and-

   c. The absolute values of all electric field measurements at the surface, within 5 NM of the flight path and at the mill(s) specified in subparagraph 1.4.A.2.b, have been less than 1000 Volts/meter (V/m) for 15 minutes.

Notes:

i) Anvils are covered in section 1.4.C.

ii) If a cumulus cloud remains 30 minutes after the last lightning occurs in a thunderstorm, then section 1.4.B. applies.

Definitions: Anvil, Electric Field Measurement at the Surface, Flight Path, Thunderstorm, Within

B. Cumulus Clouds

1. Do not launch if the flight path will carry the SSV within 10 NM of any cumulus cloud with its cloud top higher than the -20 degrees Celsius (C) level.

2. Do not launch if the flight path will carry the SSV within 5 NM of any cumulus cloud with its cloud top higher than the -10 degrees C level.

3. Do not launch if the flight path will carry the SSV through any cumulus cloud with its cloud top higher than the -5 degrees C level.

4. Do not launch if the flight path will carry the SSV through any cumulus cloud with its cloud top between the +5 degrees C and -5 degrees C levels unless:

   a. The cloud is not producing precipitation;

   -and-

   b. The horizontal distance from the center of the cloud top to at least one working field mill is less than 2 NM;

-and-

c. All electric field measurements at the surface within 5 NM of the flight path and at the mill(s) specified in subparagraph 1.4.B.4.b. above have been between -100 V/m and +500 V/m for 15 minutes.

Note: Cumulus clouds in section 1.4.B. do not include altocumulus, cirrocumulus or stratocumulus.

Definitions: Cloud Top, Electric Field Measurement at the Surface, Flight Path, Precipitation, Within

C. Anvil Clouds

1. Attached Anvil Clouds

a. Do not launch if the flight path will carry the SSV through or within 10 NM of a nontransparent part of any attached anvil cloud for the first 30 minutes after the last lightning discharge in or from the parent cloud or anvil cloud.

b. Do not launch if the flight path will carry the SSV through or within 5 NM of a nontransparent part of any attached anvil cloud between 30 minutes and three hours after the last lightning discharge in or from the parent cloud or anvil cloud unless both of the following conditions are satisfied:

1) The portion of the attached anvil cloud within 5 NM of the flight path is located entirely at altitudes where the temperature is colder than 0 degrees C;

-and-

2) The VAHIRR is less than +33 Range Corrected Reflectivity (dBZ)-thousand feet(kft) (+10 dBZ-kilometers (km)) everywhere along the portion of the flight path where any part of the attached anvil cloud is within the specified volume.

c. Do not launch if the flight path will carry the SSV through a nontransparent part of any attached anvil cloud more than 3 hours after the last lightning discharge in or from the parent cloud or anvil cloud unless both of the following conditions are satisfied:

1) The portion of the attached anvil cloud within 5 NM miles of the flight path is located entirely at altitudes where the temperature is colder than 0 degrees C;

-and-

2) The VAHIRR is less than +33 dBZ-kft (+10 dBZ-km) everywhere along the portion of the flight path where any part of the attached anvil cloud is within the specified volume.

2. Detached Anvil Clouds.

For the purposes of this section, detached anvil clouds are never considered debris clouds.

a. Do not launch if the flight path will carry the SSV through or within 10 NM of a nontransparent part of a detached anvil cloud for the first 30 minutes after the last lightning discharge in or from the parent cloud or anvil cloud before detachment or after the last lightning discharge in or from the detached anvil cloud after detachment.

b. Do not launch if the flight path will carry the SSV between 0 (zero) and 5 NM from a nontransparent part of a detached anvil cloud between 30 minutes and 3 hours after the time of the last lightning discharge in or from the parent cloud or anvil cloud before detachment or after the last lightning discharge in or from the detached anvil cloud after detachment unless subparagraph 1.4.C.2.b.1) or subparagraph 1.4.C.2.b.2) is satisfied:

1) This section is satisfied if all three of the following conditions are met:

a) There is at least one working field mill within 5 NM of the detached anvil cloud;

-and-

b) The absolute values of all electric field measurements at the surface within 5 NM of the flight path and at each field mill specified in subparagraph 1.4.C.2.b.1)a) have been less than 1000 V/m for 15 minutes;

-and-

c) The maximum radar return from any part of the detached anvil cloud within 5 NM of the flight path has been less than 10 dBZ for 15 minutes.

2) This section is satisfied if both of the following conditions are met:

a) The portion of the detached anvil cloud within 5 NM of the flight path is located entirely at altitudes where the temperature is colder than 0 degrees C;

-and-

b) The VAHIRR is less than +33 dBZ-kft (+10 dBZ-km) everywhere along the portion of the flight path where any part of the detached anvil cloud is within the specified volume.

c. Do not launch if the flight path will carry the SSV through a nontransparent part of a detached anvil cloud unless subparagraph 1.4.C.2.c.1) or subparagraph 1.4.C.2.c.2) is satisfied

1) This section is satisfied if both of the following conditions are met.

a) At least 4 hours have passed since the last lightning discharge in or from the detached anvil cloud;

-and-

b) At least 3 hours have passed since the time that the anvil cloud is observed to be detached from the parent cloud.

2) This section is satisfied if both of the following conditions are met.

a) The portion of the detached anvil cloud within 5 nautical miles of the flight path is located entirely at altitudes where the temperature is colder than 0 degrees C;

-and-

b) The Volume-Averaged, Height-Integrated Radar Reflectivity (VAHIRR) is less than +33 dBZ-kft (+10 dBZ-km) everywhere along the portion of the flight path where any part of the detached anvil cloud is within the specified volume.

Note: Detached anvil clouds are never considered debris clouds, nor are they covered by section 1.4.D.

Definitions: Anvil; Cloud Base; Cloud Edge; Cloud Top; Debris Cloud; Electric Field Measurements at the Surface; Field Mill; Flight Path; Volume-Averaged, Height-Integrated Radar Reflectivity (VAHIRR); Nontransparent; Specified Volume; Transparent; Within

D. Debris Clouds

1. Do not launch if the flight path will carry the SSV through any nontransparent parts of a debris cloud during the 3 hour period defined below.

2. Do not launch if the flight path will carry the vehicle within 5 NM of any nontransparent parts of a debris cloud during the 3 hour period defined below, unless:

a. There is at least one working field mill within 5 NM of the debris cloud;

-and-

b. The absolute values of all electric field measurements at the surface within 5 NM of the flight path and at the mill(s) specified in section 1.4.D.2.a. have been less than 1000 V/m for 15 minutes;

-and-

c. The maximum radar return from any part of the debris cloud within 5 NM of the flight path has been less than 10 dBZ for 15 minutes.

The 3 hour period in subparagraphs 1.4.D.2.a. and 1.4.D.2.b. begins at the time when the debris cloud is observed to have detached from the parent cloud or when the debris cloud is observed to have formed from the decay of the parent cloud top below the altitude of the -10 degrees C level. The 3 hour period begins anew at the time of any lightning discharge that occurs in the debris cloud.

Definitions: Cloud Top, Debris Cloud, Electric Field Measurement at the Surface, Flight Path, Nontransparent, Within

E. Disturbed Weather

Do not launch if the flight path will carry the vehicle through any nontransparent clouds that are associated with a weather disturbance having clouds that extend to altitudes at or above the 0 degree C level and contain moderate or greater precipitation or a radar bright band or other evidence of melting precipitation within 5 NM of the flight path.

Definitions: Associated, Flight Path, Moderate Precipitation, Nontransparent, Weather Disturbance, Within

F. Thick Cloud Layers

Do not launch if the flight path will carry the SSV through nontransparent parts of a cloud layer that is:

1. Greater than 4,500 foot thick and any part of the cloud layer along flight path is located between the 0 degrees C and the -20 degrees C levels;

-or-

2. Connected to a cloud layer that, within 5 NM of the flight path, is greater than 4,500 foot thick and has any part located between the 0 degrees C and the -20 degrees C levels;

unless the cloud layer is a cirriform cloud that has never been associated with convective clouds, is located entirely at temperatures of -15 degrees C or colder, and shows no evidence of containing liquid water (e.g., aircraft icing).

Definitions: Associated, Cloud Layer, Flight Path, Nontransparent

G. Smoke Plumes

Do not launch if the flight path will carry the SSV through any cumulus cloud that has developed from a smoke plume while the cloud is attached to the smoke plume, or for the first 60 minutes after the cumulus cloud is observed to have detached from the smoke plume.

Note: Cumulus clouds that have formed above a fire but have been detached from the smoke plume for more than 60 minutes are considered cumulus clouds and are covered in section 1.4.B.

Definitions: Flight Path

H. Surface Electric Fields

1. Do not launch for 15 minutes after the absolute value of any electric field measurement at the surface within 5 NM of the flight path has been greater than 1500 V/m.

2. Do not launch for 15 minutes after the absolute value of any electric field measurement at the surface within 5 NM of the flight path has been greater than 1000 V/m unless:

   a. All clouds within 10 NM of the flight path are transparent;

   -or-

   b. All nontransparent clouds within 10 NM of the flight path have cloud tops below the +5 degrees C level and have not been part of convective clouds with cloud tops above the -10 degrees C level within the last 3 hours.

Notes:

i) Electric field measurements at the surface are used to increase safety by detecting electric fields due to unforeseen or unrecognized hazards.

ii) For confirmed failure of one or more field mill sensors, the countdown and launch may continue.

Definitions: Cloud Top, Electric Field Measurement at the Surface, Flight Path, Nontransparent, Transparent, Within

I. Definitions:

1. Anvil: Stratiform or fibrous cloud produced by the upper level outflow or blow-off from thunderstorms or convective clouds.

2. Associated: Used to denote that two or more clouds are causally related to the same weather disturbance or are physically connected. Associated is not synonymous with occurring at the same time. An example of clouds that are not associated is air mass clouds formed by surface heating in the absence of organized lifting. Also, a cumulus cloud formed locally and a physically

separated cirrus layer generated by a distant source, are not associated, even if they occur over or near the launch site at the same time.

Subsidiary Definition: Weather Disturbance

3. Bright Band: An enhancement of radar reflectivity caused by frozen hydrometeors falling through the 0 degrees C level and beginning to melt.

4. Cloud Base: The visible cloud base is preferred. If this is not possible, then the 0 (zero) dBZ radar-reflectivity cloud base is acceptable.

5. Cloud Edge: The visible cloud edge is preferred. If this is not possible, then the 0 (zero) dBZ radar reflectivity cloud edge is acceptable.

6. Cloud Layer: A vertically continuous array of clouds, not necessarily of the same type, whose bases are approximately at the same level.

7. Cloud Top: The visible cloud top is preferred. If this is not possible, then the 0 (zero) dBZ radar reflectivity cloud top is acceptable.

8. Cumulonimbus Cloud: Any convective cloud with any part above the -20 degrees C temperature level.

9. Debris Cloud: Any cloud, except an anvil cloud, that has become detached from a parent cumulonimbus cloud or thunderstorm, or that results from the decay of a parent cumulonimbus cloud or thunderstorm.

Subsidiary Definition: Cumulonimbus Cloud

10. Electric Field Measurement at the Surface: The one-minute arithmetic average of the vertical electric field (Ez) at the ground measured by a ground based field mill. The polarity of the electric field is the same as that of the potential gradient; that is, the polarity of the field at the ground is the same as the dominant charge overhead.

Note: Electric field contours shall not be used for the electric field measurement at the surface.

Subsidiary Definition: Field Mill

11. Field Mill: A specific class of electric-field sensor that uses a moving, grounded conductor to induce a time-varying electric charge on one or more sensing elements in proportion to the ambient electrostatic field

12. Flight Path: The planned flight path including its uncertainties (“error bounds”).

13. Moderate Precipitation: A precipitation rate of 0.1 inches/hour or a radar reflectivity factor of 30 dBZ.

14. Nontransparent: Sky cover through which forms are blurred, indistinct, or obscured is nontransparent.

    Note: Nontransparency must be assessed for launch time. Sky cover through which forms are seen distinctly only through breaks in the cloud cover is considered nontransparent. Clouds with a radar reflectivity of 0 (zero) dBZ or greater, are also considered nontransparent.

    Subsidiary Definition: Transparent

15. Precipitation: Detectable rain, snow, sleet, hail or graupel at the ground, or virga, or a radar reflectivity greater than 18 dBZ.

16. Specified Volume: is the volume bounded in the horizontal by vertical, plane, perpendicular sides located 5.5 km (3 NM) north, east, south, and west of the point on the flight track, on the bottom by the 0 degree C level, and on the top by the upper extent of all cloud.

17. Transparent: Sky cover is transparent if higher clouds, blue sky, stars, etc., can be distinctly seen from below, or if terrain, buildings, lights on the ground, etc., can be distinctly seen from above.

    Note: Visible transparency is required. Transparency must be assessed for launch time. Sky cover through which forms are seen distinctly only through breaks in the cloud cover is considered nontransparent.

    Subsidiary Definitions: Nontransparent

18. Thunderstorm: Any convective cloud that produces lightning.

19. Volume-Averaged, Height-Integrated Radar Reflectivity (VAHIRR): Product of the Volume-Averaged Radar Reflectivity (VARR) and the average cloud thickness within a specified volume relative to a point along the flight track (units of dBZ-km)

    -where-

    The VARR is the arithmetic average (in dBZ) of the cloud radar reflectivity within the Specified Volume. Normally, a radar processor will report reflectivity values interpolated onto a regular, three-dimensional array of grid points. Any such grid point within the specified volume is included in the average if and only if it has a radar reflectivity equal to or greater than 0 dBZ.

    -and where-

    The average cloud thickness is the altitude difference (in kilometres) between the average top and the average base of all

clouds within the specified volume. The cloud base to be averaged is the higher of (1) the 0 degree C level and (2) the lowest extent (in altitude) of all cloud radar reflectivities 0 dBZ or greater. Similarly, the cloud top to be averaged is the highest extent (in altitude) of all cloud radar reflectivities 0 dBZ or greater. Given the grid-point representation of a typical radar processor, allowance must be made for the vertical separation of grid points in computing cloud thickness: The cloud base at any horizontal position shall be taken as the altitude of the corresponding base grid point minus half of the grid-point vertical separation. Similarly, the cloud top at that horizontal position shall be taken as the altitude of the corresponding top grid point plus half of this vertical separation.
Thus, a cloud represented by only a single grid point having a radar reflectivity equal to or greater than 0 dBZ within the specified volume would have an average cloud thickness equal to the vertical grid-point separation in its vicinity.

Note: The VAHIRR measurement must be made in the absence of significant attenuation by intervening storms or by water or ice on the radome itself. The VAHIRR measurement is invalid at any point on the flight track that is within 20 km of any radar reflectivity of 35 dBZ or greater at altitudes of 4 kilometres above mean sea level or greater, and at any point that is within 20 km of any type of lightning that has occurred in the previous 5 minutes. The specified volume must not contain any portion of the cone of silence above the radar, nor any portion of any sectors that may have been blocked out for payload-safety reasons. The individual grid-point reflectivities used to determine either the VARR or the average cloud thickness must be meteorological reflectivities.

Subsidiary Definition: Specified Volume

Note: See below “Interim Instructions for Implementation of VAHIRR”

20. Weather Disturbance: A weather system where dynamical processes destabilize the air on a scale larger than the individual clouds or cells. Examples of disturbances are fronts, troughs and squall lines.

21. Within: Used as a function word to specify a margin in all directions (horizontal, vertical, and slant separation) between the cloud edge, base, or top and the flight path. For example, "Within 10 NM of a thunderstorm cloud" means that there must be a 10 NM margin between every part of a thunderstorm cloud and the flight path.

    Subsidiary Definitions: Cloud Base, Cloud Edge, Cloud Top, Flight Path

J. Interim Instructions for Implementation of VAHIRR

The VAHIRR quantity referred to in section 1.4.C. and the definitions require computation of both a volume average reflectivity and an

average cloud thickness. These quantities are then multiplied to produce the VAHIRR. Neither of these quantities is available yet as a product on the WSR-88D and WSR-74C radar systems used to support launch operations. This instruction provides a methodology for evaluating VAHIRR criteria with currently available radar products. The methodology provides a result that is more conservative than a direct VAHIRR computation, but it should still permit the launch users to achieve much of the benefit of the VAHIRR feature.

1. Part I. Determination of average cloud thickness. The definition of VAHIRR requires determination of the average cloud top and the average cloud base above the height of the 0C isotherm within a square having sides 5.5 km (3 NM) north, east, south, and west of the ground projection of each point in the flight track. Average cloud thickness is defined as the difference of these two numbers. If the average cloud thickness cannot be determined at each point on the flight track, the maximum thickness within 5.5 km (3 NM) of the flight track may be used.

   To determine the average cloud top height, the launch weather team may use any existing radar product that gives the height of the 0 dBZ cloud top, including "maximum height of reflectivity" and cross section products. If the average height cannot be determined, the maximum height of the 0 dBZ reflectivity may be used. If the maximum height cannot be determined, use 18 km (60 kft) for the average cloud top.

   The average height of the cloud base should be derived from radar data. It is the average of the higher of (a) the bottom of the portion of the cloud producing a radar reflectivity of 0 dBZ or greater or (b) the height of the 0C isotherm where the 0 dBZ reflectivity extends below that level. If the average height of the cloud base cannot be determined, use the higher of (a) the height of the 0 degree C isotherm or (b) the lowest portion of the cloud producing a radar reflectivity of 0 dBZ or greater anywhere within each 5.5 km (3 n. mi.) square defined above.

2. Part II. Volume Averaged Radar Reflectivity (VARR). There is no operationally feasible way to use existing radar products to compute a volume average reflectivity. A conservative substitute is the maximum reflectivity since the volume average will always be smaller than the maximum. The WSR-88D has a "User Selectable Layer Composite Reflectivity (URL)" product and the WSR-74C has a "Max" product with user selectable base and top. The Launch Weather Team should configure these products with the bottom of the layer at the height of the 0 degree C isotherm and the top above the height of the highest radar beam within 7.8 km (4.2 n. mi.) of the ground-projected flight track in the scan strategy being used. The WSR-88D product will have to be configured at the Radar Product Generator (RPG) and included in the product scheduler for the Principal User Processor (PUP) used by the launch weather team.

3. Part III. Evaluating the constraint. The VAHIRR constraint is satisfied for a point on the flight track if the "URL" or "Max" radar product (see Part II above) everywhere within the

corresponding square (defined above) is less than 10 dBZ-km divided by the average cloud thickness in km within the same square (see Part I above). (In English units, this threshold would become 33 dBZ-kft divided by the average cloud thickness in kft.) This constraint must be satisfied for every point on the flight track.

SECTION 05

RANGE SAFETY CRITERIA

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1.0 RANGE SAFETY CRITERIA.

The rationale for items listed below is shown in upper case.

1.1 POLICY. The Memorandum of Agreement (MOA) between the 45th Space Wing (45 SW) and the John F. Kennedy Space Center for missile/space vehicle safety on Kennedy Space Center (KSC) and the Eastern Range (ER), effective 04 Feb. 1999, delineates the agency responsible for missile/space vehicle flight and ground safety for launches from the ER and KSC and identifies certain responsibilities associated with missile/space vehicle mishaps. Range Safety policies and criteria are specified in Eastern Western Range (EWR) 127-1, dated 31 Mar. 1995.

Conditions which do not violate the constraints contained herein but are believed by the Flight Control Officer (FCO) to be hazardous will be assessed as to the nature and severity of the threat and will be reported to the Launch Director.

The final decision on Range Safety compliance with Go/No Go criteria and possible waivers/changes to this criteria will be made by the 45 SW Commander. The 45 SW Commander will normally delegate waiver authority to the FCO after L-5 minutes.

The Flight Control Officer (FCO) will be the Range Safety interface to the NASA Test Director (NTD).

THE 45 SW IS RESPONSIBLE FOR THE MANAGEMENT AND OPERATION OF THE ER WHICH IS DESIGNATED A MAJOR RANGE AND TEST FACILITY BASE BY THE DEPARTMENT OF DEFENSE. DOD DIRECTIVE 3200.11 LEVIES THE SAFETY RESPONSIBILITY AT THESE RANGES ON THE 45 SW COMMANDER. REFERENCE: EWR 127-1, PARAGRAPH 1.3.

1.1.1 ETR-01 WAIVERS/DEVIATIONS. As stated above, the 45 SW Commander has final decision on Range Safety compliance with Go/No Go criteria contained in EWR (Eastern Western Range) 127-1 and possible waivers/changes to that criteria. This section of the Launch Commit Criteria (LCC) document, ETR-01, is a reflection of portions of the EWR 127-1 criteria. In the event that the 45 SW Commander waives or deviates from criteria in EWR 127-1 which is specifically stated in ETR-01, a NSTS 16007 Deviation or Waiver to ETR-01 will be processed post launch to document the occurrence unless otherwise directed by the Mission Management Team (MMT) chair. Post launch, NSTS 16007 Waivers/Deviations to ETR-01 will only require MMT chair approval. If the 45 SW Commander's deviation/waiver to EWR 127-1 justifies a permanent change to ETR-01 then an appropriate LCC Change Notice (LCN) will be released post launch and processed through the LCC Working Group and Daily Program Requirements Control Board (DPRCB).

1.2 INSTRUMENTATION - GENERAL. A Range Safety system is designated mandatory if, without it, a single failure would deny the FCO the means to monitor missile/space vehicle performance or to send flight termination commands. A Range Safety system is designated, as required, if support from that system is requested for launch. A required system may or may not be designated mandatory. All mandatory systems are so designated in a 45 SW Range Safety document called the Operations Supplement (OP SUP) to the Range Safety Operational Requirement (RSOR). This document is published and distribution is made by launch minus ten work days.

ALL INSTRUMENTATION SHALL BE DESIGNED TO ENSURE THAT NO SINGLE-POINT FAILURE WILL DENY THE CAPABILITY TO MONITOR OR TERMINATE A MISSILE/SPACE VEHICLE FLIGHT. RANGE SAFETY INSTRUMENTATION DATA SOURCES ARE REQUIRED TO PROVIDE THE FCO WITH REALTIME INFORMATION ON MISSILE/SPACE VEHICLE BEHAVIOR. AT LEAST TWO ADEQUATE DATA SOURCES ARE REQUIRED THROUGHOUT EACH PHASE OF POWERED FLIGHT OR UNTIL ORBITAL INSERTION OF A SPACE VEHICLE. REFERENCE: EWR 127-1, PARAGRAPH 7.5.1.

1.2.1 Tracking Systems. Two adequate and independent tracking data sources are mandatory. An adequate source is one that provides data of an accuracy that enables the FCO to determine when flight termination criteria are violated while ensuring that a vehicle proceeding within established limits is not jeopardized. Optics (contraves), telemetry guidance (navigation) and radar provide tracking data. Tracking data is mandatory through 400 seconds for easterly (28.5 deg), 440 sec for mid-inclinations (39, 51.6 deg) and 500 seconds for high inclinations (57 deg).

RADAR IS THE PRINCIPAL DATA SOURCE FOR VEHICLE PRESENT-POSITION AND IMPACT-PREDICTION DISPLAYS. AT LEAST TWO RADARS OPERATING IN BEACON-TRACK MODE OR SKIN-TRACK MODE, EACH WITH AT LEAST 95% OR BETTER ESTIMATED COVERAGE, WILL NORMALLY PROVIDE ADEQUATE COVERAGE. THESE TIMES CORRESPOND TO THE NOMINAL VEHICLE POSITION AFTER WHICH THE VEHICLE CAN NO LONGER ENDANGER LAND AND THUS CANNOT REACH A LATERAL MECO LIMIT LINE. REFERENCE: EWR 127-1, PARAGRAPH 2.5.4.1.

1.2.2 Computers and Display Systems.

1.2.2.1 Range Safety Display (RSD).

2 of 2 mandatory to T-10 seconds

RSD String "A"
RSD String "B"

THE RSD IS REQUIRED AS THE PRIMARY INFORMATION SYSTEM USED BY THE FCO TO MONITOR MISSILE FLIGHT. THE 45 SW/SEOS (STS OPERATIONS & SYSTEMS ANALYSIS) ELEMENT SHALL PROVIDE RSD REQUIREMENTS, INSTRUCTIONS AND DATA NECESSARY FOR DISPLAY GENERATION. REFERENCE: EWR 127-1, PARAGRAPH 2.12.3.

1.2.2.2 Computer Systems.

2 of 2 mandatory to T-10 seconds

Backbone LAN A
Backbone LAN B

CAP A
CAP B

AB Red Switch
AB Black Switch

RTP A
RTP B

Launch Control LAN A
Launch Control LAN B

4 of 4 mandatory to T-10 seconds

IOPP Red A
IOPP Red B
IOPP Black A
IOPP Black B

1 of 2 mandatory to T-10 seconds

LMC/SC 1
LMC/SC 2

1 of 1 mandatory to T-10 seconds

SPARC

1 of 1 mandatory to T-10 seconds

FDC

TWO COMPLETE INDEPENDENT RANGE SAFETY COMPUTER SYSTEMS (STRINGS A AND B) ARE REQUIRED TO BE OPERATIONALLY READY AND COMMITTED BY THE RANGE PRIOR TO LAUNCH. A STRING CONSISTS OF ALL PROCESSORS AND HARDWARE NECESSARY TO PROVIDE DATA TO THE RANGE SAFETY DISPLAY (RSD) SYSTEM. REFERENCE EWR 127-1, PARAGRAPH 7.6.1.

1.2.3 Command Control Systems. One dual command control system is required.

1.2.3.1 Central Control Remoting Systems.

2 of 2 mandatory to T-10 seconds

CME/V system 1
CME/V system 2

COMMAND REMOTING SYSTEM (CRS). THE CRS IS REQUIRED FOR REMOTE CONTROL OF THE COMMAND SYSTEM TRANSMITTERS FROM THE COMMAND CONTROL PANEL ON THE FCO CONSOLE AT THE RANGE OPERATIONS CONTROL CENTER (ROCC). THE CRS SHALL MONITOR STATUS OF THE COMMAND TRANSMITTERS LOCATED AT THE REQUIRED SITES AND SHALL AUTOMATICALLY SELECT THE COMMAND TRANSMITTER THAT WILL RADIATE AN ADEQUATE CARRIER SIGNAL TO THE MISSILE OR SPACE VEHICLE BASED ON ITS PRESENT POSITION. IT SHALL BE CAPABLE OF ENABLING AND DISABLING REMOTE STATION COMMAND CAPABILITY. CRS MANUAL CONTROL CAPABILITY IS REQUIRED TO BACK UP THE AUTOMATIC CONTROL. REFERENCE: EWR 127-1, PARAGRAPH 7.7.1.

1.2.3.2 Command Destruct Systems.

1. 1 of 2 mandatory to T-10 seconds for all missions.

   Cape dual High Power (HP) system and related command remoting links/equipment.

   Cape dual Low Power (LP) system and related command remoting links/equipment.

2. 1 of 2 strings mandatory to T-10 seconds for inclinations greater than 28.5 degrees (39, 51.6 and 57 degrees).

   JDMTA (Jonathan Dickinson Missile Tracking Annex) dual High Power system and related command remoting links/equipment.

3. Mandatory to T-10 seconds for all missions. Omni-directional capability from Cape dual High Power system.

4. 2 command remoting links are mandatory to T-10 seconds for all missions through 125 seconds.

THE GENERAL RANGE SAFETY COMMAND CONTROL REQUIREMENT IS ONE COMPLETE (DUAL) COMMAND SYSTEM FROM LIFTOFF THROUGH ORBITAL INSERTION. FOR SHUTTLE, THE REQUIREMENT IS LIFT-OFF THROUGH SRB SEPARATION (TYPICALLY 125 SEC) AND IS APPLICABLE FOR 28.5 THROUGH 57-DEGREE INCLINATION LAUNCHES. THE COMMAND COVERAGE OF THIS INTERVAL IS PROVIDED BY THE CAPE DUAL HIGH OR LOW POWER SYSTEMS FOR 28.5-DEGREE INCLINATION LAUNCHES AND CAPE DUAL HIGH OR LOW POWER SYSTEMS AND JDMTA DUAL HIGH POWER SYSTEM FOR 39, 51.6 AND 57-DEGREE INCLINATIONS.

CURRENTLY, ONLY STATION 1 HP IS CONFIGURED WITH AN OMNI-DIRECTIONAL ANTENNA. HOWEVER, THE LAUNCH COUNTDOWN CAN CONTINUE IF STATION 1 HP IS DISPOSITIONED AS PARTIALLY MISSION CAPABLE (PMC). GIVEN THE SCENARIO WHERE ONE OF THE STATION 1 HPS TRANSMITTERS OR ASSOCIATED HARDWARE ARE INOPERATIVE, THE MISSION COULD CONTINUE IF THE REMAINING HP TRANSMITTER, THE OMNI-DIRECTIONAL ANTENNA, AND BOTH STRINGS OF STATION 1 LP WERE DESIGNATED AS MANDATORY. THIS CONFIGURATION WOULD SATISFY BOTH THE REQUIREMENT FOR A DUAL COMMAND SYSTEM AT THE CAPE AND OMNI-DIRECTIONAL ANTENNA CAPABILITY. THERE ARE FAILURE MODES FOR STATION 1 HP WHERE A DETERMINATION OF PMC MAY REQUIRE ANALYSIS. THESE FAILURE MODES WILL REQUIRE THE STATION TO BE DECLARED NON MISSION CAPABLE (NMC) AND WILL RESULT IN A SAFETY NO GO WHILE THIS DETERMINATION IS BEING MADE. EVERY ATTEMPT WILL BE MADE TO STREAMLINE AND RAPIDLY ASSESS THE CAPABILITY OF THE SYSTEM TO SUPPORT THE LAUNCH IN A PMC STATUS. THE STATION 1 HP SYSTEM IS SUBSTANTIALLY REDUNDANT AND THE PROBABILITY OF ITS READINESS TO SUPPORT IN A PMC STATUS IS EXPECTED TO BE HIGH.

THE CRITERIA OF JDMTA COMMAND SUPPORT (1 OF 2 MANDATORY) IS PREDICATED ON THE EWR 127-1 REQUIREMENTS FOR CAPTURE OF THE COMMAND RECEIVERS FOR EACH SRB (SECTION 7.2.1.3,E) AND MAINTAIN LINK MARGIN (SECTIONS 4.2.1.2.1, D&E; 7.2.1.3,C). ANALYSIS HAS REVEALED THAT THE LINK MARGIN IS NOT CONTINUOUSLY SUSTAINED THROUGH SRB SEPARATION WITH ONLY THE CAPE BASED COMMAND SITES. THE JOINT NASA-AF STUDY ENTITLED "SPACE SHUTTLE FREE FLYING RSRB TRACKING ANALYSIS" CONDUCTED BY ACTA (SEPTEMBER 1999) RESULTS SUPPORT THAT LATE IN FIRST STAGE, SUFFICIENT TIME INTERVALS ARE AVAILABLE FOR THE CAPE COMMAND DESTRUCT SIGNAL TO REACH EACH SRB BETWEEN VEHICLE BREAK-UP AND POTENTIAL LAND IMPACT.

1.2.4 Communications.

1. Holdfire capability

   1 of 2 mandatory to T-10 seconds

   Holdfire circuit
   NTD Voice Comm (OIS 212)

EACH LAUNCH SYSTEM SHALL HAVE A HOLDFIRE CAPABILITY WHICH STOPS THE LAUNCH SEQUENCER IN THE EVENT OF UNSAFE RANGE CONDITIONS OR LOSS OF CRITICAL RANGE SAFETY SYSTEMS. THE HOLDFIRE SWITCH SHALL BE AVAILABLE ON THE RANGE SAFETY REPRESENTATIVE (RSR) CONSOLE, THE FCO CONSOLE AND THE SRO CONSOLE. REFERENCE: EWR 127-1, PARAGRAPH 7.8.3.

2. Between the FCO and FD/FDO

2 of 3 mandatory to T-10 seconds

FCO Loop
FCO/FDO Private Line
Flight Director Loop

RANGE SAFETY COMMUNICATIONS CIRCUITS ARE REQUIRED AS TYPICAL FOR LAUNCH OPERATIONS. THESE CIRCUITS SHALL BE ROUTED TO THE FCO CONSOLE AND CONNECTED IN PARALLEL AT THE SENIOR FCO POSITION. SPECIFICALLY FOR STS, VERBAL COMMUNICATION IS MANDATORY BETWEEN THE FCO AND THE JSC FD/FDO FOR REPORTING IN ACCORDANCE WITH SECTION A4.1.6-3 FCO TO MCC WARNING NOTIFICATION, A4.1.6-4 MCC TO FCO REPORTING, A4.1.6-5 CONTROLLABILITY, A4.1.6-6 FLIGHT TERMINATION/MANUAL MECO EVALUATION, AND A4.1.6-8 FLIGHT TERMINATION/MANUAL MECO ACTION IN THE NSTS-12820, SPACE SHUTTLE OPERATIONAL FLIGHT RULES. REFERENCE: EWR 127-1, PARAGRAPH 7.11.1.

1.2.5 Controllability Verification.

2 of 5 mandatory to T-10 seconds

Range Safety Telemetry Display System
Controllability Lights
FCO Loop
FCO/FDO Private Line
Flight Director Loop

AT LEAST TWO INDEPENDENT MEANS FOR THE FCO TO DETERMINE CONTROLLABILITY (CONTROL OR LOSS OF CONTROL) ARE MANDATORY. REFERENCE SECTION A4.1.6-5, "CONTROLLABILITY", IN NSTS 12820, SPACE SHUTTLE OPERATIONAL FLIGHT RULES.

1.2.6 FCO Abort Light Switch and Hardware

1 of 2 Abort Light Command Paths to T-10 seconds

THE ABORT LIGHT IS THE PRIME ER ELEMENT OF CONTROL FOR PUBLIC SAFETY DURING THE PORTION OF FLIGHT FOLLOWING SRB SEPARATION AND EXTENDING UNTIL MAIN ENGINE CUTOFF.

1.3 SURVEILLANCE.

1.3.1 Launch Area - Surveillance of the launch danger zone (area to be cleared of shipping) is mandatory until the final Range Safety clearance to launch is given at approximately L-15 minutes.

1.3.2 SRB and ET RTLS Impact Area - The SRB retrieval ships will survey the SRB and ET RTLS impact area, using available equipment, and report any sightings to the Surveillance Control Officer (SCO) through the Landing/Recovery Director (LRD).

Available aircraft will also survey the area and report any sightings to the SCO.

NOTE: A Hold may be required but no later than T-5 minutes to allow any intruding vessels to clear the launch area and the SRB and ET RTLS impact area.

LAUNCH AREA SURVEILLANCE ENCOMPASSES THOSE LAND, AIR AND SEA AREAS DESIGNATED AS THE LAUNCH DANGER AREA AND THE LAUNCH DANGER ZONE. THE FCO SHALL ENSURE THAT THESE AREAS ARE CLEAR OF UNAUTHORIZED SHIPS, BOATS, AIRCRAFT AND PEOPLE PRIOR TO THE ER ISSUING A CLEAR TO LAUNCH TO THE NTD. REFERENCE EWR 127-1, PARAGRAPH 7.9.1.

1.4 FLIGHT TERMINATION SYSTEMS.

1. Specific Launch Commit Criteria for flight hardware are contained in Section 12, Booster Range Safety System (BRSS).

2. A Range Safety Hold will be initiated by the Range Safety Representative (RSR) after T-9 minutes, whenever a mandatory flight termination system item fails. The NASA Test Director (NTD) will be advised of the Hold prior to Holdfire initiation (automatic Hold), time permitting. After T-31 seconds, a Holdfire will be initiated only if a critical mandatory item fails. No Range Safety System Holdfire will be initiated after T-10 seconds.

FLIGHT TERMINATION SYSTEMS. ALL VEHICLES LAUNCHED ON THE RANGE MUST BE EQUIPPED WITH A FLIGHT TERMINATION SYSTEM. FOR THE STS, THE ER HAS DETERMINED THAT THE PUBLIC RISK DURING SECOND STAGE IS ACCEPTABLE ASSUMING MANUAL MECO ACTION IS TAKEN PRIOR TO THE VEHICLE CROSSING WELL DEFINED LIMIT LINES. BASED ON THIS RATIONALE, THE ER HAS AUTHORIZED REMOVAL OF THE FLIGHT TERMINATION SYSTEM (FTS/RSS) FROM THE EXTERNAL TANK FOR 28.5 THROUGH 57-DEGREE INCLINATION MISSIONS. REFERENCE: EWR 127-1, PARAGRAPH 2.3.3.

1.5 WEATHER RESTRICTIONS.

1.5.1 Wind Restrictions. Launch area wind restrictions will be provided on a test-by-test basis.

FOR ALL MAJOR LAUNCHES FROM THE CAPE AND KSC, THE CAPE CANAVERAL FORECAST FACILITY (CCFF) SHALL PROVIDE RANGE SAFETY WITH A FORECAST OF LAUNCH WINDS ON F-1 DAY, ON LAUNCH DAY AND AT OTHER TIMES AS MUTUALLY AGREED. REFERENCE EWR 127-1, PARAGRAPH 2.12.6.

1.5.2 Blast Propagation Restrictions. These launch restrictions are derived from a blast propagation computer model using realtime meteorological parameters. Predicted fatality probability of less than one in a million will allow the launch to continue. Predicted fatality probability of greater than one in one hundred thousand will result in Holding or scrubbing of the launch. Predicted fatality probability falling between the above values will require an evaluation by the 45 SW Commander.

LAUNCH WILL NOT BE PERMITTED UNDER WEATHER CONDITIONS WHERE DEBRIS, RADIOLOGICAL MATERIAL, TOXIC FUEL DISPERSIONS OR OVERPRESSURES FROM DETONATING PROPELLANT CAN CREATE AN UNACCEPTABLE HAZARD. LAUNCHES WILL NOT BE PERMITTED WHEN WEATHER

POSES A THREAT TO FLIGHT SAFETY. REFERENCE: EWR 127-1, APPENDIX 1D, PARAGRAPH 1D.1.b.

1.5.3 Lightning Restrictions. Range safety lightning constraints are contained in the paragraph titled "Natural and Triggered Lightning Constraints", of Section 4, Weather Rules.

1.5.4 Ceiling and Visibility.

CEILING: A ceiling of 4,000 feet is permitted only if all the following criteria are met.

1. Any cloud layers between 4,000 and 8,000 feet are no more than 500 feet thick.

2. The airborne Forward Observer is in proper position and visibility is sufficient to monitor the Vehicle integrity from the top of the ceiling through the 8,000 foot level.

3. The ground based Forward Observer has sufficient visibility to monitor the Vehicle integrity from the pad to the lower base of the ceiling.

4. Positive communications are available between the Forward Observers and the FCO.

CEILING: A ceiling of 6,000 feet with unlimited thickness will be allowed for all short duration launch windows (e.g., Mir rendezvous flights). Additionally, this limit may be approved by the 45th Space Wing Commander for longer duration windows, when the weather/ceiling forecast does not offer a reasonable probability of launch throughout the launch window. In all cases, this constraint will be permitted only if:

1. Two secondary or one secondary and one tertiary vehicle behavior cue are available prior to commit to launch.

If any of the above ceiling criteria (4,000 foot and 6,000 foot) are not met, the cloud ceiling limit is 8,000 feet.

VISIBILITY: 5 miles of visibility is mandatory if metric optical trackers are mandatory; otherwise, visibility is constrained by Paragraphs 2 and 3 of the Ceiling limits (above).

A CEILING OF 8,000 FEET MINIMUM IS HIGHLY DESIRABLE FOR THE FLIGHT CONTROL OFFICER TO ENSURE PROTECTION OF PEOPLE AND PROPERTY LOCATED BEHIND THE PRIMARY LIMIT LINE (VAB) IN THE LAUNCH AREA. DIRECT VISUAL OBSERVATION IS NECESSARY TO MINIMIZE THE FCO REACTION TIME FOR MALFUNCTIONS IN THE IMMEDIATE LAUNCH AREA THAT WOULD RESULT IN FREE-FLYING SRBs OR INTACT IMPACT OF THE ET OR SRBs.

DIRECT VISUAL OBSERVATION MAY BE PROVIDED BY VIDEO PRESENTATION OR FCO OBSERVERS ON THE GROUND AND/OR AIRBORNE PLATFORMS. AT APPROXIMATELY T+28 SECONDS AND 8,000 FEET (NOMINAL VEHICLE) ALTITUDE, THE REACTION TIME NECESSARY FOR THE FCO TO PROTECT THE PRIMARY IMPACT LIMIT LINE (ILL) (VAB) BECOMES LARGE ENOUGH (GREATER THAN 10 SECONDS) TO ALLOW INTERPRETATION OF MULTIPLE VEHICLE BEHAVIOR CUES TO DISCERN VEHICLE INTEGRITY.

THE CEILING MAY BE AS LOW AS 4,000 FEET IF THE AIRBORNE AND GROUND FORWARD OBSERVER CAN INDIVIDUALLY OR COLLECTIVELY MONITOR VEHICLE INTEGRITY THROUGH THE REQUIRED 8,000 FEET WITH THE EXCEPTION OF THE TIME THE VEHICLE IS OBSCURED WITHIN THE CLOUDS. AN UPPER BOUND OF 500 FEET THICKNESS OR APPROXIMATELY ONE SECOND OF VEHICLE OBSCURATION CAN BE ACCOMMODATED WITHIN THE SEVEN SECOND REACTION TIME (RSS SYSTEM DELAY PLUS FCO REACTION TIME) CURRENTLY EMPLOYED WITH MINIMUM IMPACT TO PUBLIC OR CREW SAFETY. ANY DECREASE IN REACTION TIME ALLOWANCE LOWER THAN SEVEN SECONDS WILL HAVE NEGATIVE IMPACTS ON CREW AND PUBLIC SAFETY. SINCE THE FORWARD OBSERVERS MUST COMMUNICATE VEHICLE STATUS TO THE FCOs, POSITIVE COMMUNICATIONS BETWEEN THE FORWARD OBSERVERS AND THE FCO ARE MANDATORY TO PERMIT THESE LOWER CEILING CONSTRAINTS.

A CEILING OF 6,000 FEET WITH UNLIMITED THICKNESS IS PERMITTED WHEN THE INTEGRITY OF THE VEHICLE CAN BE MONITORED WITHOUT INTERRUPTION TO THE 6,000 FOOT LEVEL AND SUFFICIENT VEHICLE BEHAVIOR CUES AS DEFINED IN THE FLIGHT RULES (NSTS 12820 VOLUME A, SECTION 4, RANGE SAFETY FLIGHT RULES PARAGRAPH, CONTROLLABILITY SUB-PARAGRAPH) - ARE AVAILABLE. THESE CUES ARE REQUIRED AS NECESSARY AND SUFFICIENT FOR AN FCO FLIGHT TERMINATION DECISION IN THE ABSENCE OF A PRIMARY VISUAL CUE TO VEHICLE INTEGRITY.

FIVE MILES OF VISIBILITY IS MANDATORY FOR LAUNCH WHEN METRIC OPTICAL TRACKERS ARE MANDATORY TO PROVIDE 2 ADEQUATE AND INDEPENDENT TRACKING SOURCES TO THE FCO. WHEN OPTICAL TRACKERS ARE MANDATORY, THE VISIBILITY FROM THE SENSOR TO THE PAD AND VEHICLE THROUGH THE EARLY BOOST PHASE ULTIMATELY DETERMINES IF THE METRIC OPTICAL SOURCES CAN BE COMMITTED AND THE LAUNCH MAY PROCEED. WHEN THE METRIC OPTICAL TRACKERS ARE NOT MANDATORY, THE ONLY VISIBILITY REQUIREMENTS ARE DETERMINED BY THE GROUND AND AIRBORNE FORWARD OBSERVERS ASSESSMENT OF VISIBILITY TO THE PAD AND THE PROJECTED LAUNCH TRAJECTORY UP TO THE 8,000 FOOT LIMIT.

1.6 COLLISION AVOIDANCE (COLA) RESTRICTIONS. Launch time restrictions will be imposed on STS missions, as necessary, to preclude a close approach to an orbiting vehicle capable of being manned. For purposes of this rule, a close approach is defined as:

1. 200 km downtrack or 50 km vertical or 50 km crosstrack if the orbiting spacecraft is manned.

2. 50 km if the orbiting spacecraft is unmanned.

AS A RESULT OF VERBAL AGREEMENT DURING THE APOLLO PROGRAM, RANGE SAFETY ACCEPTED THE RESPONSIBILITY OF PREVENTING COLLISIONS BETWEEN ORBITING MANNED SPACECRAFT AND ROCKETS BEING LAUNCHED FROM THE CAPE.

1.7 RF RESTRICTIONS. A Hold will be required if a source other than the authorized command destruct system is radiating on the flight termination system frequency. The Frequency Control and Analysis (FCA) unit will report any detected interference to the Range Contractor Frequency Control Coordinator and the representative of 45 SW/Communications Computer Systems who will contact the necessary governmental agencies to identify and secure the interfering RF signal.

NO OPEN LOOP (FREE SPACE) TRANSMISSIONS ARE TO BE MADE ON COMMAND DESTRUCT FREQUENCIES BY LAUNCH AGENCY TRANSMISSIONS UNLESS PROPER FREQUENCY CLEARANCE IS OBTAINED FROM THE FREQUENCY CONTROLLER. REFERENCE: EWR 127-1, PARAGRAPH 7.7.1.f.

SECTION 06

KSC FLIGHT CREW AND PAD PERSONNEL SAFETY

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1.0 KSC FLIGHT CREW AND PAD PERSONNEL SAFETY. (No LCC requirements exist in this section.)

1.1 EFFECTIVITY.

1.1.1 This SSID is applicable from the start of ET Cryogenic Loading (T-6 hours) and will be effective as long as any of the following personnel are at the Launch Pad (through Launch or Launch Abort).

1. Flight Crew
2. Closeout Crew
3. Ice/Frost Inspection Team
4. Red Crew
5. Fire/Rescue Team

1.2 DEFINITIONS.

1.2.1 Pad Personnel.

1. Flight Crew - Shuttle Crew members for designated mission up to a maximum of eight members.
2. Closeout Crew - Personnel who are scheduled to enter the launch pad after ET LO2 & LH2 cryogenic loading to prepare the Orbiter for Flight Crew ingress, assist the Flight Crew during ingress, close the Orbiter hatch and secure the White Room/Orbiter Access Arm for launch. The Closeout Crew leader is responsible for directing on-site emergency operations involving the Flight Crew and Closeout Crew (nominally six personnel).
3. Ice/Frost Inspection Team - Personnel who are scheduled to enter the launch pad after ET LO2 & LH2 cryogenic loading to conduct visual observations and obtain instrument readings of the Shuttle and launch complex equipment/facilities based upon the cryogenic and atmospheric environment (nominally eight personnel).
4. Red Crew - Personnel who may have to enter the launch pad to correct on-site anomalies that have occurred in Shuttle or launch complex equipment/facilities (nominally two personnel minimum).
5. Fire/Rescue Team - Personnel who may have to enter the launch pad to aid and assist personnel who are either injured or incapacitated, or to conduct fire fighting operations (nominally seven personnel).

1.2.2 Condition Yellow - An LCC violation has occurred or an abnormal situation exists in the Shuttle/Payload or Launch Complex equipment which could affect the safety of the Flight Crew and/or Pad Personnel. The adverse physical condition of a member of the Flight Crew or Pad Personnel is also a condition YELLOW.

1.2.3 Condition Critical - An uncontrollable hazardous situation exists in the Shuttle/Payload or Launch Complex equipment which directly affects the survivability of the FLIGHT CREW and/or PAD PERSONNEL.

1.2.4 Pad Emergency Egress Modes.

As defined in OMI S9913 "Orbiter Flight Crew. Emergency Egress and Escape, Launch Pad."

A. Mode I: An emergency egress condition when the Flight Crew is in the Orbiter Crew Compartment and is able to egress and escape without assistance.

B. Mode II: An aided Emergency Egress/Escape of the Flight Crew performed by the Closeout Crew.

C. Mode III: An emergency egress condition in which the Closeout Crew is not on station, and the Pad Fire/Rescue Crew is required to proceed from the fallback area to the 195 foot level of the FSS and rescue an incapacitated Flight Crew.

D. Mode IV: An aided emergency Egress/Escape of the Flight Crew performed by the Fire/Rescue Team with the Closeout Crew on station and also needing assistance.

1.3 RESPONSIBILITIES.

1.3.1 Pad Personnel Management.

1. Flight Crew - Since the number of Flight Crew members is determined by each particular mission, knowledge of and location of each member inside the Orbiter must be evaluated from an emergency standpoint by the NASA Test Director (NTD), Closeout Crew Leader (OVCC) and the Fire/Rescue Team Leader (Pad Rescue).

2. The NTD is responsible for the tracking and accountability of all personnel within the Launch Pad during the effectivity period. (T-6 hours)

3. The Launch Director's permission is required for all red crew activity, or other activity requiring additional personnel with the Launch Pad during the effectivity period. (T-6 hours)

1.3.2 The Systems Engineer is responsible for reporting any LCC violation or other abnormal situation which could affect the immediate safety of the Flight Crew or Pad Personnel and shall indicate if the LCC violation is a condition CRITICAL or condition YELLOW situation.

1.3.3 The NASA Test Director (NTD) is responsible for determining the appropriate response to a condition CRITICAL or condition YELLOW from the launch team and will determine if immediate action is required to ensure the safety of the Flight Crew and Pad Personnel.

1.3.4 If the NTD determines that a condition CRITICAL requires Flight Crew/Pad Personnel Emergency Egress/Escape, the NTD will declare a Mode I, II, III or IV Emergency Egress.

1.3.4.1 For emergency situations within the Orbiter Crew Compartment when time does not permit coordination with the NTD, the Orbiter Test Conductor (OTC), Flight Crew or Closeout Crew will initiate Emergency Egress/Escape.

1.3.5 The NTD has overall responsibility for directing operations in the event of an emergency situation and will control entry into the Launch Danger Area (LDA). The on-scene commander is responsible for taking immediate action as appropriate to ensure pad personnel safety based upon observed conditions.

The on-scene commander for Mode 1 is CDR; for Mode 2, Closeout Crew Leader (OVCC); and for Mode 3 and 4, Fire Rescue Leader (FRL).

1.4 EMERGENCY EGRESS/ESCAPE SYSTEM.

1.4.1 Emergency Egress/Escape System Description. The Launch Complex 39 Shuttle Emergency Escape System (SEES) consists basically of the Orbiter Access Arm and the seven slidewire baskets on the Fixed Service Structure (FSS) at the 195-foot level, which provides an escape route from the Orbiter Crew Module to a landing zone approximately 1200 feet to the west. A bunker adjacent to the landing zone provides immediate shelter and a Marshalling Area. The bunker is equipped with a wash-down shower, toxic vapor detectors, phone to the firing room, breathing air manifold and basic first aid equipment. An M113 armored personnel carrier is parked outside the bunker for Pad Egress as directed by the NTD.

1.4.2 Emergency Egress Flame Detection System (EEFDS) Description.

The launch pad EEFDS consists of ten temperature sensors and 14 ultraviolet (UV) hydrogen fire detectors.

Nine UV fire detectors are located in the area of the OAA Environmental Chamber, OAA Truss, and the FSS 195 foot level, both above and below the Fire Barrier. Also there are five UV fire detectors vertically spaced down the FSS from the 175 foot level to the 95 foot level to view a profile of the Orbiter.

The ten temperature sensors are located along the egress path from the OAA Environmental Chamber (White Room), to the slidewire basket embarkation area. The sensors are located both above and below the fire barrier. The signals from these sensors are processed through redundant HIMs and displayed on Firing Room console C-7 in the Launch Control Center. The Launch Accessories System Engineer (call sign CGSS) will monitor this system in addition to his existing function of monitoring the OAA and Sound Suppression Water.

1.5 CREW INGRESS WEATHER CONSIDERATION. The weather condition will be considered in reaching a decision for Flight Crew ingress. Consideration must be given to adequately support a Pad Emergency Egress, Triage Operations and Medevac Operations. The Launch Director is responsible for determining satisfactory weather condition for crew ingress.

1.6 PAD DEPARTURE ROUTES.

1.6.1 Emergency Egress/Escape Route - Emergency Egress/Escape Modes I, II, III, IV require use of the OAA, FSS 195 foot level slidewire system unless otherwise directed by the NTD.

1.6.2 Egress/Evacuation Route - Condition YELLOW Egress/Evacuation operations will use the OAA, FSS 195 foot level, FSS elevators, stairways and ground transportation unless otherwise directed by the NTD.

1.6.3 Detailed Procedures for emergency egress or evacuation are contained in OMI S9913 Orbiter Flight Crew Emergency Egress and Escape, Launch Pad.

1.7 CONDITION YELLOW

1.7.1 The declaration by the NTD that a condition YELLOW exists will be in response to System Engineers reporting LCC violations that are identified as affecting Flight Crew and Pad Personnel safety or by Shuttle Launch Team members who have detected the existence of an abnormal situation during Launch Countdown Operations. Condition YELLOW is based upon the rationale that sufficient time is available to determine whether an Egress/Evacuation of the Flight Crew and/or evacuation of Pad Personnel is required.

1.7.2 Each LCC that would effect Flight Crew and Pad Personnel safety has been identified and marked as such. Exceeding the established limits of these criteria would result in the Systems Engineer notifying the NTD of a condition YELLOW LCC violation and would be cause for declaration of a condition YELLOW by the NTD. A full description of these LCC items is contained in Sections 10 thru 44 of this document.

1.7.3 Other problem situations which may occur during the Launch Countdown may, based upon the decision of the NTD, be declared a condition YELLOW. This includes adverse weather conditions which jeopardize the safety of the Flight Crew and Pad Personnel on the pad or along Egress/Escape or Evacuation Routes, or by compromising the performance of equipment necessary during an Egress/Escape/Evacuation Operation. It also includes an adverse physical condition of Flight or Ground Crew Members.

1.8 CONDITION CRITICAL EMERGENCY

1.8.1 Identification by Shuttle Launch Team personnel, Flight Crew or Pad Personnel that a situation exists which immediately affects the survivability of personnel at the pad is a condition CRITICAL emergency. Although the criteria for determining condition CRITICAL is not solely based upon Launch Commit Criteria, certain combinations of LCC violations could cause a condition CRITICAL emergency. Also, situations during Launch Countdown that would require the performance of the emergency section of either OMI S0007 or supporting OMIs could, if unable to control the situation, be declared a condition CRITICAL emergency. Specific items in this category are:

1. Fire external to any vehicle element (ORB, ET, SRB), which is uncontrollable, and jeopardizes the ET or SRBs.

2. Fire internal to any vehicle element (ORB, ET, SRB).

3. Ruptured fuel or LO2 line inside of any vehicle element (ORB, ET, SRB) that could lead to an explosion or fire.

4. Uncontrolled pressurization of tanks or vessels on or inside any vehicle element (ORB, ET, SRB).

5. Fire, hyper leak (MMH, N2H4) external to any vehicle element (ORB, ET, SRB) that would prevent the crew normal egress.

6. Loss of GN2 purge and a LO2 or H2 leakage in Orbiter aft compartment of TSM.

7. H2 concentration in the Orbiter aft fuselage, midbody, payload bay, or ET intertank greater than 1 percent (10,000 ppm).

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SECTION 06

KSC FLIGHT CREW AND PAD PERSONNEL SAFETY

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1.0 KSC FLIGHT CREW AND PAD PERSONNEL SAFETY. (No LCC requirements exist in this section.)

1.1 EFFECTIVITY.

1.1.1 This SSID is applicable from the start of ET Cryogenic Loading (T-6 hours) and will be effective as long as any of the following personnel are at the Launch Pad (through Launch or Launch Abort).

1. Flight Crew
2. Closeout Crew
3. Ice/Frost Inspection Team
4. Red Crew
5. Fire/Rescue Team

1.2 DEFINITIONS.

1.2.1 Pad Personnel.

1. Flight Crew - Shuttle Crew members for designated mission up to a maximum of eight members.
2. Closeout Crew - Personnel who are scheduled to enter the launch pad after ET LO2 & LH2 cryogenic loading to prepare the Orbiter for Flight Crew ingress, assist the Flight Crew during ingress, close the Orbiter hatch and secure the White Room/Orbiter Access Arm for launch. The Closeout Crew leader is responsible for directing on-site emergency operations involving the Flight Crew and Closeout Crew (nominally six personnel).
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1.2.2 Condition Yellow - An LCC violation has occurred or an abnormal situation exists in the Shuttle/Payload or Launch Complex equipment which could affect the safety of the Flight Crew and/or Pad Personnel. The adverse physical condition of a member of the Flight Crew or Pad Personnel is also a condition YELLOW.

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1.3.1 Pad Personnel Management.

1. Flight Crew - Since the number of Flight Crew members is determined by each particular mission, knowledge of and location of each member inside the Orbiter must be evaluated from an emergency standpoint by the NASA Test Director (NTD), Closeout Crew Leader (OVCC) and the Fire/Rescue Team Leader (Pad Rescue).

2. The NTD is responsible for the tracking and accountability of all personnel within the Launch Pad during the effectivity period. (T-6 hours)

3. The Launch Director's permission is required for all red crew activity, or other activity requiring additional personnel with the Launch Pad during the effectivity period. (T-6 hours)

1.3.2 The Systems Engineer is responsible for reporting any LCC violation or other abnormal situation which could affect the immediate safety of the Flight Crew or Pad Personnel and shall indicate if the LCC violation is a condition CRITICAL or condition YELLOW situation.

1.3.3 The NASA Test Director (NTD) is responsible for determining the appropriate response to a condition CRITICAL or condition YELLOW from the launch team and will determine if immediate action is required to ensure the safety of the Flight Crew and Pad Personnel.

1.3.4 If the NTD determines that a condition CRITICAL requires Flight Crew/Pad Personnel Emergency Egress/Escape, the NTD will declare a Mode I, II, III or IV Emergency Egress.

1.3.4.1 For emergency situations within the Orbiter Crew Compartment when time does not permit coordination with the NTD, the Orbiter Test Conductor (OTC), Flight Crew or Closeout Crew will initiate Emergency Egress/Escape.

1.3.5 The NTD has overall responsibility for directing operations in the event of an emergency situation and will control entry into the Launch Danger Area (LDA). The on-scene commander is responsible for taking immediate action as appropriate to ensure pad personnel safety based upon observed conditions.

The on-scene commander for Mode 1 is CDR; for Mode 2, Closeout Crew Leader (OVCC); and for Mode 3 and 4, Fire Rescue Leader (FRL).

1.4 EMERGENCY EGRESS/ESCAPE SYSTEM.

1.4.1 Emergency Egress/Escape System Description. The Launch Complex 39 Shuttle Emergency Escape System (SEES) consists basically of the Orbiter Access Arm and the seven slidewire baskets on the Fixed Service Structure (FSS) at the 195-foot level, which provides an escape route from the Orbiter Crew Module to a landing zone approximately 1200 feet to the west. A bunker adjacent to the landing zone provides immediate shelter and a Marshalling Area. The bunker is equipped with a wash-down shower, toxic vapor detectors, phone to the firing room, breathing air manifold and basic first aid equipment. An M113 armored personnel carrier is parked outside the bunker for Pad Egress as directed by the NTD.

1.4.2 Emergency Egress Flame Detection System (EEFDS) Description.

The launch pad EEFDS consists of ten temperature sensors and 14 ultraviolet (UV) hydrogen fire detectors.

Nine UV fire detectors are located in the area of the OAA Environmental Chamber, OAA Truss, and the FSS 195 foot level, both above and below the Fire Barrier. Also there are five UV fire detectors vertically spaced down the FSS from the 175 foot level to the 95 foot level to view a profile of the Orbiter.

The ten temperature sensors are located along the egress path from the OAA Environmental Chamber (White Room), to the slidewire basket embarkation area. The sensors are located both above and below the fire barrier. The signals from these sensors are processed through redundant HIMs and displayed on Firing Room console C-7 in the Launch Control Center. The Launch Accessories System Engineer (call sign CGSS) will monitor this system in addition to his existing function of monitoring the OAA and Sound Suppression Water.

1.5 CREW INGRESS WEATHER CONSIDERATION. The weather condition will be considered in reaching a decision for Flight Crew ingress. Consideration must be given to adequately support a Pad Emergency Egress, Triage Operations and Medevac Operations. The Launch Director is responsible for determining satisfactory weather condition for crew ingress.

1.6 PAD DEPARTURE ROUTES.

1.6.1 Emergency Egress/Escape Route - Emergency Egress/Escape Modes I, II, III, IV require use of the OAA, FSS 195 foot level slidewire system unless otherwise directed by the NTD.

1.6.2 Egress/Evacuation Route - Condition YELLOW Egress/Evacuation operations will use the OAA, FSS 195 foot level, FSS elevators, stairways and ground transportation unless otherwise directed by the NTD.

1.6.3 Detailed Procedures for emergency egress or evacuation are contained in OMI S9913 Orbiter Flight Crew Emergency Egress and Escape, Launch Pad.

1.7 CONDITION YELLOW

1.7.1 The declaration by the NTD that a condition YELLOW exists will be in response to System Engineers reporting LCC violations that are identified as affecting Flight Crew and Pad Personnel safety or by Shuttle Launch Team members who have detected the existence of an abnormal situation during Launch Countdown Operations. Condition YELLOW is based upon the rationale that sufficient time is available to determine whether an Egress/Evacuation of the Flight Crew and/or evacuation of Pad Personnel is required.

1.7.2 Each LCC that would effect Flight Crew and Pad Personnel safety has been identified and marked as such. Exceeding the established limits of these criteria would result in the Systems Engineer notifying the NTD of a condition YELLOW LCC violation and would be cause for declaration of a condition YELLOW by the NTD. A full description of these LCC items is contained in Sections 10 thru 44 of this document.

1.7.3 Other problem situations which may occur during the Launch Countdown may, based upon the decision of the NTD, be declared a condition YELLOW. This includes adverse weather conditions which jeopardize the safety of the Flight Crew and Pad Personnel on the pad or along Egress/Escape or Evacuation Routes, or by compromising the performance of equipment necessary during an Egress/Escape/Evacuation Operation. It also includes an adverse physical condition of Flight or Ground Crew Members.

1.8 CONDITION CRITICAL EMERGENCY

1.8.1 Identification by Shuttle Launch Team personnel, Flight Crew or Pad Personnel that a situation exists which immediately affects the survivability of personnel at the pad is a condition CRITICAL emergency. Although the criteria for determining condition CRITICAL is not solely based upon Launch Commit Criteria, certain combinations of LCC violations could cause a condition CRITICAL emergency. Also, situations during Launch Countdown that would require the performance of the emergency section of either OMI S0007 or supporting OMIs could, if unable to control the situation, be declared a condition CRITICAL emergency. Specific items in this category are:

1. Fire external to any vehicle element (ORB, ET, SRB), which is uncontrollable, and jeopardizes the ET or SRBs.

2. Fire internal to any vehicle element (ORB, ET, SRB).

3. Ruptured fuel or LO2 line inside of any vehicle element (ORB, ET, SRB) that could lead to an explosion or fire.

4. Uncontrolled pressurization of tanks or vessels on or inside any vehicle element (ORB, ET, SRB).

5. Fire, hyper leak (MMH, N2H4) external to any vehicle element (ORB, ET, SRB) that would prevent the crew normal egress.

6. Loss of GN2 purge and a LO2 or H2 leakage in Orbiter aft compartment of TSM.

7. H2 concentration in the Orbiter aft fuselage, midbody, payload bay, or ET intertank greater than 1 percent (10,000 ppm).

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SECTION 07

HOLD/CUTOFF GUIDELINES

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Hold/Cutoff Guidelines

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SECTION 08

SPACE SHUTTLE VEHICLE FUNCTIONAL SEQUENCE

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1.0 SPACE SHUTTLE VEHICLE FUNCTIONAL SEQUENCE

1.1 GUIDELINES

The Space Shuttle Vehicle (SSV) functional sequence details actions to be followed in the event malfunctions or other problems are encountered during the countdown. Specified times represent recommended hold-points if required. Specific constraints for scrub/recycle operations shall be contained in the applicable file of the Space Shuttle Program Operations and Maintenance Requirements and Specification Document (OMRSD).

Time Period	Condition	Action/Comment
Prior to T-6 hours.	Malfunction of any repairable SSV element or operational support element.	Proceed or hold. Proceed if the malfunction is acceptable for continuation of launch countdown or if correction of malfunction can be accomplished in parallel with other operations; otherwise, hold for repair of mandatory items prior to removing access to the system or when the system is necessary for countdown continuation. Hold/recycle at T-6 hours if repair cannot continue in parallel with or after completion of cryogenic loading.
T-6 hours to T-3 hours (Start of ET Cryo Tanking to Ready for FLIGHT CREW Wakeup.)	Malfunction of any repairable SSV element or operational support element.	Proceed or hold. Proceed if the malfunction is acceptable for continuation of launch countdown or if correction of malfunction can be accomplished in parallel with other operations; otherwise, hold for repair of mandatory items prior to removing access to the system. Delay FLIGHT CREW wakeup or ingress as appropriate.
T-3 hours to T-20 minutes (Ready for FLIGHT CREW Wakeup to Operations Sequence (OPS) 1 Transition.)	Malfunction of any repairable SSV element or operational support element. Problem in Crew Module (CM) cabin closeout.	Proceed or hold. Proceed if the malfunction is acceptable for continuation of launch countdown or if correction of malfunction can be accomplished in parallel with other operations; otherwise, hold for repair of mandatory items prior to removing access to the system. Launch window and crew restrictions to determine hold times are defined in Section 3. A 10-minute hold at T-20 minutes is planned.

T-20 minutes to T-9 minutes (OPS 1 Transition to Go for GLS Start.)	Malfunction of any mandatory SSV element or operational support element applicable to this time period.	Hold at T-9 minutes. Proceed if the malfunction is acceptable for continuation of launch countdown.
T-9 minutes to T-5 minutes (GLS Start to Go for APU Start.)	Malfunction of any mandatory SSV element or operational support element applicable to this time period.	Hold at T-5 minutes. A manual hold at T-7 minutes, 30 seconds (prior to Orbiter Access Arm (OAA) retract) is available. Proceed if the malfunction is acceptable for continuation of launch countdown. If hold is planned for longer than 10 minutes, the OAA will be extended.
T-5 minutes to T-31 seconds (APU Start to Go for RSLS Start.)	Malfunction of any mandatory SSV element or operational support element applicable to this time period.	Hold at T-4 minutes/T-31 seconds. A capability to hold is based on the HOLD TIME CONSTRAINTS shown below. Manual holds are available at T-2 minutes, 55 seconds and T-1 minute, 57 seconds in the event of a desire to prevent ET pressurization. Proceed if the malfunction is acceptable for continuation of launch countdown.
T-31 seconds to Solid Rocket Booster ignition command.	Malfunction of any mandatory SSV element or operational support element applicable to this time period.	CUTOFF is the only option after T-31 seconds. The result will be an automatic recycle and Redundant Set Launch Sequencer (RSLS)/Ground Launch Sequencer (GLS) safing.

1.2 HOLD TIME CONSTRAINTS

- Launch window
- Auxiliary Power Unit (APU) ground run time
- Performance hold time
- SSME Liquid Oxygen (LO2) inlet temperature limit
- SSME High Pressure Oxidizer Turbopump (HPOTP) purge sequence 4 time limitation (continuous)
- Gaseous Oxygen (GO2) ullage pressurization generic certification hold time limit

These constraints are defined below. The actual hold time available will be the constraint that allows the shortest time.

A. LAUNCH WINDOW

Mission dependent.

B. APU GROUND RUN TIME

Cumulative APU ground run time without reservicing is 24 minutes maximum. This is based on APU fuel and Water Spray Boiler (WSB) water requirements for an Abort Once Around (AOA) to Edwards Air Force Base or White Sands with one APU failed. This becomes a prime hold time constraint only if previous scrubs have used much of the ground run time capability.

C. PERFORMANCE HOLD TIME AFTER START OF LO2 DRAINBACK

LO2 drainback is initiated at LO2 replenish termination (T-4 minutes, 55 seconds). Performance hold time available after the start of LO2 drainback will be computed by MOD based on the Day of launch Indicator Load Update (DOLILU) Operational Support System (DOSS) assessment of propellant load and given to the Mission Management Team (MMT) via the Flight Director.

D. SSME LO2 INLET TEMPERATURE LIMIT

The hold time available after start of LO2 drainback and before violation of the SSME inlet temperature limit is predicted in OMRSD S00E00.125; the actual criteria is defined in LCC MPS-25 (MPS Engine LO2 Inlet Temperature Anomaly).

E. SSME HPOTP PURGE SEQUENCE 4 TIME LIMITATION (CONTINUOUS)

The hold time available for engines after initiation of Purge Sequence Number (PSN) 4 (approximately T-4 minutes) will not exceed 26 minutes. This limit is to ensure that the HPOTP roller bearing outer race temperature does not exceed (warmer) 420 degrees Rankin (R) at engine start. The colder temperature maintains a pre-load between the rollers/race, thus preventing "skidding". This limit is based on a nominal issuance of the PSN4 command at T-3 minutes 59 seconds (total PSN4 time limitation of 30 minutes). If this hold time is exceeded, the engines shall be recycled to PSN3 for a minimum of sixty (60) minutes.

F. GO2 ULLAGE PRESSURE GENERIC CERTIFICATION HOLD TIME LIMIT

The hold time available after the start of LO2 drainback will not exceed 5.0 minutes for Super Light Weight Tank (SLWT) ETs with any Orbiter. This hold time was assumed in the generic certification analysis of ET GO2 four way swap fixed orifice pressurization system performance. ET LO2 tank ullage volume increases with hold duration because of LO2 drainback, and the rate at which GO2 ullage pressure decays following lift-off is inversely proportional to ullage volume. The maximum ullage volume generically certified assumed the use of the 100% sensors for replenish control, and the specific hold times after the start of LO2 drainback indicated above. The ET GO2 ullage pressure Interface Control Document (ICD) upper limit closely conforms to the maximum predicted ullage pressure from this analysis. Exceeding the hold time assumed could therefore result in violation of the upper ICD limit, and operation with undefined margins. Reference Program Requirements Control Board Directive (PRCBD) S052333CE.

1.3 REQUIREMENTS FOR RECOVERY FROM LO2/LIQUID HYDROGEN (LH2) FLOW INTERRUPTIONS OR OTHER CONTINGENCIES

The flow requirements, replenish time, and hold time capability following flow interruption or other contingencies depend on which condition exists:

- LO2 replenish flow interrupt without ET LO2 vent valve cycling.
- LO2 replenish flow interrupt with ET LO2 vent valve cycling initiated.
- Recovery into replenish from LO2 prepressurization.
- LO2 bleed flow interrupt.
- LH2 recirculation flow interrupt.

A. LO2 REPLENISH FLOW INTERRUPT WITHOUT ET LO2 VENT VALVE CYCLING

For requirements and predicted hold time capability following replenish interruption, see OMRSD S00E00.125. OMRSD Table S00E00.125 predicts the hold time to the SSME LO2 inlet temperature limit versus the time in stable replenish.

B. LO2 REPLENISH FLOW INTERRUPT WITH ET LO2 VENT VALVE CYCLING INITIATED

The minimum stable LO2 replenish time following an LO2 flow interruption in which ET LO2 vent valve cycling has been initiated is 50 minutes. (Reference DOLILU Operations Support Plan, National Space Transportation System (NSTS) 08329, Volume VIII).
Note: LO2 vent valve cycling is initiated as a result of LO2 liquid level falling below 98 percent. This minimum replenish time includes 20 minutes of stable replenish data followed by 30 minutes of data analysis prior to the Flight Director's "Go" for launch. The performance hold time is computed as described in the previous section. The hold time to the SSME LO2 inlet temperature limit is predicted in OMRSD S00E00.125.

C. RECOVERY INTO REPLENISH FROM LO2 PREPRESSURIZATION

The requirements for recovery into replenish from LO2 prepressurization are the same as those described in the above paragraph on vent valve cycling.

D. LO2 BLEED FLOW INTERRUPT

The SSME LO2 thermal conditioning requirements are defined in LCC MPS-24 (MPS LO2 Engine Inlet Temperature Anomaly - High).

E. LH2 RECIRCULATION FLOW INTERRUPT

The SSME LH2 thermal conditioning requirements are defined in LCC MPS-33 (Main Engine LH2 Recirculation Anomaly).

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SECTION 10

SOLID ROCKET MOTOR

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SECTION 10: SOLID ROCKET MOTOR

SSID No.	Description/Violation Call	Page
SRM-01	SRB Ignition Safe and Arm Safed Anomaly	10-01.1
SRM-02	SRB Ignition Safe and Arm Armed Anomaly	10-02.1
SRM-03	SRB Igniter PIC Cap Voltage Anomaly	10-03.1
SRM-04	SRM Chamber Pressure Anomaly	10-04.1
SRM-05	SRB Igniter PICs Properly Charged Anomaly	10-05.1
SRM-06	SRM Field Joint Temperature Anomaly	10-06.1
SRM-07	SRM Nozzle-To-Case Joint Temperature Anomaly	10-07.1
SRM-08	SRM Nozzle Flex Bearing Temperature (REQUIREMENT DELETED)	10-08.1
SRM-09	SRM Ignition Fire 2 Test Power ON Command Anomaly	10-09.1
SRM-10	SRM Igniter Joint Temperature Anomaly	10-10.1
SRM-11	SRM Case Acreage Temperature Anomaly	10-11.1

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LCC VIOLATION CALL: SRB Ignition Safe and Arm Safed Anomaly | EMERG COND: Yellow (3)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B55X1842X	LH Event Ign S&A Device Armed		OFF	NA	Event	CI
B55X2842X	RH Event Ign S&A Device Armed		OFF	NA	Event	CI
B55X1843X	LH Event Ign S&A Device Safed		ON	NA	Event	CI
B55X2843X	RH Event Ign S&A Device Safed		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Ignition S&A Device Arm Command ON (T-5 minutes)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(2) a. SSID Intent Summary - Each Reusable Solid Rocket Motor (RSRM) includes a sequential assembly of a pyrotechnic basket, an igniter initiator, and igniter to cause ignition of the motor propellant. A Safe-and-Arm (S&A) device is used to isolate the output of two SRM Ignition Initiators (SII) from the pyrotechnic basket and RSRM igniter initiator. This LCC is designed to ensure that the S&A device is in the SAFED position, physically blocking the output of each SII, thereby prohibiting unintentional ignition. Unintentional ignition is 1-fault tolerant since a stray current surge may cause an SII to fire.

b. Voting Logic - N/A

c. Redline Development - The redline is the indicated position of each switch when the S&A devices are in the SAFED configuration.

d. Time Period - The end of the LCC period coincides with the planned initiation of the arm command at T-5 minutes. At that time the S&A devices are rotated to the ARMED position.

e. Requirements - N/A

f. Preplanned Contingency - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(3) If the positional state of an S&A device is unknown it must be presumed ARMED. For an ARMED S&A device (presumed or indicated) there is the possibility of unintended ignition of an RSRM but multiple failures are required.

CAUSES OF EXCEEDING REDLINE:

(4) S&A device accidentally commanded to the ARMED position.
(5) S&A device failure.
(6) Instrumentation failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO JSC 11174	SHEET 10.2	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS72-948099	SHEET 24	ZONE B4

ELEMENT: RSRM SUBSYSTEM: RSRM

LCC VIOLATION CALL: SRB Ignition Safe and Arm Armed Anomaly | EMERG COND: Yellow (4)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B55X1842X	LH Event Ign S&A Device Armed		ON	NA	Event	CI
B55X2842X	RH Event Ign S&A Device Armed		ON	NA	Event	CI
B55X1843X	LH Event Ign S&A Device Safed		OFF	NA	Event	CI
B55X2843X	RH Event Ign S&A Device Safed		OFF	NA	Event	CI

TIME PERIOD:

(1) From Ten Seconds After Initiation of S&A Device Arm Command (approximately T-5 minutes) to SRM Ignition (T-0)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) Igniter heaters are turned off per OMRS S00FA0.980 prior to rotation of the Safe-and-Arm (S&A) devices to the ARMED position.

REDLINE DERIVATION: CRITICALITY: 1R

(3) a. SSID Intent Summary - Each Reusable Solid Rocket Motor (RSRM) includes a sequential assembly of a pyrotechnic basket, an igniter initiator, and igniter to cause ignition of the motor propellant. A S&A device is used to isolate the output of two SRM Ignition Initiators (SII) from the pyrotechnic basket and RSRM igniter initiator. This LCC is designed to ensure that the S&A device is in the ARMED position which allows the output from the each SII to pass into the RSRM igniter assembly for motor ignition. The system is 0-fault tolerant because the S&A device must be in the ARMED position for RSRM ignition to occur.

b. Voting Logic - N/A

c. Redline Development - The redline is the indicated position of each switch when the S&A devices are in the ARMED configuration.

d. Time Period - The beginning of the LCC period coincides with the verification that the S&A devices are in the ARMED position which occurs at 10 seconds after initiation of the arm command. The S&A devices must remain in the ARMED position until T-0 when the RSRM-FIRE command is given.

e. Requirements - N/A

f. Preplanned Contingency - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(4) If an S&A device is not armed there will be no ignition of that RSRM. If the positional state of an S&A device is unknown after the ARM command is given, the S&A device must be assumed to be not armed. An emergency condition exists if one S&A device is ARMED and the other is not or if the ARMED states are uncertain. Although multiple failures are required the possibility exists of igniting only one or neither RSRM leading to loss of vehicle.

CAUSES OF EXCEEDING REDLINE:

(5) Insufficient power reaching S&A device.
(6) S&A device failure.
(7) Instrumentation failure.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO JSC 11174 SHEET 10.2 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS72-948099 SHEET 24 ZONE B4

ELEMENT: RSRM SUBSYSTEM: RSRM

SRB Igniter PIC Cap Voltage Anomaly

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LCC VIOLATION CALL: SRM Chamber Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B47P1300C	LH Press A SRM Chamber		-7.0	33.0	psia	CI
B47P1301C	LH Press B SRM Chamber		-7.0	33.0	psia	CI
B47P1302C	LH Press C SRM Chamber		-7.0	33.0	psia	CI
B47P2300C	RH Press A SRM Chamber		-7.0	33.0	psia	CI
B47P2301C	RH Press B SRM Chamber		-7.0	33.0	psia	CI
B47P2302C	RH Press C SRM Chamber		-7.0	33.0	psia	CI

TIME PERIOD:

(1) From Completion of Chamber Pressure Simulation Test (Approximately T-1 hours, 30 minutes) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) For instrumentation readings within the LCC redlines but observed to be exhibiting non-steady or other off-nominal characteristics including exhibiting a step function then instrumentation failure is confirmed; LCC violation confirmed, No Go for launch.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) RSRM chamber pressure bias and calibration check is performed per OMRS S00FF0.180.

REDLINE DERIVATION: CRITICALITY: 1R

(4) a. SSID Intent Summary - The intent is to launch with full redundancy; six Operational Pressure Transducer (OPT) instruments that are functioning and providing reliable measurements for both Reusable Solid Rocket Motors (RSRM). The RSRM combustion chamber pressure is monitored by the General Purpose Computer (GPC) in the Orbiter beginning at T+100 seconds. The GPC initiates a series of events to cause SRB separation based on the mid-value-select voted chamber pressure. Voted chamber pressures for both motors must go below 50 psia within 5 seconds of each other to trigger the separation sequence with the pressure cue. The 50 psia value ensures that both motors fall away and to the aft of the Orbiter's trajectory thereby avoiding any damage to the Orbiter.

The Backup Flight System (BFS) software uses the OPT measurements as a redundant method to determine when liftoff has occurred. If the mid-value-selected chamber pressure is greater than 50 psi on either motor, the BFS will transition to Major Mode 102 for powered ascent.

REDLINE DERIVATION: (Continued)

The system is 1-fault tolerant because 2 OPTs on the same motor must fail in the same direction (high or low) to cause loss of the separation pressure cue. Prior to launch, the same fault tolerance for OPTs failing high is applicable to the possible loss of the BFS for powered ascent.

b. Voting Logic - N/A

c. Redline Development - The basic redline is normal atmospheric pressure at the launch site with instrument error added algebraically and translated to the calibration used in the Launch Processing System (LPS). The procedure is performed for both minimum and maximum values. This redline is designed to ensure that the transducers and monitor circuits in the orbiter are functional.

c.1 Redline calculation:	Minimum	Maximum
Ambient Pressure	14.7 psia	14.7 psia
Allowable OPT bias	-10.0 psia	30.0 psia
KSC LPS offset	-11.3 psia	-11.3 psia
Redline (rounded)	-7.0 psia	33.0 psia

d. Time Period - The LCC expiration time of T-31 seconds was chosen to ensure all OPTs are functional as late as practical in the count. The likelihood of failure was deemed to be no more probable from T-31 seconds to T-0 than after T-0.

e. Requirements - Erratic behavior signifying probable instrumentation failure but reading within the LCC redlines indicates an unacceptable loss of full redundancy.

f. Preplanned Contingency - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Loss of primary SRB/ET separation cue and RSRM nozzle vector limiting criteria (multiple failures). Without the primary pressure cue, the separation sequence is initiated by the mission-elapsed-timer (normally at 131.28 seconds) which may result in an Abort-to-Orbit and loss of Primary Mission Objectives.

(6) Early separation due to 2 OPTs on each motor failing low before T+100 seconds (4 independent failures) could cause loss of vehicle.

(7) Loss of BFS (multiple failures). Failure of two or more OPTs greater than 50 psi on either motor prior to launch may cause a premature BFS software transition to Major Mode 102. If this occurs prior to all three Shuttle Main Engines achieving 30% thrust the BFS will incorrectly confirm Main Engine Cutoff resulting in loss of the BFS for guidance and control functions during powered ascent (Major Modes 102, 103, and 601). These multiple failures would also cause the loss of some fault monitoring of critical orbiter systems performed by BFS as well as loss of the primary separation cue (5).

CAUSES OF EXCEEDING REDLINE:

(8) Chamber pressure monitor circuits failure.
(9) Chamber pressure transducer failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1 for left booster, 2 for right booster									
UNITS-->	psia								
B47Pn300C	1.998	-11.33	987.6						
B47Pn301C	1.998	-11.33	987.6						
B47Pn302C	1.998	-11.33	987.6						

METER/DISPLAY RANGE - MSID: LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO JSC 11174 SHEET 10.2 ZONE S7
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS72-948099 SHEET 24 ZONE B4

ELEMENT: RSRM SUBSYSTEM: RSRM

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SRB Igniter PICs Properly Charged Anomaly

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LCC VIOLATION CALL: SRM Field Joint Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	LH Fwd Joint Temps					
B06T7060A	Pri LH SRB Sta 851.5/15 Temp		86	123	deg F	CI
B06T7160A	Sec LH SRB Sta 851.5/15 Temp		86	123	deg F	CI
B06T7061A	Pri LH SRB Sta 851.5/135 Temp		86	123	deg F	CI
B06T7161A	Sec LH SRB Sta 851.5/135 Temp		86	123	deg F	CI
B06T7062A	Pri LH SRB Sta 851.5/195 Temp		86	123	deg F	CI
B06T7162A	Sec LH SRB Sta 851.5/195 Temp		86	123	deg F	CI
B06T7063A	Pri LH SRB Sta 851.5/285 Temp	(4)	86	123	deg F	CI
B06T7163A	Sec LH SRB Sta 851.5/285 Temp	(4)	86	123	deg F	CI
	LH Center Joint Temps					
B06T7064A	Pri LH SRB Sta 1171.5/15 Temp		86	123	deg F	CI
B06T7164A	Sec LH SRB Sta 1171.5/15 Temp		86	123	deg F	CI
B06T7065A	Pri LH SRB Sta 1171.5/135 Temp		86	123	deg F	CI
B06T7165A	Sec LH SRB Sta 1171.5/135 Temp		86	123	deg F	CI
B06T7066A	Pri LH SRB Sta 1171.5/195 Temp		86	123	deg F	CI
B06T7166A	Sec LH SRB Sta 1171.5/195 Temp		86	123	deg F	CI
B06T7067A	Pri LH SRB Sta 1171.5/285 Temp	(4)	86	123	deg F	CI
B06T7167A	Sec LH SRB Sta 1171.5/285 Temp	(4)	86	123	deg F	CI
	LH Aft Joint Temps					
B06T7068A	Pri LH SRB Sta 1491.5/15 Temp		86	123	deg F	CI
B06T7168A	Sec LH SRB Sta 1491.5/15 Temp		86	123	deg F	CI
B06T7069A	Pri LH SRB Sta 1491.5/135 Temp		86	123	deg F	CI
B06T7169A	Sec LH SRB Sta 1491.5/135 Temp		86	123	deg F	CI
B06T7070A	Pri LH SRB Sta 1491.5/195 Temp		86	123	deg F	CI
B06T7170A	Sec LH SRB Sta 1491.5/195 Temp		86	123	deg F	CI
B06T7071A	Pri LH SRB Sta 1491.5/285 Temp	(4)	86	123	deg F	CI
B06T7171A	Sec LH SRB Sta 1491.5/285 Temp	(4)	86	123	deg F	CI
	RH Fwd Joint Temps					
B06T8060A	Pri RH SRB Sta 851.5/15 Temp		86	123	deg F	CI
B06T8160A	Sec RH SRB Sta 851.5/15 Temp		86	123	deg F	CI
B06T8061A	Pri RH SRB Sta 851.5/135 Temp		86	123	deg F	CI
B06T8161A	Sec RH SRB Sta 851.5/135 Temp		86	123	deg F	CI
B06T8062A	Pri RH SRB Sta 851.5/195 Temp		86	123	deg F	CI
B06T8162A	Sec RH SRB Sta 851.5/195 Temp		86	123	deg F	CI
B06T8063A	Pri RH SRB Sta 851.5/285 Temp	(4)	86	123	deg F	CI
B06T8163A	Sec RH SRB Sta 851.5/285 Temp	(4)	86	123	deg F	CI
	RH Center Joint Temps					
B06T8064A	Pri RH SRB Sta 1171.5/15 Temp		86	123	deg F	CI
B06T8164A	Sec RH SRB Sta 1171.5/15 Temp		86	123	deg F	CI
B06T8065A	Pri RH SRB Sta 1171.5/135 Temp		86	123	deg F	CI
B06T8165A	Sec RH SRB Sta 1171.5/135 Temp		86	123	deg F	CI
B06T8066A	Pri RH SRB Sta 1171.5/195 Temp		86	123	deg F	CI
B06T8166A	Sec RH SRB Sta 1171.5/195 Temp		86	123	deg F	CI

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B06T8067A	Pri RH SRB Sta 1171.5/285 Temp	(4)	86	123	deg F	CI
B06T8167A	Sec RH SRB Sta 1171.5/285 Temp	(4)	86	123	deg F	CI
	RH Aft Joint Temps					
B06T8068A	Pri RH SRB Sta 1491.5/15 Temp		86	123	deg F	CI
B06T8168A	Sec RH SRB Sta 1491.5/15 Temp		86	123	deg F	CI
B06T8069A	Pri RH SRB Sta 1491.5/135 Temp		86	123	deg F	CI
B06T8169A	Sec RH SRB Sta 1491.5/135 Temp		86	123	deg F	CI
B06T8070A	Pri RH SRB Sta 1491.5/195 Temp		86	123	deg F	CI
B06T8170A	Sec RH SRB Sta 1491.5/195 Temp		86	123	deg F	CI
B06T8071A	Pri RH SRB Sta 1491.5/285 Temp	(4)	86	123	deg F	CI
B06T8171A	Sec RH SRB Sta 1491.5/285 Temp	(4)	86	123	deg F	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For APU Start (T-5 minutes)
(2) When using As-Built temperatures only - From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds). (6)

REQUIREMENTS: FIGURES/TABLES:

(3) In the event of confirmed instrumentation failure(s), the minimum configuration for each field joint is 1 of the 2 measurements must be functional for 2 of the 4 sensor locations on that joint. (5)
(4) In the event of confirmed instrumentation failures on multiple field joints, the minimum configuration must include 1 functional measurement at the 285-degree location on 2 of the 3 field joints on each motor. (5)

PREPLANNED CONTINGENCY PROCEDURE:

(5) If a measurement indicates off scale high or off scale low, exhibits a step function change, known bias, or erratic behavior, then instrumentation failure is confirmed. If minimum functional measurement requirements are satisfied then LCC violation cleared, continue countdown.
(6) In the event the minimum redline is violated for reasons other than confirmed instrumentation failure, revise minimum LCC redline based on as-built hardware limits consistent with the temperature data for the affected field joint, presented at the Flight Readiness Review (FRR). In addition, revise the LCC time period to expire at T-31 seconds. For field joint temperatures above the revised minimum limit, LCC violation cleared, continue countdown.

NOTES:

(7) There are 4 platinum Resistance Temperature Detector (RTD) sensors on each case segment field joint (fwd, ctr, and aft), 12 per Reusable Solid Rocket Motor (RSRM). Output from each sensor is connected to a Programmable Logic Controller (PLC) signal conditioner input. The signal from each sensor is retransmitted by the PLC from a voltage output channel and split to form two measurements per sensor. Each measurement is connected to the data collection system via a different Hardware Interface Module (HIM) card.

NOTES: (Continued)

(8) Heaters are enabled at T-8 hours and remain operational until T-1 minute.

REDLINE DERIVATION: CRITICALITY: 1R

(9) a. SSID Intent Summary - The segmented RSRM combustion chamber is sealed at the three field joints by O-rings. These O-rings must be thermally conditioned to have the resiliency required to provide a dynamic joint seal for the joint at RSRM ignition. The minimum O-ring temperature required is based on the squeeze of the O-ring and the rate of gap opening due to pressurization of the combustion chamber. The maximum O-ring temperature is to prevent permanent deformation of the O-ring while compressed in the mated joint. The joints are essentially two-fault tolerant. Failure to contain combustion chamber gasses would require failure of the internal thermal protection system, the primary joint seal, and the secondary joint seal. While the internal thermal protection system is not considered a seal and cannot be verified as such, it does prevent combustion chamber gasses from entering the joint.

b. Voting Logic - N/A

c. Minimum and/or Maximum Redline Development - The basic redline is the generic minimum seal temperature and has been selected using the worst-case tolerance stack up of sealing surfaces, standard repair allowances, O-ring diameter, gap opening, and pressurization rate. Instrumentation error and several independent sources of thermal variation are combined using Root of the Sum of Squares (RSS) and added to the minimum seal temperatures to establish the minimum redlines. The maximum seal temperature is the highest temperature at which no permanent deformation will occur while under the worst-case compression of a mated joint. Applicable instrumentation error and independent thermal variations are combined using the RSS method and subtracted from the maximum seal temperature to obtain the maximum redline. Instrumentation error is the RSS of instrument component errors including a cable-induced error that results from the variation in resistance of the 3-wire circuit from one motor set to another.

c.1 Redline Calculation:

		Min		Max
Basic Redline (deg F)		81.0		130.0
O-ring/RTD differential (deg F)	+3.0		-1.0	
One minute cool down (deg F)	+0.7		NA	
Circumferential joint temp. (deg F)	+2.8		-6.7	
Heater gap depression (deg F)	+2.7		NA	
Instrumentation error (deg F)	+2.31		-2.31	
RSS total errors (deg F)		+5.47		-7.16
Redline (deg F) (Rounded)		86.0		123.0

c.2 Instrumentation error development:

Sensor (RTD) error (deg F)	+/- 0.50
Cable resistance variation (deg F)	+/- 1.86
Signal Conditioner PLC input (deg F)	+/- 1.15

REDLINE DERIVATION: (Continued)

PLC output (deg F)	+/- 0.25
LPS (deg F)	+/- 0.50
RSS instrumentation error	+/- 2.31

d. Time Period - The LCC expiration time of T-5 minutes was chosen due to the fact that technical factors following resumption of the count at T-5 minutes limits the time remaining to launch. In the event of field joint heater failure after the T-5 minute mark, it is possible that the joint temperatures will violate the generic LCC lower limit but unlikely to violate the as-built LCC limits prior to T-0. This is true even with a hold at T-31 seconds since that hold time is limited by these technical constraints.

   In the event that as-built contingency temperature limits are implemented via Preplanned Contingency Procedure, the expiration of this LCC will be T-31 seconds. This is due to the fact that the as-built temperature requirements are derived such that all margins are reduced to bare minimums. With minimum margins and no built-in cooldown, the temperature of the joint must be monitored as long as practical.

e. Requirements - The requirements for continuation with failed instrumentation are written to reflect the instrumentation design where each sensor location has a single sensor with its signal split to provide two independent measurements in the LPS data system. In the event of a failure of either measurement, the remaining measurement can be used for LCC verification. In the event of a failed sensor, both measurements will fail. Combining these two forms of instrumentation failure, it is acceptable to verify LCC compliance if at least one measurement is functional and within limits for at least two sensor locations per joint. This is true for all three joints per motor with the added constraint that two of the three inboard sensor locations (285 degree location) must be represented by a functioning measurement.

f. Preplanned Contingency Procedures - The basic redline is calculated using a worst on worst tolerance stack-up of the generic design requirements. As each RSRM is assembled, actual hardware dimensions are obtained. These "as built" measurements are used to calculate minimum seal temperature requirements for each joint. A 3.63 deg F margin (rounded to 4) is added to the minimum seal temperature to account for instrumentation error and possible thermal differences between the sensor and the seal to obtain the as-built LCC temperature. This 4 deg F margin is derived by eliminating the O-ring/RTD deferential and the heater gap depression from the redline derivation table shown in C.1. Both of these values are driven by joint heater operation, and become negligible in the event of heater failure. In the event that the heater fails after a period of operation, the O-ring would be warmer than the RTD for a period of time, thus the O-ring/RTD differential would be beneficial but is neglected in favor of conservatism. In addition, the one minute cooldown is eliminated because the rate of cooling is dependent upon the time of T-0 relative

REDLINE DERIVATION: (Continued)

to the heater failure. This rate can only be estimated in real time. Since these margins are reduced to bare minimums, and do not include cooling for possible hold times, it is necessary to monitor the joint temperatures down to T-31 seconds. The contingency LCC temperature for all joints are compiled and published in the FRR and provided to appropriate members of the launch team prior to start of countdown.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Field joint O-ring seals will not meet the required seal tracking safety factor at temperatures outside this range. Failure of the joint seals to contain combustion gasses would cause an RSRM case failure. The resulting jet of combustion products, if directed inboard, could cause catastrophic failure of the external tank and/or orbiter.

CAUSES OF EXCEEDING REDLINE:

(11) Cold ambient air temperature.
(12) Proximity to Cryogenic material.
(13) Instrumentation failure.
(14) Heater failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 7 for left booster, 8 for right booster									
UNITS-->	deg.F								
B06Tn060A	0.50	10.2	135.2						
B06Tn061A	0.50	10.2	135.2						
B06Tn062A	0.50	10.2	135.2						
B06Tn063A	0.50	10.2	135.2						
B06Tn064A	0.50	10.2	135.2						
B06Tn065A	0.50	10.2	135.2						
B06Tn066A	0.50	10.2	135.2						
B06Tn067A	0.50	10.2	135.2						
B06Tn068A	0.50	10.2	135.2						
B06Tn069A	0.50	10.2	135.2						
B06Tn070A	0.50	10.2	135.2						
B06Tn071A	0.50	10.2	135.2						
B06Tn160A	0.50	10.2	135.2						
B06Tn161A	0.50	10.2	135.2						
B06Tn162A	0.50	10.2	135.2						
B06Tn163A	0.50	10.2	135.2						
B06Tn164A	0.50	10.2	135.2						
B06Tn165A	0.50	10.2	135.2						
B06Tn166A	0.50	10.2	135.2						
B06Tn167A	0.50	10.2	135.2						
B06Tn168A	0.50	10.2	135.2						
B06Tn169A	0.50	10.2	135.2						
B06Tn170A	0.50	10.2	135.2						
B06Tn171A	0.50	10.2	135.2						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: RSRM SUBSYSTEM: RSRM

LCC VIOLATION CALL: SRM Nozzle-To-Case Joint Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	LH Nozzle-to-Case-Joint Temps					
B06T7091A	Pri LH SRB Sta 1876.6/50 Temp	(3,4)	75	115	deg F	CI
B06T7191A	Sec LH SRB Sta 1876.6/50 Temp	(3,4)	75	115	deg F	CI
B06T7092A	Pri LH SRB Sta 1876.6/130 Temp	(3,4)	75	115	deg F	CI
B06T7192A	Sec LH SRB Sta 1876.6/130 Temp	(3,4)	75	115	deg F	CI
B06T7093A	Pri LH SRB Sta 1876.6/270 Temp	(3,4)	75	115	deg F	CI
B06T7193A	Sec LH SRB Sta 1876.6/270 Temp	(3,4)	75	115	deg F	CI
	RH Nozzle-to-Case-Joint Temps					
B06T8091A	Pri RH SRB Sta 1876.6/50 Temp	(3,4)	75	115	deg F	CI
B06T8191A	Sec RH SRB Sta 1876.6/50 Temp	(3,4)	75	115	deg F	CI
B06T8092A	Pri RH SRB Sta 1876.6/130 Temp	(3,4)	75	115	deg F	CI
B06T8192A	Sec RH SRB Sta 1876.6/130 Temp	(3,4)	75	115	deg F	CI
B06T8093A	Pri RH SRB Sta 1876.6/270 Temp	(3,4)	75	115	deg F	CI
B06T8193A	Sec RH SRB Sta 1876.6/270 Temp	(3,4)	75	115	deg F	CI
	LH Flex Bearing Aft End Ring					
B06T7087A	Pri LH SRB Sta 1847/50 Temp	(6)	78	115	deg F	BU
B06T7088A	Pri LH SRB Sta 1847/130 Temp	(6)	78	115	deg F	BU
B06T7089A	Pri LH SRB Sta 1847/230 Temp	(6)	78	115	deg F	BU
B06T7090A	Pri LH SRB Sta 1847/310 Temp	(6)	78	115	deg F	BU
	RH Flex Bearing Aft End Ring					
B06T8087A	Pri RH SRB Sta 1847/50 Temp	(6)	78	115	deg F	BU
B06T8088A	Pri RH SRB Sta 1847/130 Temp	(6)	78	115	deg F	BU
B06T8089A	Pri RH SRB Sta 1847/230 Temp	(6)	78	115	deg F	BU
B06T8090A	Pri RH SRB Sta 1847/310 Temp	(6)	78	115	deg F	BU

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for APU Start (T-5 minutes)
(2) For the use of As-Built temperatures only - From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds). (7)

REQUIREMENTS: FIGURES/TABLES:

(3) 5 of 6 individual measurements within limits on each motor is acceptable for verification of nozzle-to-case joint temperature compliance.
(4) In the event of multiple confirmed instrumentation failures on a single motor, the minimum instrumentation configuration for verification of LCC compliance is 1 of 2 measurements functional for 2 of the 3 nozzle-to-case joint sensor locations. (5,6)

PREPLANNED CONTINGENCY PROCEDURE:

(5) If a measurement indicates off scale high or off scale low, exhibits a step function change, known bias, or erratic behavior, then instrumentation failure is confirmed. If the minimum instrumentation configuration (4) is met, and all functional measurements are within limits, LCC violation cleared, continue countdown.

(6) In the event that the minimum instrumentation configuration cannot be satisfied using nozzle-to-case instrumentation, the following flex bearing aft end ring sensors may be selected to verify LCC compliance:

Failed Meas. No.	Substitute	Description
B06T7m91A	B06T7087A	Pri LH SRB Sta 1847/50 Temp
B06T7m92A	B06T7088A	Pri LH SRB Sta 1847/130 Temp
B06T7m93A	B06T7089A	Pri LH SRB Sta 1847/230 Temp
	OR	
	B06T7090A	Pri LH SRB Sta 1847/310 Temp
B06T8m91A	B06T8087A	Pri RH SRB Sta 1847/50 Temp
B06T8m92A	B06T8088A	Pri RH SRB Sta 1847/130 Temp
B06T8m93A	B06T8089A	Pri RH SRB Sta 1847/230 Temp
	OR	
	B06T8090A	Pri RH SRB Sta 1847/310 Temp

m = 0 for primary; 1 for secondary

If the minimum instrumentation configuration is met using the backup measurements, and all selected measurements are within limits, LCC violation cleared, continue countdown.

(7) In the event the minimum redline is violated for reasons other than confirmed instrumentation failure, revise minimum LCC redline based on as-built hardware consistent with the temperature data presented at the Flight Readiness Review (FRR). In addition, revise the time period to expire at T-31 seconds. For nozzle-to-case joint temperatures above the revised limit, LCC violation cleared, continue countdown.

NOTES:

(8) There are 3 platinum Resistance Temperature Detector (RTD) sensors per Reusable Solid Rocket Motor (RSRM) nozzle-to-case joint and 4 RTD sensors on each RSRM flex bearing. Output from each sensor is connected to a Programmable Logic Controller (PLC) signal conditioner input. The signal from each sensor is retransmitted by the PLC from a voltage output channel and split to form two measurements per sensor. Each measurement is connected to the data collection system via a different Hardware Interface Module (HIM) card.

REDLINE DERIVATION: CRITICALITY: 1R

(9) a. SSID Intent Summary - The segmented RSRM combustion chamber is sealed at the nozzle-to-case joint by O-rings. These seals must be thermally conditioned to assure the resiliency required to provide a dynamic joint seal for the nozzle-to-case joint at RSRM ignition. The minimum seal temperature requirement is based on the squeeze of the O-ring and the rate of gap opening due to pressurization of the combustion chamber, and assures a 2.0 tracking safety factor based on worst-case tolerances. The maximum seal temperature is imposed to prevent permanent deformation of the O-ring while compressed in the mated joint, and ensures thermal conditioning of the nozzle does not degrade nozzle phenolic bondline adhesive strength. The nozzle to case joint is essentially two-fault tolerant. Failure to contain combustion chamber gasses would require failure of the internal thermal protection system, the primary joint seal, and the secondary joint seal. While the internal thermal protection system is not considered a seal and cannot be verified as such, it does prevent combustion chamber gasses from entering the joint.

b. Voting Logic - The requirement for 5 of the 6 measurements on a joint to be within limits ensures a safe launch after a single measurement has gone out of limit by reason of instrumentation failure, instrumentation bias or temperature excursion. The 5 of 6 philosophy is based on empirical data review and model analysis indicating minimal circumferential variation and limited primary-secondary differences once steady-state condition is achieved within the nozzle cavity. Confirmation of instrumentation failure is not required for the first measurement that goes out of limit; however, continuation with additional measurements out of limit requires confirmation that the condition is due to instrumentation failure.

c. Minimum and Maximum Redline Development - The basic minimum constraint is the generic minimum seal temperature and has been selected using the worst-case tolerance stack up of sealing surfaces, standard repair allowances, O-ring diameter, gap opening, and pressurization rate. Instrumentation error and several independent sources of thermal variation are combined using Root of the Sum of Squares (RSS) and the result added to the minimum seal temperature to establish the minimum redline. The maximum seal temperature is the highest temperature at which no permanent deformation will occur while under the worst-case compression of a mated joint. Instrumentation error and independent thermal variations are combined using the RSS method and subtracted from the maximum seal temperature to obtain the maximum redline.

The minimum redline for the Flex Bearing measurements is 3 deg F greater than the redline for the nozzle-to-case joint sensors to allow for the temperature differential between the seal and the sensor. The value of 3 deg F was determined by a thermal analysis of the GN2 aft skirt purge affect on nozzle components including verification with empirical data. The maximum redline remains at 115 deg F, since the bondlines being protected are adjacent to the flex bearing cavity and the temperature differential is not required.

REDLINE DERIVATION: (Continued)

Instrumentation error is the RSS of instrument component errors including a cable-induced error that results from the variation in the resistance of the 3-wire circuit from one motor set to another. A review of historical data indicated that two measurements from a single sensor have rarely differed by and never more than 3 bits of digital resolution. For the specified instrument range, 4 bits (2 deg F) are incorporated into the margin for instrumentation error as "Primary-Secondary Deviation".

c.1 Redline Calculation:

	Nozzle-to-Case Joint Min	Nozzle-to-Case Joint Max	Flex Bearing Min
Basic redline (deg F)	72.0	118.0	72.0
O-ring/RTD differential (deg F)	+0.0	0.0	+3.0
Circumferential joint temp. (deg F)	+0.0	0.0	0.0
Instrumentation error (deg F)	+3.0	-3.0	+3.0
Redline (deg F)	75.0	115.0	78.0

c.2 Instrumentation Error Calculation:

Sensor Error (deg F)	+/-0.50
Cable Resistance Variation (deg F)	+/-1.23
Signal Conditioner PLC input (deg F)	+/-1.15
PLC output (deg F)	+/-0.25
LPS (deg F)	+/-0.50
Primary-Secondary Deviation (deg F)	+/-2.00
RSS Instrumentation Error (deg F)	+/-2.72 --> +/-3.0

d. Time Period - The LCC expiration time of T-5 minutes was chosen due to the fact that technical factors following resumption of the count at T-5 minutes limits the time remaining to launch. In practice, the Aft Skirt GN2 Purge system will have conditioned the aft skirt environment starting early in the countdown if heating is necessary. A high GN2 flow rate is established at T-15 minutes for the purpose of removing hazardous gasses from the nozzle cavity prior to launch. Since this high flow rate continues until launch, a failure of the GN2 heater after T-5 minutes would cause cold gas to fill the nozzle cavity. In this condition, it is possible that the joint temperatures will violate the generic LCC lower limit but it is unlikely that the contingency LCC temperature limits would be violated prior to T-0. This is true even with an extended hold at T-31 seconds since that hold is limited by the orbiter APU run time and other time constraining factors. In the event that as-built contingency LCC temperatures are implemented via preplanned contingency procedure, the expiration of this LCC will be moved from T-5 minutes to T-31 seconds since the contingency margins are reduced to bare minimums and do not include cooling for possible hold times.

e. Requirements - Requirement (3) allows continuation without any action after a single measurement per RSRM violates the LCC limits. The

REDLINE DERIVATION: (Continued)

rational for this is discussed in the voting logic section above. Continuation of the count with additional violations is contingent upon the verification that the violation(s) are due to instrumentation failure and not actual temperature departures from the established limits.

For continuation with failed instrumentation requirement (4) is written to reflect the instrumentation design where each sensor location has a single sensor with its signal split to provide two independent measurements in the LPS data system. In the event of a failure of either measurement, the remaining measurement can be used for LCC verification. In the event of a failed sensor, both measurements will fail. Combining these two forms of instrumentation failure, it is acceptable to verify LCC compliance if at least one measurement is functional and within limits for at least two of the three sensor locations for the joint.

f. Preplanned Contingency Procedures - Flex bearing temperature measurements may be used as backup measurements for verification of LCC compliance in the event of multiple instrumentation failures at more than one of the three nozzle-to-case sensor locations per joint. An additional margin of 3 deg F is added to the lower limit to compensate for the distance between the nozzle-to-case joint and the flex bearing and the fact that the flex bearing cavity is normally a warmer environment.

The basic redline is calculated using a worst on worst tolerance stack up of the generic design requirements. As each RSRM is assembled, actual hardware dimensions are obtained. These "as built" measurements are used to calculate minimum seal temperature requirements for each joint. A 3 deg F margin is added to the minimum seal temperature to account for instrumentation error to obtain the as-built contingency LCC temperature.

Since the contingency margins are reduced to bare minimums and do not include cooling for possible hold times, it is necessary to monitor the temperatures down to T-31 seconds. The as-built contingency LCC temperatures for all joints are compiled and published in the FRR and provided to appropriate members of the launch team prior to start of the countdown.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Nozzle-to-case joint O-ring seals will not meet the required seal tracking safety factor below the minimum required temperature. Failure of the joint seals to contain combustion gasses would cause an RSRM case or nozzle failure resulting in loss of thrust and/or loss of thrust vector control.
(11) Adhesive temperatures above the maximum redline may result in loss of redundancy in nozzle phenolic bondlines.

CAUSES OF EXCEEDING REDLINE:

(12) Extreme ambient air temperature.
(13) Cryogenic leakage.
(14) Instrumentation failure.
(15) Aft skirt heated GN2 purge failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 7 for left , 8 for right		m = 0 for primary, 1 for secondary							
UNITS-->	deg.F								
B06Tnm91A	0.5	10.2	135.2						
B06Tnm92A	0.5	10.2	135.2						
B06Tnm93A	0.5	10.2	135.2						
B06Tn087A	0.5	10.2	135.2						
B06Tn088A	0.5	10.2	135.2						
B06Tn089A	0.5	10.2	135.2						
B06Tn090A	0.5	10.2	135.2						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: RSRM SUBSYSTEM: RSRM

SRM Nozzle Flex Bearing Temperature

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SRM Ignition Fire 2 Test Power ON Command Anomaly

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LCC VIOLATION CALL: SRM Igniter Joint Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	LH Igniter Temperatures					
B06T7085A	PRI LH SRB IGN 484.2/185 TEMP		74	125	deg F	CI
B06T7185A	SEC LH SRB IGN 484.2/185 TEMP		74	125	deg F	CI
B06T7086A	PRI LH SRB IGN 484.2/356 TEMP		74	125	deg F	CI
B06T7186A	SEC LH SRB IGN 484.2/356 TEMP		74	125	deg F	CI
	RH Igniter Temperatures					
B06T8085A	PRI RH SRB IGN 484.2/356 TEMP		74	125	deg F	CI
B06T8185A	SEC RH SRB IGN 484.2/356 TEMP		74	125	deg F	CI
B06T8086A	PRI RH SRB IGN 484.2/185 TEMP		74	125	deg F	CI
B06T8186A	SEC RH SRB IGN 484.2/185 TEMP		74	125	deg F	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for APU Start (T-5 minutes)
(2) For the use of as-built contingency temperatures only - From Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds) (6)

REQUIREMENTS: FIGURES/TABLES:

(3) In the event of confirmed instrumentation failure, the minimum configuration for verification of LCC compliance is at least one functional measurement per motor. (4)

PREPLANNED CONTINGENCY PROCEDURE:

(4) If a measurement indicates off scale high or off scale low, exhibits a step function change, known bias, or erratic behavior, then instrumentation error is confirmed. If minimum functional measurement requirements are satisfied then LCC violation cleared, continue countdown.
(5) In the event the minimum redline is violated as a result of an extended hold between T-9 and T-5 minutes, the heaters will be reactivated to maintain temperatures between the LCC limits. After temperatures have returned to within redline limits, LCC violation cleared, continue countdown.
(6) In the event the minimum redline is violated for reasons other than confirmed instrumentation failure, revise the minimum redline based on as-built hardware limits consistent with the igniter joint temperature data presented at the Flight Readiness Review (FRR). In addition, revise the time period to expire at T-31 seconds. For igniter joint temperatures above the revised minimum limit, LCC violation cleared, continue countdown.

NOTES:

(7) There are 2 platinum Resistance Temperature Detector (RTD) sensors per Reusable Solid Rocket Motor (RSRM) Igniter Joint. Output from each sensor is connected to a Programmable Logic Controller (PLC) signal conditioner

NOTES: (Continued)

input. The signal from each sensor is retransmitted by the PLC from a voltage output channel and split to form two measurements per sensor. Each measurement is connected to the data collection system via a different Hardware Interface Module (HIM) card.

(8) Heaters are activated at approximately T-11 hours and remain operational until their deactivation just prior to T-9 minutes. (Ref. OMRSD S00FA0.620, 960 and 980)

(9) For an extended hold between T-9 and T-5 minutes the heaters may be reactivated per OMRSD S00E00.742 to maintain igniter temperatures. If heaters are reactivated, they will be deactivated prior to SRB Ignition S&A rotation per OMRSD S00FA0.980.

REDLINE DERIVATION: CRITICALITY: 1R

(10) a. SSID Intent Summary - The RSRM igniter assembly includes inner and outer bolted joint compound-gasket seals and packing-with-retainer seals at the bolts. The compound-gasket consists of a metal retainer and four elastomeric seals. These seals must be thermally conditioned to have the resiliency required to provide a dynamic seal for the joint at RSRM ignition. This LCC is designed to protect the inner gasket seal because the inner seal of the inner gasket opens at ignition. The minimum seal temperature requirement is based on the compression of the gasket and the rate of gap opening due to pressurization of the igniter (2159 psia) for the interim-design hardware. The maximum seal temperature is to prevent permanent deformation of the gasket while compressed in the mated joint. Exceeding the maximum seal temperature for significant periods of time may require the replacement of the igniter assembly. The joints are essentially 2-fault tolerant. Failure to contain igniter chamber gasses would require failure of the internal thermal protection system, the primary joint seal, and the packing-with-retainer seal. While the internal thermal protection system is not considered a seal and cannot be verified as such, it does prevent combustion gasses from entering the joint.

b. Voting Logic - N/A

c. Minimum and/or Maximum Redline Development - The basic redline is the generic minimum seal temperature using the worst-case tolerance stack up of sealing surfaces, standard repair allowances, gasket thickness, gap opening, and pressurization rate. Instrumentation error and several independent sources of thermal variation are combined using Root of the Sum of Squares (RSS) and added to the minimum seal temperatures to establish the minimum redlines. The maximum seal temperature is the highest temperature at which no permanent deformation will occur while under the worst-case compression of a mated joint. Applicable instrumentation error and independent thermal variations are combined using the RSS method and subtracted from the maximum seal temperature to obtain the maximum redline. Instrumentation error is the RSS of instrument component errors including a cable-induced error that results from the variation in resistance of the 3-wire circuit from one motor set to another.

REDLINE DERIVATION: (Continued)

c.1 Redline Calculation:

		Min		Max
Basic Redline (deg F)		70.0		130.0
Seal/RTD differential (deg F)	+3.1		-4.5	
Circumferential joint temp (deg F)	+0.2		-0.2	
Instrumentation error (deg F)	+3.05		-3.05	
RSS total errors (deg F)		+4.35		-5.44
Redline (deg F) (rounded)		74.0		125.0

c.2 Instrumentation error development:

Sensor (RTD) error (deg F)	+/- 0.50
Cable resistance variation (deg F)	+/- 2.72
Signal Conditioner PLC input (deg F)	+/- 1.15
PLC output (deg F)	+/- 0.25
LPS (deg F)	+/- 0.50
RSS instrumentation error (deg F)	+/- 3.05

d. Time Period - The LCC expiration time of T-5 minutes was chosen due to the fact that technical factors following resumption of the count at T-5 minutes limits the time remaining to launch. In the event of igniter joint heater failure prior to normal heater shutoff, it is possible that the joint temperatures could violate the generic LCC lower limit after T-5 minutes but then it would be highly unlikely to violate the contingency LCC limits prior to T-0. This is true even with a hold at T-31 seconds since that hold time is limited by these technical constraints. If there is a violation of the generic LCC limit prior to T-5, the period of effectivity is extended to T-31 seconds to protect the hardware from a violation of the as-built contingency limit.

e. Requirements - Specifies the minimum configuration necessary to confirm LCC compliance.

f. Preplanned Contingency Procedure - The basic redline for the contingency temperature is calculated using a worst on worst tolerance stack-up of the as-built baseline-design hardware. Instrumentation error and circumferential joint temperature margin are combined using RSS to yield a margin of 3 deg F which is added to the basic contingency redline.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) The S&A and Igniter Joint seals will not meet the required seal tracking factor of safety at temperatures outside this range. Failure of the joint seals to contain combustion gases would cause RSRM case failure. The resulting jet of hot gases would be directed into the forward skirt and could cause loss of vehicle.

CAUSES OF EXCEEDING REDLINE:

(12) Cold ambient air temperature.
(13) Instrumentation failure.
(14) Heater failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 7 for left booster, 8 for right booster									
UNITS-->	deg.F								
B06Tn085A	0.50	10.2	135.2						
B06Tn185A	0.50	10.2	135.2						
B06Tn086A	0.50	10.2	135.2						
B06Tn186A	0.50	10.2	135.2						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: RSRM SUBSYSTEM: RSRM

LCC VIOLATION CALL: SRM Case Acreage Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	LH Case Surface Temp					
B06T7007A	Pri LH SRB Sta 694.5/270 Temp	(4)	35	NA	deg F	CI
B06T7010A	Pri LH SRB Sta 931.5/045 Temp		35	NA	deg F	CI
B06T7011A	Pri LH SRB Sta 931.5/135 Temp		35	NA	deg F	CI
B06T7013A	Pri LH SRB Sta 931.5/270 Temp	(4)	35	NA	deg F	CI
B06T7018A	Pri LH SRB Sta 1091.5/270 Temp	(4)	35	NA	deg F	CI
B06T7021A	Pri LH SRB Sta 1411.5/045 Temp		35	NA	deg F	CI
B06T7022A	Pri LH SRB Sta 1411.5/135 Temp		35	NA	deg F	CI
B06T7024A	Pri LH SRB Sta 1411.5/270 Temp	(4)	35	NA	deg F	CI
B06T7038A	Pri LH SRB Sta 1751.5/270 Temp	(4)	35	NA	deg F	CI
B06T7138A	Sec LH SRB Sta 1751.5/270 Temp	(4)	35	NA	deg F	CI
	RH Case Surface Temp					
B06T8007A	Pri RH SRB Sta 694.5/270 Temp	(4)	35	NA	deg F	CI
B06T8010A	Pri RH SRB Sta 931.5/135 Temp		35	NA	deg F	CI
B06T8011A	Pri RH SRB Sta 931.5/045 Temp		35	NA	deg F	CI
B06T8013A	Pri RH SRB Sta 931.5/270 Temp	(4)	35	NA	deg F	CI
B06T8018A	Pri RH SRB Sta 1091.5/270 Temp	(4)	35	NA	deg F	CI
B06T8021A	Pri RH SRB Sta 1411.5/135 Temp		35	NA	deg F	CI
B06T8022A	Pri RH SRB Sta 1411.5/045 Temp		35	NA	deg F	CI
B06T8024A	Pri RH SRB Sta 1411.5/270 Temp	(4)	35	NA	deg F	CI
B06T8038A	Pri RH SRB Sta 1751.5/270 Temp	(4)	35	NA	deg F	CI
B06T8138A	Sec RH SRB Sta 1751.5/270 Temp	(4)	35	NA	deg F	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For APU Start (T-5 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) In the event of confirmed instrumentation failure, the minimum configuration for verification of LCC compliance is at least one functional measurement for 3 of 5 sensors per motor at the 270 degree location (3,4).

PREPLANNED CONTINGENCY PROCEDURE:

(3) If a measurement indicates off scale high or off scale low, exhibits a step change, known bias, or erratic behavior, then instrumentation failure is confirmed. If minimum functional measurement requirements (2) are satisfied then LCC violation cleared, continue countdown.

(4) Loss of three or more sensors per motor at the 270-degree location due to instrumentation failure (3) is acceptable only if ambient temperature is greater than or equal to:

63 deg F, or

49 deg F with a 5 minute average wind speed greater than 3 knots, or

46 deg F with a 5 minute average wind speed greater than 5 knots.

If these conditions are met then LCC violation cleared, continue countdown.

NOTES:

(5) There are 9 platinum Resistance Temperature Detector (RTD) sensors on each Reusable Solid Rocket Motor (RSRM); 5 inboard and 4 outboard. Output from each sensor is connected to a Programmable Logic Controller (PLC) signal conditioner input. The signal from each sensor is retransmitted by the PLC from a voltage output channel as a single measurement except for sensors at station 1751.5 which are split into 2 measurements. Each measurement is connected to the data collection system via a different Hardware Interface Module (HIM) card.

REDLINE DERIVATION: CRITICALITY: 1

(6) a. SSID Intent Summary - The RSRM combustion chamber case is made from D6AC steel which exhibits a ductile-to-brittle transition. The temperature of the case must be sufficiently high to maintain the required fracture toughness at RSRM ignition. There is no fault-tolerance associated with a case failure. Case failure at ignition would be catastrophic and is prevented by conservative design constraints, assurance of no flaws larger than critical size, and minimum allowable temperature at launch.

b. Voting Logic - N/A

c. Minimum and/or Maximum Redline Development - The basic redline is the generic minimum case temperature and has been selected based on fracture toughness data and consideration of the ductile-to-brittle transition temperature. Instrumentation error, two independent sources of thermal variation and an 11 minute cool down are combined using Root of the Sum of Squares (RSS) and added to the minimum case temperature to establish the minimum redline. Instrumentation error is the RSS of instrument component errors including a cable-induced error that results from the variation in resistance of the 3-wire circuit from one motor set to another. There is no need to establish a maximum temperature.

c.1 Redline Calculation:

		Minimum
Basic Redline (deg F)		30.0
Case/Remote RTD differential (deg F)	+2.50	
Differential temperature (deg F)	+2.50	
11-minute Cooldown (deg F)	+1.65	
Instrumentation error (deg F)	+2.28	
RSS total errors (deg F)		+4.52
Redline (rounded) (deg F)		35.0

c.2 Instrumentation error development:

Sensor (RTD) error (deg F)	+/- 0.50
Cable resistance variation (deg F)	+/- 1.82
Signal Conditioner PLC input (deg F)	+/- 1.15
PLC output (deg F)	+/- 0.25
LPS (deg F)	+/- 0.50

REDLINE DERIVATION: (Continued)

RSS instrumentation error (deg F) +/- 2.28

d. Time Period - The LCC expiration time of T-5 minutes was chosen due to the fact that technical factors limit the time remaining to launch after T-5 minutes. That remaining time defines a period of possible cooling due to ambient changes. The cooling period is constrained to a maximum of 11 minutes and the cooling rate is the design-maximum rate of ambient change when the temperature is below 40 deg F. It is possible that the LCC redline could be violated after T-5 minutes due to significant ambient cooling, however, incorporation of the cooling provision ensures that the basic redline is not violated.

e. Requirements - The requirements for continuation with failed instrumentation are written to reflect the ability to verify LCC compliance with gages that have historically been at the coldest case temperature for the majority of prior launches.

f. Preplanned Contingency Procedures - The contingency procedure (4) specifies the ambient conditions that will allow verification of LCC compliance regardless of the minimum instrumentation requirement and without additional thermal analysis.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) The steel case may not meet the required fracture toughness outside this range resulting in the potential of case fracture at ignition.

CAUSES OF EXCEEDING REDLINE:

(8) Extreme ambient air temperature.
(9) Cryogenic leakage.
(10) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 7 for left booster, 8 for right booster									
UNITS-->	deg.F								
B06Tn007A	0.50	10.2	135.2						
B06Tn010A	0.50	10.2	135.2						
B06Tn011A	0.50	10.2	135.2						
B06Tn013A	0.50	10.2	135.2						
B06Tn018A	0.50	10.2	135.2						
B06Tn021A	0.50	10.2	135.2						
B06Tn022A	0.50	10.2	135.2						
B06Tn024A	0.50	10.2	135.2						
B06Tn038A	0.50	10.2	135.2						
B06Tn138A	0.50	10.2	135.2						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS72-948099 SHEET 24 ZONE B4

ELEMENT: RSRM SUBSYSTEM: RSRM

SECTION 11

BOOSTER THRUST VECTOR CONTROL SUBSYSTEM

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SECTION 11: BOOSTER THRUST VECTOR CONTROL SUBSYSTEM

SSID No.	Description/Violation Call	Page
BTVC-01	SRB HPU Fuel Supply Pressure Anomaly	11-01.1
BTVC-02	SRB HPU Fuel Supply Module GN2 Pressure Anomaly	11-02.1
BTVC-03	SRB Hydraulic Fluid Reservoir Level Anomaly	11-03.1
BTVC-04	SRB Hydraulic Fluid Reservoir Level Anomaly	11-04.1
BTVC-05	SRB APU Hydrazine Isolation Valve Position Anomaly	11-05.1
BTVC-06	SRB HPU Secondary Speed Control Anomaly	11-06.1
BTVC-07	SRB HPU Turbine Speed Anomaly	11-07.1
BTVC-08	SRB HPU Turbine Speed Anomaly	11-08.1
BTVC-09	SRB Hydraulic Fluid Supply Pressure Anomaly	11-09.1
BTVC-10	SRB TVC Gimbal Profile Anomaly	11-10.1
BTVC-11	SRB TVC Hydraulic Actuator Secondary Delta Pressure	11-11.1
BTVC-12	SRB Rock and Tilt Actuator Fail Indication	11-12.1
BTVC-13	SRB TVC Secondary Delta Pressure Post Gimbal Profile	11-13.1
BTVC-14	SRB TVC Hydraulic Actuator Null Position Anomaly	11-14.1
BTVC-15	SRB APU Gas Generator Temperature Anomaly	11-15.1
BTVC-16	SRB HPU Primary Pressure OK Anomaly	11-16.1

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LCC VIOLATION CALL: SRB HPU Fuel Supply Pressure Anomaly | EMERG COND: Yellow (7)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B46P1305C	LH Press N2H4/GN2 Bottle Out Sys A	(2,3)	325	425	psia	CI
B46P1306C	LH Press N2H4/GN2 Bottle Out Sys B	(2,3)	325	425	psia	CI
B46P2305C	RH Press N2H4/GN2 Bottle Out Sys A	(2,3)	325	425	psia	CI
B46P2306C	RH Press N2H4/GN2 Bottle Out Sys B	(2,3)	325	425	psia	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 Hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Violation is acceptable for confirmed instrumentation failure.(4),(5)
(3) Temporary violation of the maximum redline limit is acceptable if the violation is determined to be the result of thermal effects and the pressure returns to within limits prior to T-31 seconds.

PREPLANNED CONTINGENCY PROCEDURE:

(4) Instrumentation failure confirmed if a measurement exhibits a step function to the high or low end of the measurement, or functions erratically, LCC violation cleared, continue countdown.
(5) Instrumentation failure confirmed if a violation of the maximum redline limit is not attributable to thermal effects (pressure change due to temperature change is in the relationship of 1.0 psi/deg F.), LCC violation cleared, continue countdown.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1

(6) a. SSID Intent Summary - At APU start, because the turbine driven fuel pump is not yet operating, the Fuel Supply Module (FSM) bottle out pressure must force N2H4 into the gas generator (GG) bed to start the turbine. Thereafter, the bottle pressure serves to provide N2H4 at a positive head to the fuel pump to ensure reliable operation to SRB separation. The fuel supply for a system is zero fault tolerant. The bottle pressure measurement for each system is not redundant. However, the measurement is not used for command or control. It is used for pressure monitoring during pre-launch fuel loading and during countdown. This SSID ensures that sufficient pressure exists to start the APU within the launch countdown time constraints to assure adequate turbine speeds.

b. Voting Logic - N/A

REDLINE DERIVATION: (Continued)

c. Minimum and Maximum Redline Development - The minimum redline provides sufficient hydrazine to the GG beds at APU startup and ensures (during normal APU operation) that at least 200 psia will remain at SRB separation. Two hundred psia is the lowest N2H4 supply pressure for which the APU was tested for reliable operation. A pressure measurement exhibiting erratic behavior is considered instrumentation failure. Intermittent electrical connections to the valves downstream of the FSM are not considered to be a plausible cause of an erratic pressure measurement. Two of the three downstream valves are normally closed valves and are not powered during this time. Multiple failures would be required to create a flow path for the N2H4. Such an occurrence would manifest as a pressure reduction rather than as an erratic measurement since there is no supply to replenish lost pressure.

   The maximum redline is derived from the Assembly Check Out (ACO) hotfire testing of each SRB's assembled TVC system. The ACO requirement for the FSM pressure is 430 +/- 5 psia at the start of the test. The 425 psia value used for the maximum redline is the pressure that any TVC system has been operationally tested as an assembly.

d. Time Period - Since the FSMs are loaded and pressurized prior to the start of LCC effectivity, the time period of this SSID begins at ET cryo tanking, which marks the beginning of all LCC monitoring. The pressure is continuously monitored to T-31 seconds to ensure that no leak has developed and that sufficient pressure is present when the system becomes active at T-28 seconds. Continuous monitoring provides early detection should a leak develop, thereby minimizing consequences.

e. Requirements - Instrumentation failure is acceptable because the system's functionality is not compromised by the failure. Instrumentation failure is also acceptable based on the system's integrity prior to the failure. Thermally induced temporary violation of the maximum redline limit is acceptable since system operation and reliability are not compromised.

f. Preplanned Contingency Procedures - The FSM is loaded with N2H4, pressurized with GN2, and sealed prior to the start of launch countdown. The FSM has no active supply of GN2 or N2H4 during the countdown. Because there is no source of supply to the FSM, any increase in pressure can only be caused by thermal effects. In the absence of thermal effects, an increase in the pressure measurement can only be attributed to instrumentation failure whether the pressure measurement drifts high or goes high as a step function. Furthermore, a pressure measurement that exhibits a step function change to the high end limit of the measurement can only be caused by instrumentation failure because thermal effects cannot occur that rapidly.

   A decrease in the pressure measurement can be caused by thermal effects, system leakage, instrumentation failure, but a step function change to the low end limit of the measurement can only be caused by instrumentation failure. Thermal effects cannot occur that rapidly. A

REDLINE DERIVATION: (Continued)

venting analysis of the FSM showed that there is no plausible leakage scenario that could produce a pressure step function to zero with the 1 sample per second data rate. Because the pressure transducer is mounted remotely from the FSM, severing of the connecting tube could cause the pressure at the transducer to vent to ambient pressure resulting in a step function to ambient pressure. However, this is not considered to be a plausible scenario. The pressure transducer is securely mounted to the upper cross member of the TVC Lower Frame. The transducer, the connecting tube, and the FSM are completely covered by several inches of FrothPak foam.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Possible N2H4 fire in aft skirt if minimum redline violation is due to N2H4 leak.
(8) Reference SRB Hazard Reports B-20-04/A-20-24 (Hydrazine Source In The Presence Of An Ignition Source) and B-20-21 (Loss of Hydraulic Pressure).
(9) GLS cutoff due to low turbine speed if minimum redline violation is due to GN2 or N2H4 leak.

CAUSES OF EXCEEDING REDLINE:

(10) Imposed thermal environment.
(11) Leakage of Fuel Supply System.
(12) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
n = 1 for left booster, 2 for right booster									
UNITS-->	psia								
B46Pn305C	1.195	0	597.5						
B46Pn306C	1.195	0	597.5						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.2 SHEET 1 ZONE N2-V2
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SRB SUBSYSTEM: TVC

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LCC VIOLATION CALL: SRB HPU Fuel Supply Module GN2 Pressure Anomaly | EMERG COND: Yellow (4)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B46P1305C	LH Press N2H4/GN2 Bottle Out Sys A	(2)	300	NA	psia	CI
B46P1306C	LH Press N2H4/GN2 Bottle Out Sys B	(2)	300	NA	psia	CI
B46P2305C	RH Press N2H4/GN2 Bottle Out Sys A	(2)	300	NA	psia	CI
B46P2306C	RH Press N2H4/GN2 Bottle Out Sys B	(2)	300	NA	psia	CI

TIME PERIOD:

(1) From RSLS Start (T-31 seconds) to Go For SSME Ignition (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Violation is acceptable for confirmed instrumentation failure if detected and cleared by BTVC-01.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 1

(3) a. SSID Intent Summary - At APU start, because the turbine driven fuel pump is not yet operating, the Fuel Supply Module (FSM) bottle out pressure must force N2H4 into the gas generator bed to start the turbine. Thereafter, the bottle pressure serves to provide N2H4 at a positive head to the fuel pump to ensure reliable operation to SRB separation. The fuel supply for a system is zero fault tolerant. The bottle pressure measurement for each system is not redundant. However, the measurement is not used for command or control. It is used for pressure monitoring during pre-launch fuel loading and countdown. This SSID ensures that sufficient pressure exists to start the APU within the launch countdown time constraints to assure adequate turbine speed and that sufficient reserve remains at SSME start to ensure that 200 psia will remain at SRB separation.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - The minimum redline ensures that sufficient pressure is present to provide hydrazine to the APU at startup and ensures that at least 200 psia will remain at SRB separation. Two hundred psia is the lowest N2H4 supply pressure for which the APU was tested for reliable operation. The redline is lowered from that of BTVC-01 to account for normal pressure draw-down after TVC system start.

REDLINE DERIVATION: (Continued)

A maximum redline limit is not needed because there is no plausible cause of an actual increase in pressure during the time period of this LCC. No supply source is connected. Thermal effect is not a plausible cause of a pressure increase because the time period of this LCC is short. An instrumentation failure is the only plausible reason for the pressure measurement to increase. The measurement is not used for command or control; therefore it is not necessary or desirable to stop the count down during this period in the event of an instrumentation failure causing a high reading.

d. Time Period - This LCC begins monitoring of the FSM pressure when BTVC-01 ends, and monitors the pressure until Go For SSME Ignition at T-10 seconds. This time period covers TVC System start-up and SRB gimbal profile. Termination of this LCC at T-10 seconds provides sufficient time to detect an unusual pressure drop.

e. Requirements - An instrumentation failure causing a low pressure indication that is detected and cleared by BTVC-01 is acceptable because the system's functionality is not compromised by the failure. Instrumentation failure occurring during the time period of this LCC and causing a low indication is not acceptable because insufficient time exists to assess the cause of the low indication.

f. Preplanned Contingency Procedures - NA

CONSEQUENCES OF EXCEEDING REDLINE:

(4) Possible N2H4 fire in aft skirt if minimum redline violation is due to N2H4 leak.
(5) GLS cutoff due to low turbine speed if minimum redline violation is due to GN2 or N2H4 leak.
(6) Reference SRB Hazard Reports B-20-04/A-20-24 (Hydrazine Source In The Presence Of An Ignition Source) and B-20-21 (Loss of Hydraulic Pressure).

CAUSES OF EXCEEDING REDLINE:

(7) Leakage of Fuel Supply System.
(8) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1 for left booster, 2 for right booster									
UNITS-->	psia								
B46Pn305C	1.195	0	597.5						
B46Pn306C	1.195	0	597.5						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO JSC 11174	SHEET 10.2	ZONE S2
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: SRB SUBSYSTEM: TVC

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LCC VIOLATION CALL: SRB Hydraulic Fluid Reservoir Level Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B58Q1350C	LH Level Hyd Fluid Rsvr Sys A		65	85	Pcnt	DI
B58Q1351C	LH Level Hyd Fluid Rsvr Sys B		65	85	Pcnt	DI
B58Q2350C	RH Level Hyd Fluid Rsvr Sys A		65	85	Pcnt	DI
B58Q2351C	RH Level Hyd Fluid Rsvr Sys B		65	85	Pcnt	DI

TIME PERIOD:

(1) Verify at Start of ET Cryo Tanking (T-6 hours) and again prior to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY:

(2) The lower limit of this redline ensures that the hydraulic system has been properly filled to provide a sufficient supply of hydraulic fluid for flight duration. The upper limit ensures that a sufficient ullage exits to accommodate fluid expansion and/or fluid transfer from one system to another. Hydraulic fluid fill procedure specifies 70 +5/-0%.

CONSEQUENCES OF EXCEEDING REDLINE:

(3) Possible reservoir overpressurization or rupture.
(4) Failure of TVC because of low hydraulic fluid availability.
(5) Potential fire if hydraulic fluid leaked.

CAUSES OF EXCEEDING REDLINE:

(6) Transfer between companion HPUs.
(7) Hydraulic system leakage.
(8) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1 for left booster, 2 for right booster									
UNITS-->	pcnt.								
B58Qn350C	0.2	0	100						
B58Qn351C	0.2	0	100						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO JSC 11174 SHEET 10.2 ZONE F1
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SRB SUBSYSTEM: TVC

LCC VIOLATION CALL: SRB Hydraulic Fluid Reservoir Level Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B58Q1350C	LH Level Hyd Fluid Rsvr Sys A		50	NA	Pcnt	CI
B58Q1351C	LH level Hyd Fluid Rsvr Sys B		50	NA	Pcnt	CI
B58Q2350C	RH level Hyd Fluid Rsvr Sys A		50	NA	Pcnt	CI
B58Q2351C	RH level Hyd Fluid Rsvr Sys B		50	NA	Pcnt	CI

TIME PERIOD:

(1) From RSLS Start (T-31 seconds) to Go For SSME Ignition (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY:

(2) Violation of this redline indicates possible hydraulic leakage or excessive air in the hydraulic system.
(3) 50% or greater after HPU start is based on oil volume required to fill the accumulator and to allow tolerance for air in the hydraulic circuit.

CONSEQUENCES OF EXCEEDING REDLINE:

(4) Failure of a TVC because of low hydraulic fluid availability.
(5) Possible fire if hydraulic fluid leaked.

CAUSES OF EXCEEDING REDLINE:

(6) Hydraulic system leakage.
(7) Instrumentation failure.
(8) Excessive air in hydraulic system.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1 for left booster, 2 for right booster									
UNITS-->	pcnt.								
B58Qn350C	0.2	0	100						
B58Qn351C	0.2	0	100						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO JSC 11174 SHEET 10.7 ZONE F1
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SRB SUBSYSTEM: TVC

LCC VIOLATION CALL: SRB APU Hydrazine Isolation Valve Position Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B46X1853X	LH Event APU A Isln Valve Closed	(2)	ON	NA	Event	CI
B46X1851X	LH Event APU A Isln Valve Open	(2)	OFF	NA	Event	CI
B46X1854X	LH Event APU B Isln Valve Closed	(2)	ON	NA	Event	CI
B46X1852X	LH Event APU B Isln Valve Open	(2)	OFF	NA	Event	CI
B46X2853X	RH Event APU A Isln Valve Closed	(2)	ON	NA	Event	CI
B46X2851X	RH Event APU A Isln Valve Open	(2)	OFF	NA	Event	CI
B46X2854X	RH Event APU B Isln Valve Closed	(2)	ON	NA	Event	CI
B46X2852X	RH Event APU B Isln Valve Open	(2)	OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 Hours) to Go For RSLS Start (T-31 seconds).

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 measurements within limits per Auxiliary Power Unit (APU) is acceptable. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) For the second discrete violation on the same APU perform BITE 4 Multiplexer/Demultiplexer (MDM) read on Hydraulic Power Unit (HPU) System A-1/B-1 Start CMD (see table on next page).

A. If the BITE 4 MDM read indicates that the HPU System A-1/B-1 Start CMD is ON then issue HPU System A-1/B-1 Start CMD OFF to the violating unit and verify that the valve indications return to within minimum LCC requirements.
   1. If the HPU System A-1/B-1 Start CMD was commanded ON due to an understood inadvertent command, and successfully reset, then LCC violation cleared, continue countdown.
   2. If the redline is not re-established, LCC violation confirmed, No Go for launch.

B. If the BITE 4 MDM read indicates that the HPU System A-1/B-1 Start CMD is OFF, or if the BITE 4 MDM read indicated that the HPU System A-1/B-1 Start CMD was ON but the reason for the command being ON was not the result of an understood inadvertent command, then LCC violation confirmed, No Go for launch.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

HPU System A-1/B-1 Start Commands

B58K3016XL LH HPU System A-1 Start CMD
B58K3018XL LH HPU System B-1 Start CMD
B58K4016XL RH HPU System A-1 Start CMD
B58K4018XL RH HPU System B-1 Start CMD

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(4) a. SSID Intent Summary - The intent of the requirement is to ensure that the APU Hydrazine Isolation Valve remains closed. The APU Hydrazine Isolation Valves are two position, normally closed valves and are opened by the HPU system A-1 and B-1 Start CMD. Each valve has a position switch with two contacts, one for the open indication and one for the closed indication. The output from each position switch is routed to the SRB MDM.

b. Voting Logic - The 1 of 2 voting logic presented for APU Hydrazine Isolation Valve position accommodates for a single failure while ensuring the minimum visibility required to verify that the valve remains closed.

c. Minimum and Maximum Redline Development - The APU Hydrazine Isolation Valves are required to remain closed. The discrete measurements being polled to establish the state of the valve both come from a single position switch. Both can not be ON or OFF at the same time. Therefore if only one of the discretes change state, it will be considered failed. With the valve being closed in the unpowered condition, and one discrete indicating it is closed, the minimum requirement to assure the closed state has been met.

d. Time Period - Start time at start of ET Cryo Tanking (T-6 Hours) to establish LCC monitoring in parallel with all other monitoring activities. The ending time at T-31 seconds is the last reasonable time prior to APU start (T-28 seconds).

e. Requirements - The APU Hydrazine Isolation Valves are required to remain closed. Each solenoid valve has a position switch with two contacts, one for the open position and one for the closed position. Therefore, only one discrete per APU is required to verify that the valve position is in the closed position.

f. Preplanned Contingency Procedures - The APU Hydrazine Isolation Valve is required to be in the closed position and the HPU System A-1/B-1 Start CMD should remain OFF. If found to be out of configuration the Preplanned Contingency Procedure will return the system to the correct configuration so that launch countdown may proceed. The method used to

REDLINE DERIVATION: (Continued)

determine if the ground command is ON is to perform a BITE 4 MDM read. The BITE 4 MDM read polls the MDM up the Launch Data Bus for the status of the ground command. The response from the MDM is a four digit hexadecimal code. When decoded, one of the digits will indicate the state of the ground command in question.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) If this redline is exceeded and the valve is open, an additional single failure of the APU secondary speed control valve would result in flowing hydrazine into the Gas Generator bed and possibly driving the APU turbine to destruction.

CAUSES OF EXCEEDING REDLINE:

(6) Valve fails to remain closed.
(7) Valve prematurely commanded open.
(8) Instrumentation failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO JSC 11174	SHEET 10.2	ZONE R2
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: SRB SUBSYSTEM: TVC

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LCC VIOLATION CALL: SRB HPU Secondary Speed Control Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B46X1861X	LH Ev APU Sec Sp Con Vlv Cld Sys A		ON	NA	Event	CI
B46X1863X	LH Ev APU Sec Sp Con Vlv Cld Sys B		ON	NA	Event	CI
B46X2861X	RH Ev APU Sec Sp Con Vlv Cld Sys A		ON	NA	Event	CI
B46X2863X	RH Ev APU Sec Sp Con Vlv Cld Sys B		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 Hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY:

(2) The secondary speed control valves are normally closed valves and are opened by the hydraulic system A2 and B2 start commands. The purpose of this redline is to ensure that the secondary speed control valve(s) is/are not prematurely opened.

CONSEQUENCES OF EXCEEDING REDLINE:

(3) If this redline is violated, it would result in possible loss of secondary speed control.
(4) The occurrence of a second failure would result in premature HPU operation and possible overspeed to destruction.

CAUSES OF EXCEEDING REDLINE:

(5) Valve failure.
(6) Control circuit failure.
(7) Instrumentation failure.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO JSC 11174 SHEET 10.2 ZONE O2
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SRB SUBSYSTEM: TVC

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LCC VIOLATION CALL: SRB HPU Turbine Speed Anomaly | EMERG COND: Yellow (2)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B46R1408C	LH Rate APU A Turbine Speed Snsr 2		10	85	krpm	CI
B46R1409C	LH Rate APU B Turbine Speed Snsr 2		10	85	krpm	CI
B46R2408C	RH Rate APU A Turbine Speed Snsr 2		10	85	krpm	CI
B46R2409C	RH Rate APU B Turbine Speed Snsr 2		10	85	krpm	CI

TIME PERIOD:

(1) From 2 Seconds After SRB HPU A2/B2 Start Commands (T-26 seconds) until MDM Lockout (T-13 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) Condition Yellow is specified because of potential turbine overspeed to destruction, or lube oil loss with potential fire.

REDLINE DERIVATION: CRITICALITY:

(3) This redline functions to monitor the overall performance of the APU/HPU. It indirectly indicates the "health" state of many TVC subsystem components. Proper indications of turbine speed sensor 2 also show proper operation of turbine speed sensor 1 and primary speed control circuitry.
(4) 85 krpm allow APU to operate up to 118% of nominal during start-up. Minimum limit ensures APU is operative.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Indicates abnormal condition of TVC system. Condition could lead to complete loss of TVC system.

CAUSES OF EXCEEDING REDLINE:

(6) Low/high fuel flow.
(7) Loss of lube oil (mech problems).
(8) Loss of MPU outputs.
(9) Loss of APU control.
(10) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1 for left booster, 2 for right booster									
UNITS-->	krpm								
B46Rn408C	0.240	0	120						
B46Rn409C	0.240	0	120						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO JSC 11174 SHEET 10.2 ZONE L2
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SRB SUBSYSTEM: TVC

LCC VIOLATION CALL: SRB HPU Turbine Speed Anomaly | EMERG COND: Yellow (3)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B46R1408C	LH Rate APU A Turbine Speed Snsr 2		66.2 (1)	77.8 (2)	krpm	CI
B46R1409C	LH Rate APU B Turbine Speed Snsr 2		66.2 (1)	77.8 (2)	krpm	CI
B46R2408C	RH Rate APU A Turbine Speed Snsr 2		66.2 (1)	77.8 (2)	krpm	CI
B46R2409C	RH Rate APU B Turbine Speed Snsr 2		66.2 (1)	77.8 (2)	krpm	CI

TIME PERIOD:

(1) Minimum redline effective from 2 +/- 0.5 sec. after last pump bypass valve closure command until SRB ignition
(2) From 7 +/- 0.5 sec. after last pump bypass valve closure command until SRB ignition

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) Condition Yellow is specified because of potential turbine overspeed to destruction, or lube oil loss with potential fire.

REDLINE DERIVATION: CRITICALITY:

(4) Redline limits are based on nominal APU operation of 72 krpm +/- 8%.
(5) These redlines monitor the overall performance of the APU/HPUs. It indirectly indicates the "health" state of many TVC subsystem components. Proper indications of turbine speed sensor 2 also show proper operation of turbine speed sensor 1 and primary speed control circuitry.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Possible loss of TVC system if maximum redline is exceeded. A safe shutdown and launch abort occurs if minimum redline is exceeded.

CAUSES OF EXCEEDING REDLINE:

(7) Low/high fuel flow.
(8) Loss of lube oil.
(9) Loss of MPU outputs.
(10) Loss of APU control.

CAUSES OF EXCEEDING REDLINE: (Continued)

(11) Instrumentation failure.
(12) Loss of primary speed control capability.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1 for left booster, 2 for right booster									
UNITS-->	krpm								
B46Rn408C	0.240	0	120						
B46Rn409C	0.240	0	120						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO JSC 11174 SHEET 10.2 ZONE L5
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SRB SUBSYSTEM: TVC

LCC VIOLATION CALL: SRB Hydraulic Fluid Supply Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B58P1303C	LH Press Hyd Fluid Supply 1		2800	3486	psia	CI
B58P1304C	LH Press Hyd Fluid Supply 2		2800	3486	psia	CI
B58P2303C	RH Press Hyd Fluid Supply 1		2800	3486	psia	CI
B58P2304C	RH Press Hyd Fluid Supply 2		2800	3486	psia	CI

TIME PERIOD:

(1) From 0.8 Seconds After Completion of SRB Gimbal Test (T-17 seconds) to Go For SSME Ignition (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY:

(2) The redlines ensure that adequate hydraulic pressure for thrust vector control is being supplied to servoactuators from the prime pump, and ensures that the modulator (flow control valve) in the pump is operating correctly.
(3) Maximum redline limit based on maximum instrumentation range (3500) less 2 bit values. Minimum redline limit based on operational requirements.

CONSEQUENCES OF EXCEEDING REDLINE:

(4) Degraded operation of HPU.

CAUSES OF EXCEEDING REDLINE:

(5) Hydraulic pump failure.
(6) Relief valve failure.
(7) Line rupture or leakage.
(8) Bypass valve fails OPEN.
(9) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1 for left booster, 2 for right booster									
UNITS-->	psia								
B58Pn303C	7	0	3500						
B58Pn304C	7	0	3500						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO JSC 11174 SHEET 10.2 ZONE H3
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SRB SUBSYSTEM: TVC

LCC VIOLATION CALL: SRB TVC Gimbal Profile Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B58H1150C	LH Position TVC Rock Actuator		(3)	(3)	in.	CI
B58H1151C	LH Position TVC Tilt Actuator		(3)	(3)	in.	CI
B58H2150C	RH Position TVC Rock Actuator		(3)	(3)	in.	CI
B58H2151C	RH Position TVC Tilt Actuator		(3)	(3)	in.	CI

TIME PERIOD:

(1) During Gimbal Test (T-21 seconds to T-17 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) The Gimbal Test shall be started a minimum of 2 seconds after closing the hydraulics pumps bypass valve. The Gimbal Test shall be completed a minimum of 4.0 seconds prior to "To GO for SSME Start".
(3) Actuator responses shall be as reflected in Table 11-01. Pass/fail criteria shall be calculated using the final position check numbers as "actual null".

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY:

(4) The redlines ensure that the thrust vector control subsystem is responding properly during the gimbal test and that it verifies "health" state of actuators.
(5) Redline limits based on commanded position response and system tolerances derived from the root sum square of the end-to-end hardware performance and measurement tolerances.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Possible loss of thrust vector control.
(7) Loss of control authority because of excessive null offset.

CAUSES OF EXCEEDING REDLINE:

(8) Actuator failure.
(9) Instrumentation failure.
(10) Control circuit polarity anomaly.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1 for left booster, 2 for right booster									
UNITS-->	in.								
B58Hn150C	-0.0256	+6.4	-6.4						
B58Hn151C	-0.0256	+6.4	-6.4						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO JSC 11174 SHEET 9.14 ZONE F3
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SRB SUBSYSTEM: TVC

SUPPORTING DATA:

Table 11-01 SRB Gimbal Test Pass Fail Criteria

Meas. Number	Description	(1)	(2)	Pass/Fail Criteria Minimum Degrees/ Inches	Maximum Degrees/ Inches
B58H1150C	LH Position TVC Rock Actuator	1.0	1.0/ 1.25	0.5/ 0.63 (3)	1.5/ 1.88
B58H1151C	LH Position TVC Tilt Actuator	1.0	1.0/ 1.25	0.5/ 0.63 (3)	1.5/ 1.88
B58H2150C	RH Position TVC Rock Actuator	1.0	1.0/ 1.25	0.5/ 0.63 (3)	1.5/ 1.88
B58H2151C	RH Position TVC Tilt Actuator	1.0	1.0/ 1.25	0.5/ 0.63 (3)	1.5/ 1.88
B58H1150C	LH Position TVC Rock Actuator	3.0	-1.0/ -1.25	-0.5/ -0.63 (3)	-1.5/ -1.88
B58H1151C	LH Position TVC Tilt Actuator	3.0	-1.0/ -1.25	-0.5/ -0.63 (3)	-1.5/ -1.88
B58H2150C	RH Position TVC Rock Actuator	3.0	-1.0/ -1.25	-0.5/ -0.63 (3)	-1.5/ -1.88
B58H2151C	RH Position TVC Tilt Actuator	3.0	-1.0/ -1.25	-0.5/ -0.63 (3)	-1.5/ -1.88
B58H1150C	LH Position TVC Rock Actuator	4.0	0.0/ 0.0	-0.4/ -0.5	0.4/ 0.5
B58H1151C	LH Position TVC Tilt Actuator	4.0	0.0/ 0.0	-0.4/ -0.5	0.4/ 0.5
B58H2150C	RH Position TVC Rock Actuator	4.0	0.0/ 0.0	-0.4/ -0.5	0.4/ 0.5
B58H2151C	RH Position TVC Tilt Actuator	4.0	0.0/ 0.0	-0.4/ -0.5	0.4/ 0.5

(1) Time from LPS command to begin SRB Gimbal Test in seconds.
(2) Nominal position commanded from GPC in degs/inches.
(3) Actual GO/NO GO values include those gimbal displacement criteria plus the final position check numbers as "ACTUAL NULL".

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LCC VIOLATION CALL: SRB TVC Hydraulic Actuator Secondary Delta Pressure | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B58P1311A	LH Delta Press Secondary A Rock		-237	+237	psid	DI
B58P1312A	LH Delta Press Secondary B Rock		-237	+237	psid	DI
B58P1313A	LH Delta Press Secondary C Rock		-237	+237	psid	DI
B58P1314A	LH Delta Press Secondary D Rock		-237	+237	psid	DI
B58P1315A	LH Delta Press Secondary A Tilt		-237	+237	psid	DI
B58P1316A	LH Delta Press Secondary B Tilt		-237	+237	psid	DI
B58P1317A	LH Delta Press Secondary C Tilt		-237	+237	psid	DI
B58P1318A	LH Delta Press Secondary D Tilt		-237	+237	psid	DI
B58P2311A	RH Delta Press Secondary A Rock		-237	+237	psid	DI
B58P2312A	RH Delta Press Secondary B Rock		-237	+237	psid	DI
B58P2313A	RH Delta Press Secondary C Rock		-237	+237	psid	DI
B58P2314A	RH Delta Press Secondary D Rock		-237	+237	psid	DI
B58P2315A	RH Delta Press Secondary A Tilt		-237	+237	psid	DI
B58P2316A	RH Delta Press Secondary B Tilt		-237	+237	psid	DI
B58P2317A	RH Delta Press Secondary C Tilt		-237	+237	psid	DI
B58P2318A	RH Delta Press Secondary D Tilt		-237	+237	psid	DI

TIME PERIOD:

(1) Verify prior to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY:

(2) The secondary delta pressure indications are used to trigger the FDIR circuitry for servovalve failure detection. This redline prevents entering the automatic portion of launch countdown with a secondary delta pressure sensor failed.
(3) Redline limits based on null position response and system tolerances derived from the root sum square of the end-to-end hardware performance and measurement tolerances.

CONSEQUENCES OF EXCEEDING REDLINE:

(4) (See redline derivation.)

CAUSES OF EXCEEDING REDLINE:

(5) Failed sensor.
(6) Electronics failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1 for left booster, 2 for right booster									
UNITS-->	psid								
B58Pn311A	23.95	-2994	2994						
B58Pn312A	23.95	-2994	2994						
B58Pn313A	23.95	-2994	2994						
B58Pn314A	23.95	-2994	2994						
B58Pn315A	23.95	-2994	2994						
B58Pn316A	23.95	-2994	2994						
B58Pn317A	23.95	-2994	2994						
B58Pn318A	23.95	-2994	2994						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO JSC 11174 SHEET 9.14 ZONE C5,I4
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS72-948099 SHEET ZONE 4
DWG NO VS72-948102 SHEET ZONE 4

ELEMENT: SRB SUBSYSTEM: TVC

LCC VIOLATION CALL: SRB Rock and Tilt Actuator Fail Indication | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V79X5100X	LH SRB Rock Actr A Fail	(2)	OFF	NA	Event	CI
V79X5101X	LH SRB Tilt Actr A Fail	(2)	OFF	NA	Event	CI
V79X5105X	LH SRB Rock Actr B Fail	(2)	OFF	NA	Event	CI
V79X5106X	LH SRB Tilt Actr B Fail	(2)	OFF	NA	Event	CI
V79X5110X	LH SRB Rock Actr C Fail	(2)	OFF	NA	Event	CI
V79X5111X	LH SRB Tilt Actr C Fail	(2)	OFF	NA	Event	CI
V79X5115X	LH SRB Rock Actr D Fail	(2)	OFF	NA	Event	CI
V79X5116X	LH SRB Tilt Actr D Fail	(2)	OFF	NA	Event	CI
V79X5150X	RH SRB Rock Actr A Fail	(2)	OFF	NA	Event	CI
V79X5151X	RH SRB Tilt Actr A Fail	(2)	OFF	NA	Event	CI
V79X5155X	RH SRB Rock Actr B Fail	(2)	OFF	NA	Event	CI
V79X5156X	RH SRB Tilt Actr B Fail	(2)	OFF	NA	Event	CI
V79X5160X	RH SRB Rock Actr C Fail	(2)	OFF	NA	Event	CI
V79X5161X	RH SRB Tilt Actr C Fail	(2)	OFF	NA	Event	CI
V79X5165X	RH SRB Rock Actr D Fail	(2)	OFF	NA	Event	CI
V79X5166X	RH SRB Tilt Actr D Fail	(2)	OFF	NA	Event	CI

TIME PERIOD:

(1) Continuously From Start of SRB Gimbal Test (T-21 seconds) to Go for SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) This redline may be satisfied by the FCS channel failure, Orbiter GNC measurement V72X4550X. (Ref. SSID GNC-38.)

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY:

(3) The redlines prevent committing the SRB to launch with an SRB actuator failure existing.

CONSEQUENCES OF EXCEEDING REDLINE:

(4) Countdown termination and recycle.

CAUSES OF EXCEEDING REDLINE:

(5) Servovalve failure.
(6) Secondary delta pressure transducer failure.

CAUSES OF EXCEEDING REDLINE: (Continued)

(7) Instrumentation failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO JSC 11174	SHEET 9.14	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: SRB SUBSYSTEM: TVC

LCC VIOLATION CALL: SRB TVC Secondary Delta Pressure Post Gimbal Profile | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B58P1311A	LH Delta Press Secondary A Rock		-990	+990	psid	DI
B58P1312A	LH Delta Press Secondary B Rock		-990	+990	psid	DI
B58P1313A	LH Delta Press Secondary C Rock		-990	+990	psid	DI
B58P1314A	LH Delta Press Secondary D Rock		-990	+990	psid	DI
B58P1315A	LH Delta Press Secondary A Tilt		-990	+990	psid	DI
B58P1316A	LH Delta Press Secondary B Tilt		-990	+990	psid	DI
B58P1317A	LH Delta Press Secondary C Tilt		-990	+990	psid	DI
B58P1318A	LH Delta Press Secondary D Tilt		-990	+990	psid	DI
B58P2311A	RH Delta Press Secondary A Rock		-990	+990	psid	DI
B58P2312A	RH Delta Press Secondary B Rock		-990	+990	psid	DI
B58P2313A	RH Delta Press Secondary C Rock		-990	+990	psid	DI
B58P2314A	RH Delta Press Secondary D Rock		-990	+990	psid	DI
B58P2315A	RH Delta Press Secondary A Tilt		-990	+990	psid	DI
B58P2316A	RH Delta Press Secondary B Tilt		-990	+990	psid	DI
B58P2317A	RH Delta Press Secondary C Tilt		-990	+990	psid	DI
B58P2318A	RH Delta Press Secondary D Tilt		-990	+990	psid	DI

TIME PERIOD:

(1) Verify one time between SRB Gimbal Test completion and Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Verify the algebraic sum of the four secondary actuator delta pressure measurements for each of the SRB-TVC actuators shall equal 0 plus 460 or minus 530 psid.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY:

(3) Indicates that a secondary delta pressure transient error in one or more channels of the SRB rock/tilt actuators is occurring possibly resulting in actuator channel failure.
(4) These redlines are to detect actuator channel incipient failures that may not be detected by the ATVC FDIR.

REDLINE DERIVATION: (Continued)

	Min	Max
Basic Redline	-753 psid	753 psid
Instr error	-237 psid	237 psid
Redline	-990 psid	990 psid

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Flight control system will not remain two-fault tolerant.

CAUSES OF EXCEEDING REDLINE:

(6) Actuator failure.
(7) Electronics failure.
(8) Large null shift.
(9) Control circuit failure.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
n = 1 for left booster, 2 for right booster									
UNITS-->	psid								
B58Pn311A	23.95	-2994	2994						
B58Pn312A	23.95	-2994	2994						
B58Pn313A	23.95	-2994	2994						
B58Pn314A	23.95	-2994	2994						
B58Pn315A	23.95	-2994	2994						
B58Pn316A	23.95	-2994	2994						
B58Pn317A	23.95	-2994	2994						
B58Pn318A	23.95	-2994	2994						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO JSC 11174 SHEET 9.14 ZONE C5,I4
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS72-948099 SHEET ZONE A
DWG NO VS72-948102 SHEET ZONE A

ELEMENT: SRB SUBSYSTEM: TVC

LCC VIOLATION CALL: SRB TVC Hydraulic Actuator Null Position Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B58H1150C	LH Position TVC Rock Actuator		-0.5	+0.5	In.	CI
B58H1151C	LH Position TVC Tilt Actuator		-0.5	+0.5	In.	CI
B58H2150C	RH Position TVC Rock Actuator		-0.5	+0.5	In.	CI
B58H2151C	RH Position TVC Tilt Actuator		-0.5	+0.5	In.	CI

TIME PERIOD:

(1) From 6.0 seconds After Command From LPS to Begin SRB Gimbal Test to Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Monitoring implementation uses negative scale factor, thereby reversing the polarity.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) + or - 0.5 inch = + or - 0.4 degree

REDLINE DERIVATION: CRITICALITY:

(4)

	Min	Max
Basic Redline	0	0
Uncertainties	-0.5 In.	+0.5 In.
Instr. error		
Redline	-0.5 In.	+0.5 In.

Ensures SRB actuators are in SRB launch position (null).

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Degraded control capability.

CAUSES OF EXCEEDING REDLINE:

(6) Erroneous command.
(7) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1 for left booster, 2 for right booster									
UNITS-->	in.								
B58Hn150C	-.0256	+6.4	-6.4						
B58Hn151C	-.0256	+6.4	-6.4						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO JSC 11174 SHEET 9.14 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SRB SUBSYSTEM: TVC

LCC VIOLATION CALL: SRB APU Gas Generator Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B06T7094A	Temp LH Gas Gen Bed Sys A Primary	1 of	75	NA	Deg F	DI
B06T7095A	Temp LH Gas Gen Bed Sys A Sec	2	75	NA	Deg F	DI
B06T7096A	Temp LH Gas Gen Bed Sys B Primary	1 of	75	NA	Deg F	DI
B06T7097A	Temp LH Gas Gen Bed Sys B Sec	2	75	NA	Deg F	DI
B06T8094A	Temp RH Gas Gen Bed Sys A Primary	1 of	75	NA	Deg F	DI
B06T8095A	Temp RH Gas Gen Bed Sys A Sec	2	75	NA	Deg F	DI
B06T8096A	Temp RH Gas Gen Bed Sys B Primary	1 of	75	NA	Deg F	DI
B06T8097A	Temp RH Gas Gen Bed Sys B Sec	2	75	NA	Deg F	DI

TIME PERIOD:

(1) Verify Just Prior to GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) If any holds occur at T-5 minutes, reverify just prior to resuming the count.
(3) For loss of both measurements/heaters function on systems A/B (LH/RH), verify SRB interior aft skirt thermal environment. (4)

PREPLANNED CONTINGENCY PROCEDURE:

(4) Initiate heated aft skirt purge GN2 (ref. GSE-22, OMRS S00FM0.430) to maintain the aft skirt interior temperature to a minimum of 75 deg F. Any one of the following alternate measurements on the corresponding booster may be utilized to determine the SRB interior aft skirt thermal environment:
   a) The GG bed temperature measurement(s), if operational, corresponding to the failed heater(s).
   b) B46T2501C1 RH TEMP GAS N2H4/GN2 BOTTLE SYS A
      B46T2502C1 RH TEMP GAS N2H4/GN2 BOTTLE SYS B
      B46T1501C1 LH TEMP GAS N2H4/GN2 BOTTLE SYS A
      B46T1502C1 LH TEMP GAS N2H4/GN2 BOTTLE SYS B
   c) B06T8072A PRI RH TVC ROCK ACTUATOR TEMP
      B06T8073A PRI RH TVC TILT ACTUATOR TEMP
      B06T8172A SEC RH TVC ROCK ACTUATOR TEMP
      B06T8173A SEC RH TVC TILT ACTUATOR TEMP
      B06T7072A PRI LH TVC ROCK ACTUATOR TEMP
      B06T7073A PRI LH TVC TILT ACTUATOR TEMP
      B06T7172A SEC LH TVC ROCK ACTUATOR TEMP
      B06T7173A SEC LH TVC TILT ACTUATOR TEMP

NOTES:

(5) Gas Generator bed temperatures provide the only indication that the GG heaters are operational.

REDLINE DERIVATION: CRITICALITY:

(6) Sufficient GG bed temperature is required to prevent poisoning which causes a pressure spike of a magnitude that could rupture the GG at APU start.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Insufficient heat to drive off possible Aniline/Ammonia poisoning of the GG bed may cause detonation and possible rupture of the GG at APU start.

CAUSES OF EXCEEDING REDLINE:

(8) Both heaters fail OFF.
(9) Loss of both GG bed temperature measurements.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 7 for left booster, 8 for right booster									
UNITS-->	deg.F								
B06Tn094A	2.0	0	500						
B06Tn095A	2.0	0	500						
B06Tn096A	2.0	0	500						
B06Tn097A	2.0	0	500						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO JSC 11174 SHEET TBD ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS72-948099 SHEET TBD ZONE
DWG NO VS72-948102 SHEET TBD ZONE

ELEMENT: SRB SUBSYSTEM: TVC

LCC VIOLATION CALL: SRB HPU Primary Pressure OK Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B58X1859X	LH EV TILT SERVO ACT PRI PRESS OK	(2)	OFF	NA	Event	CI
B58X1860X	LH EV ROCK SERVO ACT PRI PRESS OK	(2)	OFF	NA	Event	CI
B58X2859X	RH EV TILT SERVO ACT PRI PRESS OK	(2)	OFF	NA	Event	CI
B58X2860X	RH EV ROCK SERVO ACT PRI PRESS OK	(2)	OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 Hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) For a failure of system A (Rock) measurement, perform APU Resistance and Frequency BITE Test on system B (Tilt). For a failure of system B (Tilt) measurement, perform APU Resistance and Frequency BITE Test on system A (Rock). If both BITE tests pass, the SRB HPU primary pressure OK switch is OFF and redundancy is maintained, LCC violation cleared, continue countdown. For all other conditions, LCC violation confirmed, No Go for launch.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(3) The purpose of this redline is to ensure complete SRB HPU redundancy management capability. If primary pressure OK is ON when no hydraulic pressure is applied, SRB TVC will not be fault tolerant. Actuator pressure OK output is fed to the secondary SRB TVC system APU controller to control the speed band of the secondary APU. The measurement is also input to the MDM for ground monitoring. Failure of MDM output will not affect the switch functionality. If the pressure switch itself has failed to the "ON" condition, the APU Frequency BITE test will not complete successfully as the controller will be receiving a continuous 100% speed command. A successful BITE test is indicative of the switch discrete being OFF and that the system is acceptable for launch. There is no secondary measurement to use as a backup to the pressure OK, making it a 1 of 1 down to T-31 seconds.

CONSEQUENCES OF EXCEEDING REDLINE:

(4) Loss of redundancy. If followed by actual loss of primary hydraulic pressure, the HPU driving the secondary hydraulic system will not have adequate pressure and flow to supply both servoactuators. Operation of the secondary HPU in the 100% speed mode would result in a Criticality 1 loss of thrust vector control. Primary pressure OK OFF is the only HPU controller input that will initiate operation in the 110% mode.

CAUSES OF EXCEEDING REDLINE:

(5) Short circuit in electrical cables between servoactuator and Aft IEA.
(6) Failed Pressure Sensor.
(7) Instrumentation failure caused by GPC/SRB MDM Launch DATA BUS malfunction.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 9.14	SHEET 1	ZONE M5
	DWG NO 10.2	SHEET 1	ZONE M7
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: SRB SUBSYSTEM: TVC

SECTION 12

BOOSTER RANGE SAFETY SYSTEM

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SECTION 12: BOOSTER RANGE SAFETY SYSTEM

SSID No.	Description/Violation Call	Page
BRSS-01	SRB Range Safety System Armed Indication Anomaly	12-01.1
BRSS-02	SRB Range Safety System Battery Power (Amp-Hr) (REQUIREMENT DELETED)	12-02.1
BRSS-03	SRB Range Safety System Battery Open Circuit Voltage (REQUIREMENT DELETED)	12-03.1
BRSS-04	SRB Recovery Battery Power (Amp-Hr) (REQUIREMENT DELETED)	12-04.1
BRSS-05	SRB Range Safety System Inhibit Anomaly	12-05.1
BRSS-06	SRB Recovery Battery Open Circuit Voltage (REQUIREMENT DELETED)	12-06.1
BRSS-07	SRB Range Safety System Battery Voltage Anomaly	12-07.1
BRSS-08	SRB Recovery Battery Voltage Anomaly	12-08.1
BRSS-09	SRB Range Safety System Arm Latch Voltage Anomaly	12-09.1
BRSS-10	SRB Range Safety System Decoder Power Indicator (REQUIREMENT DELETED)	12-10.1
BRSS-11	SRB Range Safety System Battery Current Anomaly	12-11.1
BRSS-12	SRB Recovery Battery Current Anomaly	12-12.1
BRSS-13	SRB Range Safety System Armed Command Anomaly	12-13.1
BRSS-14	SRB Range Safety System Fire Command Anomaly	12-14.1
BRSS-15	SRB Range Safety System Receiver Signal Strength Anomaly	12-15.1
BRSS-16	SRB Range Safety System Safe & Arm Device Anomaly	12-16.1
BRSS-17	SRB Range Safety Safe and Arm Device Anomaly (REQUIREMENT DELETED)	12-17.1

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LCC VIOLATION CALL: SRB Range Safety System Armed Indication Anomaly | EMERG COND: Yellow (4)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B55X1870X	LH Event RSS S&A Device Armed		OFF	NA	Event	CI
B55X2870X	RH Event RSS S&A Device Armed		OFF	NA	Event	CI
B55X1869X	LH Event RSS S&A Device Safed		ON	NA	Event	CI
B55X2869X	RH Event RSS S&A Device Safed		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 Hours) to RSS S&A Device Arm Command Issued ON (T-5 minutes)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) As long as the RSS Inhibit indicator is ON and/or RSS power is OFF, the system is in a safe configuration.

REDLINE DERIVATION: CRITICALITY: 1R

(3) a. SSID Intent Summary - The S&A devices allow interruption of the RSS explosive train. A condition where the S&A devices are in the Armed position prior to issuance of the RSS S&A ARM command ON coupled with additional failures could result in premature destruct. This requirement serves to maintain S&A in known (Safe) position. Physical barrier safes vehicle in the event of multiple electrical failures. The Range Safety System Armed Indication is zero fault tolerant. No Preplanned Contingency Procedure, all measurements are required during LCC Time Period effectivity.

b. Voting Logic - N/A

c. Minimum Redline Development - This redline verifies that the S&A remains in the Safe position prior to issuing the RSS S&A Arm command ON.

d. Time Period - Redline is in effect until T-5 minutes when the S&A is commanded to the Arm position.

e. Requirement - N/A

f. Preplanned Contingency procedure - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(4) Loss of redundancy preventing premature RSS Arming and potential unsafe condition if additional failures occur. Any unresolved problem with position indication of S&A devices is considered to be a high risk condition.
(5) Reference SRB Hazard Reports A-70-15 (SRB RSS Detonation), and B-70-16 (Loss of Destruct Capability).

CAUSES OF EXCEEDING REDLINE:

(6) S&A device malfunction.
(7) Instrumentation malfunction.
(8) Erroneous S&A ARM command.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: SRB SUBSYSTEM: RSS

SRB Range Safety System Battery Power (Amp-Hr)

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SRB Range Safety System Battery Open Circuit Voltage

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SRB Recovery Battery Power (Amp-Hr)

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LCC VIOLATION CALL: SRB Range Safety System Inhibit Anomaly | EMERG COND: Yellow (6)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B55X1881X	LH Event RSS A Inhibit		ON	NA	Event	CI
B55X2881X	RH Event RSS A Inhibit		ON	NA	Event	CI
B55X1882X	LH Event RSS B Inhibit		ON	NA	Event	CI
B55X2882X	RH Event RSS B Inhibit		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 Hours) to Go For RSLS Start (T-31 Seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) Attempt to re-establish all RSS Inhibits by issuing the LPS RSS Inhibit ON commands (B55K3519E, B55K3520E, B55K4519E, and B55K4520E) or via the KSC GSE hardware Inhibit switch (S0007.500). Subsequently, if all RSS Inhibits indicate ON then LCC violation cleared, continue countdown.

NOTES:

(3) Inhibit removal occurs after T-10 seconds per GLS.
(4) As long as the S&A device is SAFED and/or RSS power is OFF and Arm Latch is not set, the system is in a SAFE configuration.

REDLINE DERIVATION: CRITICALITY: 1R

(5) a. SSID Intent Summary - The Inhibit command functions to establish/maintain the RSS in a safe configuration. Loss of the Inhibit condition allows Arming of the Direct Current Firing Circuits (DCFCs) upon set of the ARM Command or with another failure. This requirement serves to verify the RSS Inhibits are maintained ON through T-31 seconds to prevent unintended arming of the RSS. The RSS Inhibit function is zero fault tolerant. All RSS inhibits shall be re-established via the Preplanned Contingency Procedure to clear an LCC violation. All measurements are required during LCC Time Period effectivity.

b. Voting Logic - N/A

c. Minimum Redline Development - This Redline ensures that the RSS Inhibit commands are present and the RSS is in a safe configuration.

d. Time Period - Redline is in effect from T-6 hours until system is committed for launch at T-31 seconds.

REDLINE DERIVATION: (Continued)

e. Requirement - N/A

f. Preplanned Contingency Procedure - The PCP provides direction to perform a contingency procedure if any or all of the SRB RSS Inhibits indicate OFF. The PCP will try to re-establish the RSS Inhibits by issuing the LPS RSS Inhibit ON commands or via the KSC GSE hardware Inhibit switch if LPS commanding fails. If all Inhibit ON indications cannot be re-established, then the No Go condition remains in effect.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Any unresolved problem with the RSS Inhibit Command is considered to be a high risk condition after the RSS S&A Device is in the Armed configuration.
(7) Reference SRB Hazard Reports A-70-15 (SRB RSS Detonation), and B-70-16 (Loss of Destruct Capability).

CAUSES OF EXCEEDING REDLINE:

(8) Instrumentation malfunction.
(9) Command path Failure.
(10) GSE Inhibit relay failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: SRB SUBSYSTEM: RSS

SRB Recovery Battery Open Circuit Voltage

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LCC VIOLATION CALL: SRB Range Safety System Battery Voltage Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B55V1625C	LH Voltage RSS Battery No. 1	(2)	29.50	37.10	Vdc	CI
B55V2625C	RH Voltage RSS Battery No. 1	(2)	29.50	37.10	Vdc	CI
B55C1051C	LH Current RSS Battery No. 1		(2)	(2)	Amps	BU
B55C2051C	RH Current RSS Battery No. 1		(2)	(2)	Amps	BU

TIME PERIOD:

(1) After RSS Power Up (Battery Voltage at Steady State, approximately T-45 minutes) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) Instrumentation failure is indicated if the battery voltage is less than 24.0 Vdc or greater than 37.1 Vdc without a change in battery current, LH or RH Current RSS Battery No. 1 (B55C1051C or B55C2051C), at the time of the violation.

A. If the current remained within +/- 2 bits (+/- 0.005 Amps dc) of the steady state current prior to the violation, LCC violation cleared, continue countdown with the battery current constrained to the steady state value +/- 0.01 Amps dc (except in response to external commands). Maximum current limit does not apply during RSS S&A rotation sequence (Between T-5 minutes and T-4 minutes 55 seconds).

B. If the current is outside +/- 2 bits of the steady state value at the time of the violation, LCC violation confirmed, No Go for launch.

NOTES:

(3) Reference SSID: BRSS-11, SRB Range Safety Battery Current Anomaly.
(4) Nominal value is 30.0 to 32.0 volts.

REDLINE DERIVATION: CRITICALITY: 1R

(5) a. SSID Intent Summary - These batteries are the source of power for RSS A. An out of range battery voltage could result in loss of function for the RSS A Destruct System. This requirement monitors the Range Safety Battery operational voltage to ensure that adequate power is available for RSS A. This battery powers one of two independent range safety flight termination systems. The RSS Battery Voltage is one fault tolerant. The Preplanned Contingency Procedure allows use of the battery current as a back-up measurement in the event of an out of range battery voltage.

b. Voting Logic - N/A

REDLINE DERIVATION: (Continued)

c. Minimum and Maximum Redline Development - Redline lower limit is based on historical data and qualification data for end of battery life. Redline upper limit is based on the theoretical maximum limit of silver-zinc chemistry which equals (1.86 Vdc/cell)(20 cells) - 0.08 (1 bit).

d. Time Period - Redline is in effect from RSS power ON (Battery Voltage at Steady State, approximately T - 45 minutes) until system is committed to launch at (Go For RSLS Start) T-31 seconds.

e. Requirement - N/A

f. Preplanned Contingency Procedure - Contingency voltage limits represent the sum of maximum and minimum cell voltages that the silver zinc battery will produce. Voltage measurements outside these limits are not credible battery failures unless there is system current change. Once instrumentation failure of the battery voltage is confirmed, battery and Range Safety System health can be monitored by assuring a steady battery current.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Possible loss of RSS A Destruct System.
(7) Reference SRB Hazard Reports B-70-16 (Loss of Destruct Capability), C-70-07 (Inadvertent SRB RSS Detonation), and X-00-19 (Loss of Life, Loss of Vehicle Due to SRB Failure Leading to Fire and Explosion (RSLS Abort Declared)).

CAUSES OF EXCEEDING REDLINE:

(8) Battery out of specification (e.g. open or shorted cells).
(9) Unexplained load.
(10) Instrumentation malfunction.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
UNITS-->	Vdc								
B55V1625C	0.08	0	40						
B55V2625C	0.08	0	40						
UNITS-->	Adc								
B55C1051C	0.0025	0	1.25						
B55C2051C	0.0025	0	1.25						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: SRB SUBSYSTEM: RSS

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LCC VIOLATION CALL: SRB Recovery Battery Voltage Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B76V1602C	LH Voltage Recovery Battery	(2)	28.0	31.9	Vdc	CI
B76V2602C	RH Voltage Recovery Battery	(2)	28.0	31.9	Vdc	CI
B76C1050C	LH Current Recovery Battery		(2)	(2)	Adc	BU
B76C2050C	RH Current Recovery Battery		(2)	(2)	Adc	BU

TIME PERIOD:

(1) After RSS Power Up (Battery Voltage at Steady State, approximately T-45 minutes) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) For a redline violation, the countdown may be continued per the following criteria for a confirmed instrumentation malfunction. An instrumentation malfunction is indicated if the battery voltage is less than 22.72 Vdc or greater than 35.44 Vdc without a change in battery current at the time of the violation.

A. If the current remained within +/- 1 bit (+/- 0.01 Amps dc) of the steady state current prior to the violation, LCC violation cleared, continue countdown with the battery current constrained to the steady state value +/- 0.01 Amps dc. (except in response to external commands).

B. If the current is outside +/- 1 bit of the steady state value at the time of violation, LCC violation confirmed, No Go for launch.

NOTES:

(3) Recovery load is not connected until SRB separation.
(4) Nominal value is 29.0 to 31.0 volts.

REDLINE DERIVATION: CRITICALITY: 1R

(5) a. SSID Intent Summary - These batteries are the source of power for RSS B and the SRB Recovery System. An out of range battery voltage could result in loss of function for the RSS B Destruct System. This requirement monitors the Recovery Battery operational voltage to ensure that adequate power is available for RSS B and the SRB Recovery System. During boost phase, this battery powers one of two independent Range Safety Systems. The Recovery Battery Voltage is one fault tolerant. The Preplanned Contingency Procedure allows use of the battery current as a back-up measurement in the event of an out of range battery voltage.

b. Voting Logic - N/A

REDLINE DERIVATION: (Continued)

c. Minimum and Maximum Redline Development - Redline lower limit is based on historical data and qualification data for end of battery life. Redline upper limit is based on the maximum limit of the Recovery System instrumentation.

d. Time Period - Redline is in effect from RSS power ON (Battery Voltage at Steady State, approximately T - 45 minutes) until system is committed to launch at (Go For RSLS Start) T-31 seconds.

e. Requirement - N/A

f. Preplanned Contingency Procedure - Contingency voltage limits represent the sum of maximum and minimum cell voltages that the silver zinc battery will produce. Voltage measurements outside these limits are not credible battery failures unless there is system current change. Once instrumentation failure of the battery voltage is confirmed, battery and Range Safety System health can be monitored by assuring a steady battery current.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Possible loss of RSS B Destruct System or SRB Recovery System.
(7) Insufficient power to RSS B.
(8) Reference SRB Hazard Report B-70-16 (Loss of Destruct Capability).

CAUSES OF EXCEEDING REDLINE:

(9) Battery out of specification (e.g. open or shorted cells).
(10) Unexplained load.
(11) Instrumentation malfunction.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
UNITS-->	Vdc								
B76V1602C	0.08	0	40						
B76V2602C	0.08	0	40						
UNITS-->	Adc								
B76C1050C	0.01	0	5						
B76C2050C	0.01	0	5						

METER/DISPLAY RANGE - MSID: N/A LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: SRB SUBSYSTEM: RSS

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LCC VIOLATION CALL: SRB Range Safety System Arm Latch Voltage Anomaly | EMERG COND: Yellow (5)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B55V1623C	LH Voltage RSS Arm Latch A		NA	1.0	Vdc	CI
B55V2623C	RH Voltage RSS Arm Latch A		NA	1.0	Vdc	CI
B55V1624C	LH Voltage RSS Arm Latch B		NA	1.0	Vdc	CI
B55V2624C	RH Voltage RSS Arm Latch B		NA	1.0	Vdc	CI

TIME PERIOD:

(1) From RSS Power Issued ON (approximately T-45 minutes) to Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) These redlines monitor the Arm Latch voltages to ensure that power has not been applied to the Direct Current Firing Circuit (DCFC). The DCFC provides energy to detonate the NASA Standard Initiators (NSIs).
(3) The Command Receiver Decoder (CRD) design requires less than or equal to 1 Vdc on any uncommanded output.

REDLINE DERIVATION: CRITICALITY: 1R

(4) a. SSID Intent Summary - The Arm Latch supplies power to the DCFC which provides energy to detonate the NSIs. Unintentional application of RSS ARM Latch power could result from RSS Inhibit command removal and could result in unintentional arming of the SRB DCFCs. This requirement verifies that the DCFCs are not prematurely armed. The RSS Arm Latch Voltage is zero fault tolerant. No Preplanned Contingency Procedure, all measurements are required during LCC time period effectivity.

b. Voting Logic - N/A

c. Maximum Redline Development - This redline ensures that the DCFCs are not prematurely armed and reduce the redundancy preventing premature RSS system NSI initiation. The Command Receiver Decoder Specification (10SPC-0232) requires that the ARM Latch switch OFF output voltage shall be 0.0 VDC +/- 1.0 VDC in the reset (open) state. The 1.0 VDC is a very conservative redline limit and includes instrumentation error.

d. Time period - Redline is in effect from RSS power ON (approximately T-45 minutes) to Go for SSME Start (T-10 seconds), when the RSS Inhibit command is removed.

REDLINE DERIVATION: (Continued)

e. Requirement - N/A

f. Preplanned Contingency Procedure - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Arming of SRB DCFCs after RSS Inhibit command removal. Prior to T-10 seconds multiple failures are required to initiate the RSS system, however after RSS Inhibit command removal at T-10 seconds additional failure resulting in issuance of the FIRE command will result in loss of Crew and Vehicle.
(6) Reference SRB Hazard Report A-70-15 (SRB RSS Detonation).

CAUSES OF EXCEEDING REDLINE:

(7) Loss of inhibit command and erroneous DCFC internal ARM command.
(8) Instrumentation malfunction.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
n = 1 for left booster, 2 for right booster									
UNITS-->	Vdc								
B55Vn623C	0.08	0	40.0						
B55Vn624C	0.08	0	40.0						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SRB SUBSYSTEM: RSS

SRB Range Safety System Decoder Power Indicator

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LCC VIOLATION CALL: SRB Range Safety System Battery Current Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B55C1051C	LH Current RSS Battery No. 1		0.10	0.20(2)	Amps	CI
B55C2051C	RH Current RSS Battery No. 1		0.10	0.20(2)	Amps	CI

TIME PERIOD:

(1) From RSS Power Issued ON (approximately T-45 minutes) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Maximum limit does not apply during RSS S&A rotation sequence (Between T-5 minutes and T-4 minutes 55 seconds).

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) This is a silver-zinc battery.
(4) The nominal value for this measurement is approximately 0.150 Amps.

REDLINE DERIVATION: CRITICALITY: 1R

(5) a. SSID Intent Summary - These batteries are the source of power for the range safety system. An out of range battery current could result in depletion of battery capacity, and/or RSS failure. This battery powers one of the two independent range safety flight termination systems. The RSS Battery Current is zero fault tolerant. No preplanned Contingency Procedure, all measurements are required during LCC time period effectivity.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - These redlines are based on statistical analysis of Command Receiver Decoder (CRD) qualification data. The mean current load is 0.151 amps and is based on over 600 measurements during qualification. The 0.10 amp and 0.20 amp lower and upper limit values represent the mean +/- 3-sigma values with a +/- 4 bit margin.

d. Time Period - Redline is in effect from RSS A Power ON (approximately T-45 minutes) until system is committed to launch at T-31 seconds.

e. Requirement - During RSS S&A rotation, the CRD will indicate the higher current required to turn the S&A motor, and will exceed the maximum current limit. The current draw (approx. 1.5 Amps) is significantly higher than the normal operating current and lasts for no more than 250 milliseconds.

f. Preplanned Contingency Procedure - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Failure of SRB RSS A Destruct capability.
(7) Reference SRB Hazard Reports B-70-16 (Loss of Destruct Capability), C-70-07 (Inadvertent SRB RSS Detonation), and X-00-19 (Loss of Life, Loss of Vehicle Due to SRB Failure Leading to Fire and Explosion (RSLS Abort Declared)).

CAUSES OF EXCEEDING REDLINE:

(8) Unexplained RSS Battery load change.
(9) Instrumentation malfunction.
(10) Battery failure.
(11) Cable failure (short or open).

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
UNITS-->	Adc								
B55C1051C	0.0025	0	1.25						
B55C2051C	0.0025	0	1.25						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SRB SUBSYSTEM: RSS

LCC VIOLATION CALL: SRB Recovery Battery Current Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B76C1050C	LH Current Recovery Battery		0.10	0.20	Adc	CI
B76C2050C	RH Current Recovery Battery		0.10	0.20	Adc	CI

TIME PERIOD:

(1) From RSS Power Issued ON (Approximately T-45 minutes) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) Recovery load is not connected until SRB separation.
(3) This is a silver-zinc battery.
(4) The nominal value for this redline is approximately 0.15 Amps.

REDLINE DERIVATION: CRITICALITY: 1R

(5) a. SSID Intent Summary - These batteries provide power to operate the RSS B and SRB Recovery System. The requirements provide verification that the RSS B Recovery Battery is performing nominally and experiencing expected loading after RSS power is applied. Since SRB Recovery System loads are not connected until after SRB separation, this requirement does not protect for anomalous loads in that system. This battery powers one of the two independent range safety flight termination systems. The Recovery Battery Current is zero fault tolerant. No Preplanned Contingency Procedure, all measurements are required during LCC time period effectivity.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - These redlines are based on statistical analysis of Command Receiver Decoder (CRD) qualification data. The mean current load is 0.151 amps and is based on over 600 measurements during qualification. The 0.10 amp and 0.20 amp lower and upper limit values represent the mean +/- 3-sigma values with a +/- 3 bit margin.

d. Time Period - Redline is in effect from RSS B power ON (approximately T - 45 minutes) until system is committed to launch at T-31 seconds.

e. Requirement - N/A

f. Preplanned Contingency Procedure - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Failure of SRB RSS B Destruct System.
(7) Reference SRB Hazard Report B-70-16 (Loss of Destruct Capability).

CAUSES OF EXCEEDING REDLINE:

(8) Instrumentation malfunction.
(9) Unexplained Recovery Battery load change.
(10) Battery failure.
(11) Cable failure (short or open).

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
UNITS-->	Adc								
B76C1050C	0.01	0	5						
B76C2050C	0.01	0	5						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SRB SUBSYSTEM: RSS

LCC VIOLATION CALL: SRB Range Safety System Armed Command Anomaly | EMERG COND: Yellow (4)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B55X1877X	LH EV RSS Arm Cmd From Dcdr A		OFF	NA	Event	CI
B55X2877X	RH EV RSS Arm Cmd From Dcdr A		OFF	NA	Event	CI
B55X1878X	LH EV RSS Arm Cmd From Dcdr B		OFF	NA	Event	CI
B55X2878X	RH EV RSS Arm Cmd From Dcdr B		OFF	NA	Event	CI

TIME PERIOD:

(1) From Completion of Closed-Loop Arm Command Sequence (Approximately T-45 minutes) to Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) During Closed-Loop test; the RSS Inhibit Command prevents arming the RSS.

REDLINE DERIVATION: CRITICALITY: 1R

(3) a. SSID Intent Summary - This SSID monitors the 4 Command Receiver Decoders (CRDs) for premature RSS ARM Command ON indications and will result in termination of the count if the ON condition is detected from any of the CRDs. After RSS Inhibit removal at T-10 seconds an RSS ARM Command violation is a high risk condition which could result in loss of the Crew and vehicle if an additional failure results in generation of the RSS FIRE command. The Range Safety System Armed Command is zero fault tolerant. No Preplanned Contingency Procedure, all measurements are required during LCC time period effectivity.

b. Voting Logic - N/A

c. Minimum Redline Development - This redline monitors the RSS ARM command from the RSS CRDs to ensure that they are OFF.

d. Time Period - Redline is in effect from completion of Closed-Loop ARM Command Sequence at T-45 minutes to go for SSME start at T-10 seconds when RSS Inhibits are removed.

e. Requirement - N/A

f. Preplanned Contingency Procedure - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(4) Violation of redline could indicate transmission of Secure Flight Code (Arm Command) from an unauthorized source. After RSS Inhibit command removal arming of the SRB Direct Current Firing Circuits (DCFCs) could result in the SRB RSS no longer being single fault tolerant. One additional failure that generates a FIRE command can result in loss of Crew and Vehicle, (only after the RSS S&A Device is in the Armed configuration). Any unresolved problem involving the RSS Inhibit and/or RSS ARM Command is considered to be a high risk condition.
(5) Reference SRB Hazard Report A-70-15 (SRB RSS Detonation).

CAUSES OF EXCEEDING REDLINE:

(6) CRD malfunction.
(7) Instrumentation malfunction.
(8) Unauthorized command transmission.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: SRB SUBSYSTEM: RSS

LCC VIOLATION CALL: SRB Range Safety System Fire Command Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B55X1879X	LH EV RSS A Fire Cmd From Dcdr		OFF	NA	Event	CI
B55X2879X	RH EV RSS A Fire Cmd From Dcdr		OFF	NA	Event	CI
B55X1880X	LH EV RSS B Fire Cmd From Dcdr		OFF	NA	Event	CI
B55X2880X	RH EV RSS B Fire Cmd From Dcdr		OFF	NA	Event	CI

TIME PERIOD:

(1) From Completion of the Closed-Loop Fire Command Sequence (approximately T-45 minutes) to Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(2) a. SSID Intent Summary - This SSID verifies that the RSS FIRE commands are OFF through T-10 seconds. Activation of the system FIRE command could result in detonation of the NASA Standard Initiators (NSIs) if the system were inadvertently armed. Failure of this command could result in unintentional destruction of the Vehicle. The Range Safety System Fire Command is zero fault tolerant. No Preplanned Contingency Procedure, all measurements are required during LCC time period effectivity.

b. Voting Logic - N/A

c. Minimum Redline Development - This redline monitors the RSS FIRE command from the RSS Command Receiver Decoders (CRDs) to ensure that they are OFF.

d. Time Period - Redline is in effect from completion of Closed-Loop FIRE Command Sequence at T-45 minutes to Go for SSME start at T-10 seconds when RSS Inhibits are removed.

e. Requirement - N/A

f. Preplanned Contingency Procedure - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(3) Violation of redline could indicate transmission of Secure Flight Code (Fire Command) from an unauthorized source. Activation of an RSS FIRE

CONSEQUENCES OF EXCEEDING REDLINE: (Continued)

Command could result in loss of Crew and Vehicle if the RSS system is in an Armed configuration.

(4) Reference SRB Hazard Report A-70-15 (SRB RSS Detonation).

CAUSES OF EXCEEDING REDLINE:

(5) CRD malfunction.
(6) Instrumentation malfunction.
(7) Unauthorized command transmission.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: SRB SUBSYSTEM: RSS

LCC VIOLATION CALL: SRB Range Safety System Receiver Signal Strength Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B55E1100C	LH Power RSS Rcvr Sig Strength A	(2,3)	1.90(4)	NA	Vdc	CI
B55E2100C	RH Power RSS Rcvr Sig Strength A	(2,3)	1.90(4)	NA	Vdc	CI
B55E1101C	LH Power RSS Rcvr Sig Strength B	(2,3)	1.90(4)	NA	Vdc	CI
B55E2101C	RH Power RSS Rcvr Sig Strength B	(2,3)	1.90(4)	NA	Vdc	CI

TIME PERIOD:

(1) From Command Receiver Decoder (CRD) Captured by Eastern Range (ER) (approximately T - 45 minutes) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Fluctuations in signal strength including redline violations are acceptable during Orbiter Access Arm (OAA) or Gaseous Oxygen (GOX) Vent Arm retract.

(3) A momentary signal dropout of less than three consecutive samples is acceptable.

PREPLANNED CONTINGENCY PROCEDURE:

(4) Initiate the GSE multipath test (per S0007.500). If the RSS receivers respond appropriately to the increased GSE RF transmission, then the RSS receivers are operating correctly, however final determination for acceptability of the RSS receivers for flight is the responsibility of the ER after review of the associated Signal Strength Telemetry (SST) data. If ER concurs with RSS receiver performance assessment as acceptable, then LCC violation cleared, continue countdown.

NOTES:

(5) ER representative can call a hold/cutoff from initiation of "OAA Retract" until T-10 seconds if, in their opinion, the system is not flight worthy.

REDLINE DERIVATION: CRITICALITY: 1R

(6) a. SSID Intent Summary - The RSS Receivers require a minimum signal strength to ensure signal margin for Command Destruct. A condition where the RSS Receivers are unable to obtain reception of the minimum signal limit could result in a loss of a portion of RSS A/B Destruct capability. The Range Safety System Receiver Signal Strength is zero fault tolerant. ER concurrence with an acceptable RSS receiver performance assessment is required during the Preplanned Contingency Procedure to clear an LCC violation. All measurements are required during LCC Time Period effectivity.

b. Voting Logic - N/A

REDLINE DERIVATION: (Continued)

c. Minimum Redline Development - These redlines monitor the RSS receiver signal strength to ensure that power is ON and that the CRDs are captured by the ER Transmitter. Redline limit ensures a signal strength 12 dB higher than the specified sensitivity (-104 dBm)of the RSS Receiver. The voltage for a signal 12 dB higher than the specified sensitivity of the receiver is 1.815 Vdc. The LCC lower limit of 1.9 VDC includes approximately 8 bits for instrumentation.

d. Time Period - Redline is in effect from capture by ER (approximately T - 45 minutes) until system is committed for launch at T-31 seconds.

e. Requirement - Momentary dropouts due to signal path interference during OAA or GOX Vent Arm retract are acceptable and expected. Momentary signal dropouts due to signal path interference of less than three consecutive samples are possible and acceptable.

f. Preplanned Contingency Procedure - The PCP provides direction to provide a known GSE RF signal output to the CRDs Receivers, if the receivers respond accordingly by the GSE RF transmission, then the receivers are properly responding to the RF input and SST will return to nominal levels moments after launch based on flight history.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Possible loss of RSS A/B Destruct capability.
(8) Reference SRB Hazard Report B-70-16 (Loss of Destruct Capability).

CAUSES OF EXCEEDING REDLINE:

(9) RSS CRD A/B malfunction.
(10) Loss of RF signal because of malfunction of ER equipment.
(11) Instrumentation malfunction.
(12) Excessive loss in RF subsystem including antenna, couplers, and cables.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
n = 1 for left booster, 2 for right booster									
UNITS-->	Vdc								
B55En100C	0.01	0	5						
B55En101C	0.01	0	5						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: SRB SUBSYSTEM: RSS

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LCC VIOLATION CALL: SRB Range Safety System Safe & Arm Device Anomaly | EMERG COND: Yellow (3)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B55X1869X	LH Event RSS S&A Device Safed		OFF	NA	Event	DI
B55X2869X	RH Event RSS S&A Device Safed		OFF	NA	Event	DI
B55X1870X	LH Event RSS S&A Device Armed		ON	NA	Event	CI
B55X2870X	RH Event RSS S&A Device Armed		ON	NA	Event	CI

TIME PERIOD:

(1) From 5 Seconds after issuance of RSS S&A ARM Command ON (T-4 minutes 55 seconds) to Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(2) a. SSID Intent Summary - The Safe and Arm device functions to provide/remove a physical barrier for the pyro chain. The criteria/steps outlined in this SSID are used to monitor the RSS S&A devices to verify the ability to achieve the Armed configuration following issuance of the S&A ARM command. Failure to achieve the Armed configuration would result in a loss of destruct capability. The Range Safety System Safe & Arm Device is zero fault tolerant. No Preplanned Contingency Procedure, all measurements are required during LCC time period effectivity.

b. Voting Logic - N/A

c. Minimum Redline Development - These redlines monitor the RSS S&A Device to ensure that they are in the Armed configuration.

d. Time Period - Redline is in effect from T-4 minutes 55 seconds when the RSS S&A Device is Armed to T-10 seconds, when RSS Inhibit commands are removed.

e. Requirement - N/A

f. Preplanned Contingency Procedure - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(3) Possible loss of destruct capability and corresponding high risk condition to public if launch were to proceed.

CONSEQUENCES OF EXCEEDING REDLINE: (Continued)

(4) Uncertainty of the RSS S&A Safe/Armed configuration may impact vehicle safing activities.
(5) Reference SRB Hazard Report B-70-16 (Loss of Destruct Capability).

CAUSES OF EXCEEDING REDLINE:

(6) S&A device malfunction.
(7) Instrumentation malfunction.
(8) Failure to issue/receive ARM command.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: SRB SUBSYSTEM: RSS

SRB Range Safety Safe and Arm Device Anomaly

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SECTION 13

BOOSTER ELECTRICAL AND INSTRUMENTATION

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SECTION 13: BOOSTER ELECTRICAL AND INSTRUMENTATION

SSID No.	Description/Violation Call	Page
BEI-01	SRB Operational Bus Voltage	13-01.1
BEI-02	SRB MDM Pre-Lockout BSR Status (REQUIREMENT DELETED)	13-02.1
BEI-03	MDM Post Lockout BSR Status Anomaly	13-03.1
BEI-04	MDM PROM Bypass Anomaly	13-04.1
BEI-05	MDM Post Lockout BSR Status Anomaly	13-05.1
BEI-06	Aft MDM Power Separation Anomaly	13-06.1
BEI-07	Fwd MDM Power Separation Anomaly	13-07.1
BEI-08	SRB Igniter PIC Cap Voltage Anomaly	13-08.1
BEI-09	SRB Igniter PICs Properly Charged Anomaly	13-09.1
BEI-10	SRM Ignition Fire 2 Test Power ON Command Anomaly	13-10.1

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LCC VIOLATION CALL: SRB Operational Bus Voltage | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B76V1600H	LH Voltage Operational Bus A	1 of	24.8	32.0(2)	Vdc	CI
B76V1600C	LH Voltage Operational Bus A	2	25.5	31.3(2)	Vdc	CI
B76V1601H	LH Voltage Operational Bus B	1 of	24.8	32.0(2)	Vdc	CI
B76V1601C	LH Voltage Operational Bus B	2	25.5	31.3(2)	Vdc	CI
B76V2600H	RH Voltage Operational Bus A	1 of	24.8	32.0(2)	Vdc	CI
B76V2600C	RH Voltage Operational Bus A	2	25.5	31.3(2)	Vdc	CI
B76V2601H	RH Voltage Operational Bus B	1 of	24.8	32.0(2)	Vdc	CI
B76V2601C	RH Voltage Operational Bus B	2	25.5	31.3(2)	Vdc	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 Hours) to SRB Ignition (T-0)

REQUIREMENTS: FIGURES/TABLES:

(2) Voltage transients may exceed redline limits for a maximum of 200 milliseconds, provided they do not exceed 36.7 Vdc (hardwired) or 36.0 Vdc (PCM).

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY:

(3) Telemetered measurement instrumentation error is 0.7 Vdc. Hardwire measurement error is negligible.
(4) These redlines monitor bus A/B operational voltages to ensure that they remain within acceptable limits.
(5) Redline values based on SRB component operational specifications.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Loss or degradation of SRB subsystems powered by operational A/B bus.

CAUSES OF EXCEEDING REDLINE:

(7) Operational Bus A/B malfunction.
(8) Instrumentation malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1 for left booster, 2 for right booster									
UNITS-->	Vdc								
B76Vn600H	0.08	20	40						
B76Vn600C	0.08	0	40						
B76Vn601H	0.08	20	40						
B76Vn601C	0.08	0	40						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 2.2 SHEET 2 of 2 ZONE F7
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS72-948099 SHEET 6 ZONE D2

ELEMENT: SRB SUBSYSTEM: SRB E&I

SRB MDM Pre-Lockout BSR Status

(THIS REQUIREMENT HAS BEEN DELETED)

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LCC VIOLATION CALL: MDM Post Lockout BSR Status Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	FWD MDM Post-Lockout BSR Status	(2)				
NA	LL01 BSR (Post IOM 0 Lockout)	(3)	1000	NA	HEX	DI
NA	LL01 BSR (Post IOM 4 Lockout)	(3)	1000	NA	HEX	DI
NA	LR01 BSR (Post IOM 0 Lockout)	(3)	1000	NA	HEX	DI
NA	LR01 BSR (Post IOM 4 Lockout)	(3)	1000	NA	HEX	DI

TIME PERIOD:

(1) Verify BSR at Completion of SRB Fwd MDM Lockout (T-55 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) Onboard Software monitored. (GLS receives PASS/FAIL message from GPC.)
(3) 1000 HEX = unable to transfer data.

REDLINE DERIVATION: CRITICALITY:

(4) These redlines verify that the Fwd MDM operated properly during the MDM lockout.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) MDM failed to lockout.

CAUSES OF EXCEEDING REDLINE:

(6) Incorrect commands to MDM.
(7) MDM malfunction.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 8.8 SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SRB SUBSYSTEM: SRB E&I

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LCC VIOLATION CALL: MDM PROM Bypass Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V91X2831X	LL1/P1-P2 SRB PROM Bypass		OFF	NA	Event	CI
V91X2833X	LL2/P1-P2 SRB PROM Bypass		OFF	NA	Event	CI
V91X2835X	LR1/P1-P2 SRB PROM Bypass		OFF	NA	Event	CI
V91X2837X	LR2/P1-P2 SRB PROM Bypass		OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to SRB Ignition (T-0)

REQUIREMENTS: FIGURES/TABLES: Figure 13-01

PREPLANNED CONTINGENCY PROCEDURE:

(2) See Figure 13-01, "MDM PROM Bypass Flow Diagram," for a contingency procedure.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(3) These redlines ensure that LDB or SRB MDM failures that cause a loss of valid SRB data and subsequent potential undetected redline violations are monitored to the extent available with the MDM PROM Bypass measurements.

CONSEQUENCES OF EXCEEDING REDLINE:

(4) Loss of SRB data that could result in an undetected redline violation.
(5) Loss of SRB ignition S&A device position (Fwd MDM).
(6) Loss of APU turbine speed data (Aft MDM).
(7) Potential loss of ignition S&A safing (Fwd MDM) capability.
(8) Potential loss of SRB APU shutdown (Aft MDM) capability.

CAUSES OF EXCEEDING REDLINE:

(9) MDM malfunction.
(10) GPC/SRB MDM launch data bus malfunction.
(11) Data Bus Isolation Amplifier (DBIA) failure if all four MDMs bypass simultaneously.
(12) Loss of SRB Bus A/B power if MDM power supply is separated.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: SRB SUBSYSTEM: SRB E&I

SUPPORTING DATA:

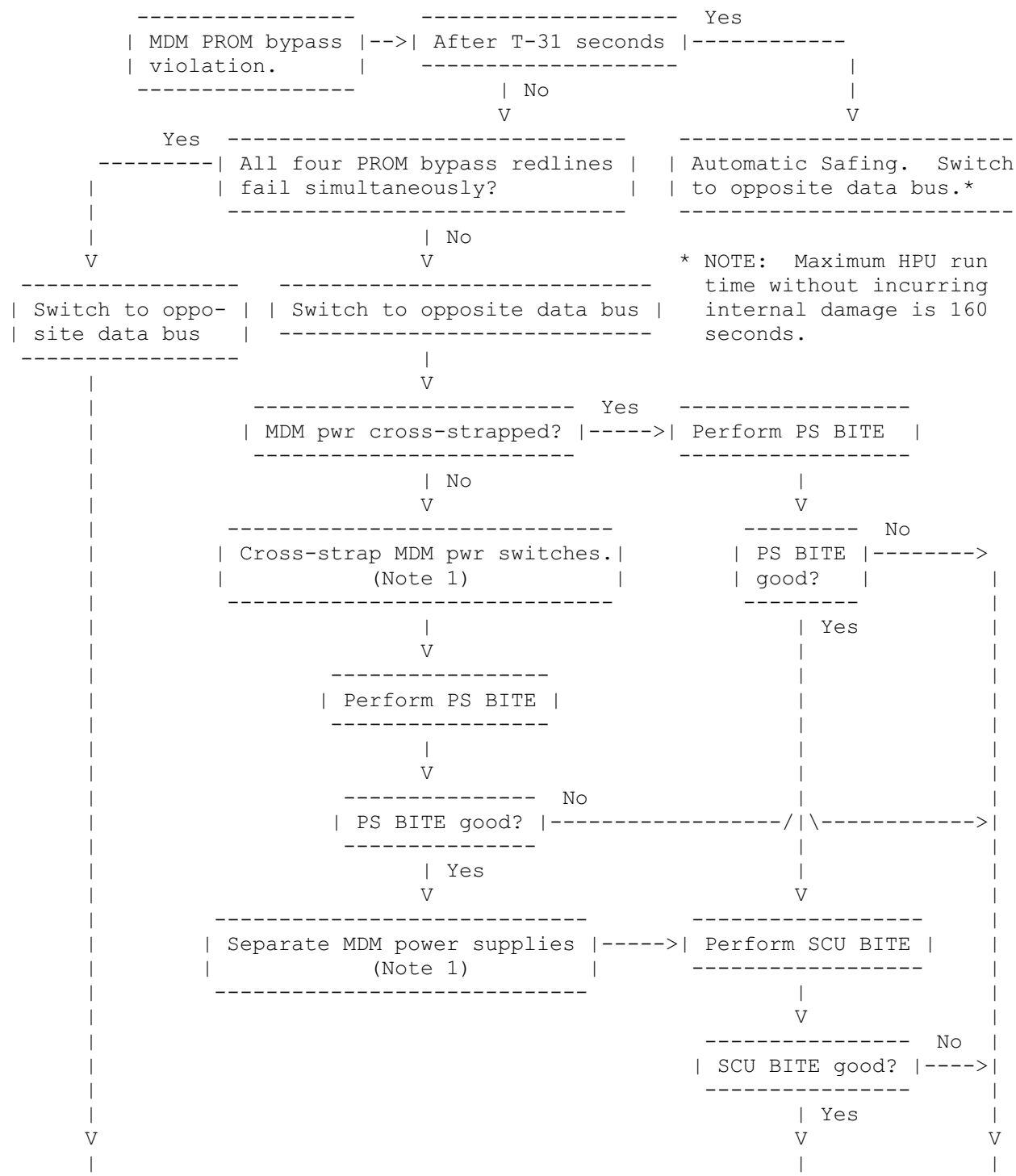
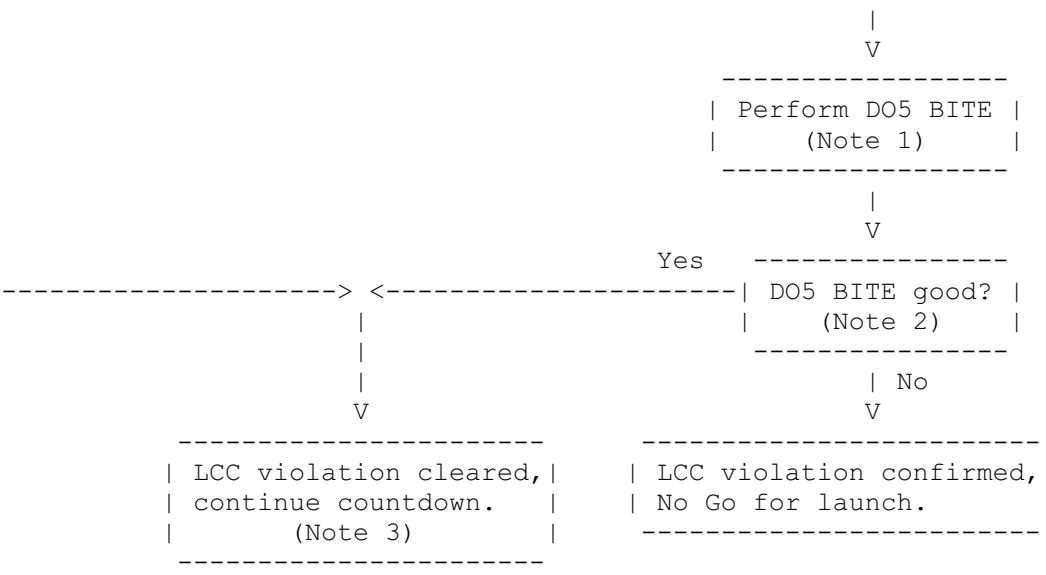


Figure 13-01 MDM PROM Bypass Flow Diagram

SUPPORTING DATA:



Note 1. DO5 Modules must be unlocked to perform this step.

Note 2. "Good" DO5 BITE verified by the following.
Fwd: BSR - X0000, Ign F2 Test Pwr & Rcvy Reset Cmds off.
Aft: BSR - X0000, Sep F2 Test Pwr off.
Other DO5s verified by secondary measurements.

Note 3. Relock MDM if unlock was performed during execution of this contingency procedure.

Figure 13-01 MDM PROM Bypass Flow Diagram (Concluded)

LCC VIOLATION CALL: MDM Post Lockout BSR Status Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	AFT MDM Post-Lockout BSR Status	(2)				
NA	LL02 BSR (Post IOM 0 Lockout)	(3)	X1000	NA	HEX	DI
NA	LL02 BSR (Post IOM 4 Lockout)	(3)	X1000	NA	HEX	DI
NA	LR02 BSR (Post IOM 0 Lockout)	(3)	X1000	NA	HEX	DI
NA	LR02 BSR (Post IOM 4 Lockout)	(3)	X1000	NA	HEX	DI

TIME PERIOD:

(1) Verify AFT BSR at Completion of SRB AFT MDM Lockout (T-13 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) Onboard-software monitored. (GLS receives PASS/FAIL message from GPC.)
(3) X1000 = unable to transfer data.

REDLINE DERIVATION: CRITICALITY:

(4) These redlines verify that the AFT MDM operated properly during MDM lockout.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Potential loss of MDM (diagnostic test required).

CAUSES OF EXCEEDING REDLINE:

(6) Incorrect commands to MDM.
(7) MDM malfunction.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SRB SUBSYSTEM: SRB E&I

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LCC VIOLATION CALL: Aft MDM Power Separation Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	MDM Redlines	(2)				
B75V2632C	RT Aft MDM PS Sep1 Sw Snsr Volts		2.02	3.8	Vdc	CI
B75V2633C	RT Aft MDM PS Sep2 Sw Snsr Volts		2.02	3.8	Vdc	CI
B75V1632C	LF Aft MDM PS Sep1 Sw Snsr Volts		2.02	3.8	Vdc	CI
B75V1633C	LF Aft MDM PS Sep2 Sw Snsr Volts		2.02	3.8	Vdc	CI
	EMDM Redlines	(2)				
B75V2632C	RT Aft MDM PS Sep1 SW Snsr Volts		-0.05	0.72	Vdc	CI
B75V2633C	RT Aft MDM PS Sep2 SW Snsr Volts		-0.05	0.72	Vdc	CI
B75V1632C	LF Aft MDM PS Sep1 Sw Snsr Volts		-0.05	0.72	Vdc	CI
B75V1633C	LF Aft MDM PS Sep2 Sw Snsr Volts		-0.05	0.72	Vdc	CI

TIME PERIOD:

(1) After Aft MDM PS Sep 1 and 2 CMD issued (T-2 hours, 30 minutes) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES: Figure 13-02

(2) The contents of SRB Aft MDM PROM location 510 indicates the type of MDM and corresponding redlines as follows:
0001 (HEX) - MDM Redlines
0002 (HEX) - EMDM Redlines

PREPLANNED CONTINGENCY PROCEDURE:

(3) See Figure 13-02, "Aft MDM Power Separation Flow Diagram," for a contingency procedure.

NOTES:

(4) Aft MDM Power Separation function is performed and verified at T-2 hours 30 minutes per OMRS S00FE0.230.

REDLINE DERIVATION: CRITICALITY: 1

(5) The maximum redline verifies that the MDM power is separated. The minimum redline helps verify the MDM internal power is acceptable for proper operation.
(6) Redline values based on circuit analysis.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) A loss of power separation.
(8) Launch with single point failure susceptibility in MDM power supplies which could degrade both SRB power busses, causing reset of all aft MDM discrete outputs, resulting in shutdown of both APUs in flight.
(9) Possible inadequate internal MDM power.

CAUSES OF EXCEEDING REDLINE:

(10) SRB Aft MDM PS SEP 1 and 2 CMDs not issued.
(11) Circuit/switch failure.
(12) Instrumentation failure.
(13) Aft MDM power circuit or other anomaly.
(14) Analog to Digital (A/D) converter failure.
(15) Discrete Output Low (DOL) card failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1 for left booster, 2 for right booster									
UNITS-->	Vdc								
B75Vn632C	0.01	-5.0	5.0						
B75Vn633C	0.01	-5.0	5.0						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO JSC11174,8.8 SHEET 3 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SRB SUBSYSTEM: SRB E&I

SUPPORTING DATA:

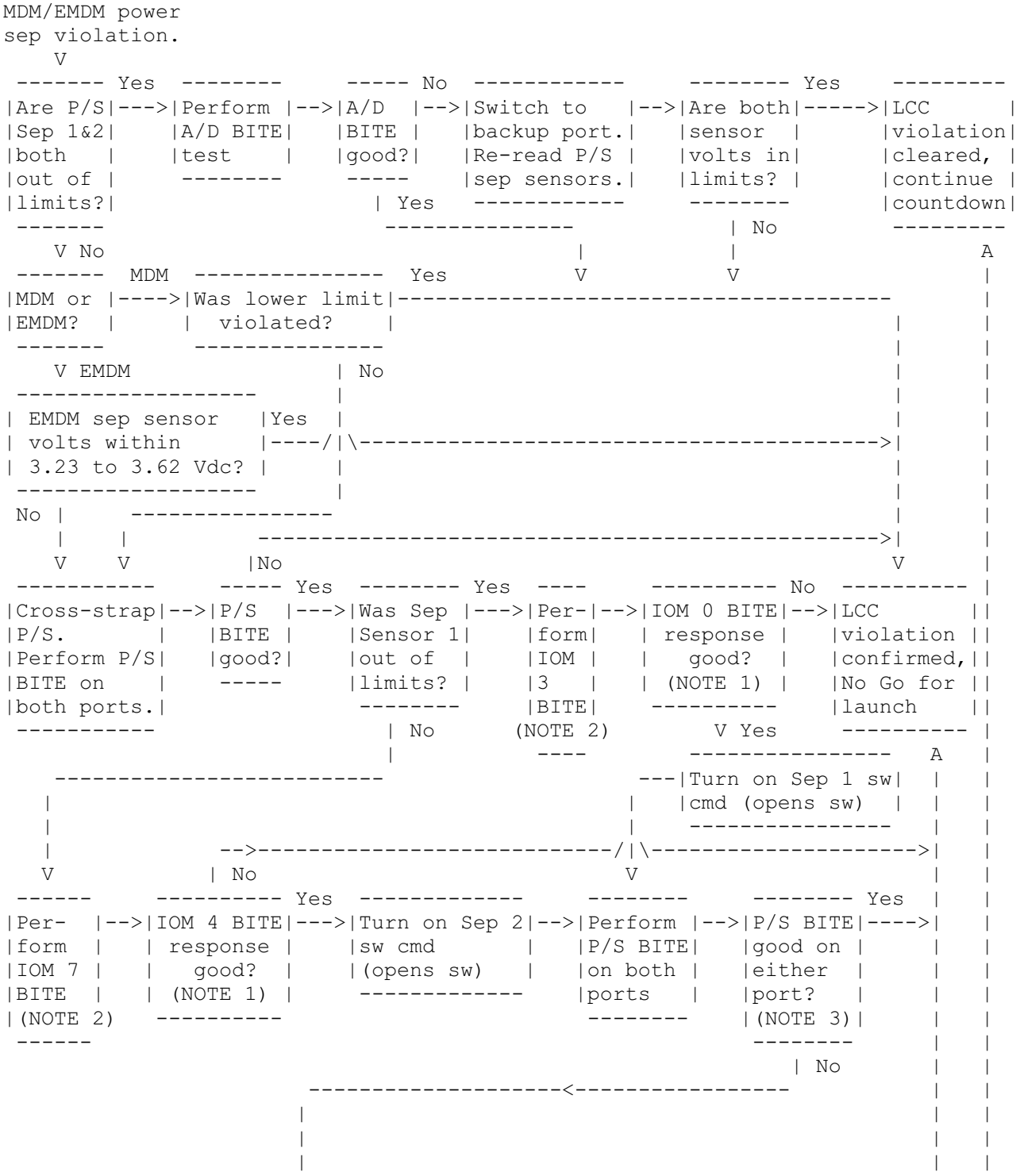
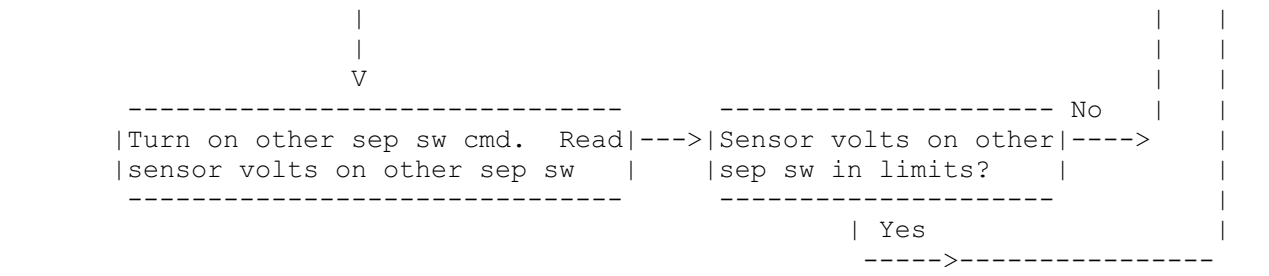


Figure 13-02 Aft MDM Power Separation Flow Diagram

SUPPORTING DATA:



NOTE 1. For IOM 0 or 4 (DOL) BITE, good response is verified by the absence of any GPC I/O errors related to the BITE command.
NOTE 2. IOM 3 and 7 (AID/DCID) BITE for information only.
NOTE 3. "P/S BITE GOOD", verify by BSR = 0023 (HEX), indicates separation switch failed to open when commanded. The expected P/S BITE failed values here are as follows:

with Sep 1 switch open, BSR = 0003 (HEX) for MDM;
BSR = 200F (HEX) for EMDM.

with Sep 2 switch open, BSR = 0002 (HEX) for MDM;
BSR = 200E (HEX) for EMDM.

Figure 13-02 Aft MDM Power Separation Flow Diagram - Concluded

LCC VIOLATION CALL: Fwd MDM Power Separation Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	MDM Redlines	(2)				
B75V1630C	LF FWD MDM PS Sep1 SW SNSR volts		2.02	3.8	Vdc	DI
B75V1631C	LF FWD MDM PS Sep2 SW SNSR volts		2.02	3.8	Vdc	DI
B75V2630C	RT FWD MDM PS Sep1 SW SNSR volts		2.02	3.8	Vdc	DI
B75V2631C	RT FWD MDM PS Sep2 SW SNSR volts		2.02	3.8	Vdc	DI
	EMDM Redlines	(2)				
B75V1630C	LF FWD MDM PS Sep1 SW SNSR volts		-0.05	0.72	Vdc	DI
B75V1631C	LF FWD MDM PS Sep2 SW SNSR volts		-0.05	0.72	Vdc	DI
B75V2630C	RT FWD MDM PS Sep1 SW SNSR volts		-0.05	0.72	Vdc	DI
B75V2631C	RT FWD MDM PS Sep2 SW SNSR volts		-0.05	0.72	Vdc	DI

TIME PERIOD:

(1) Verify after Fwd MDM PS Sep 1 and 2 Cmd issued (T-2 hours, 30 minutes) and again after Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES: Figure 13-03

(2) The contents of SRB Fwd MDM PROM location 510 indicates the type of MDM and corresponding redlines as follows:
0001 (HEX) = MDM Redlines
0002 (HEX) = EMDM Redlines

PREPLANNED CONTINGENCY PROCEDURE:

(3) See Figure 13-03, "Fwd MDM Power Separation Flow Diagram," for a contingency procedure.

NOTES:

(4) These measurements are not in the downlist. Must perform LDB read to verify.
(5) Fwd MDM Power Separation function is performed and verified at T-2 hours 30 minutes per OMRS S00FE0.225.

REDLINE DERIVATION: CRITICALITY: 1

(6) The maximum redline verifies that the MDM power is separated. The minimum redline helps verify the MDM internal power is acceptable for proper operation.
(7) Redline values based on circuit analysis.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) A loss of power separation.
(9) Launch with single point failure susceptibility in MDM power supplies which could degrade both SRB power busses, causing reset of all Aft MDM discrete outputs, resulting in shutdown of both APUs in flight.

CONSEQUENCES OF EXCEEDING REDLINE: (Continued)

(10) Possible inadequate internal MDM power.

CAUSES OF EXCEEDING REDLINE:

(11) SRB Fwd MDM PS SEP 1 and 2 CMDs not issued.
(12) Circuit/switch failure.
(13) Instrumentation failure.
(14) Fwd MDM power circuit or other anomaly.
(15) Analog to Digital (A/D) converter failure.
(16) Discrete Output Low (DOL) card failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO JSC11174,8.8	SHEET 3	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: SRB SUBSYSTEM: SRB E&I

SUPPORTING DATA:

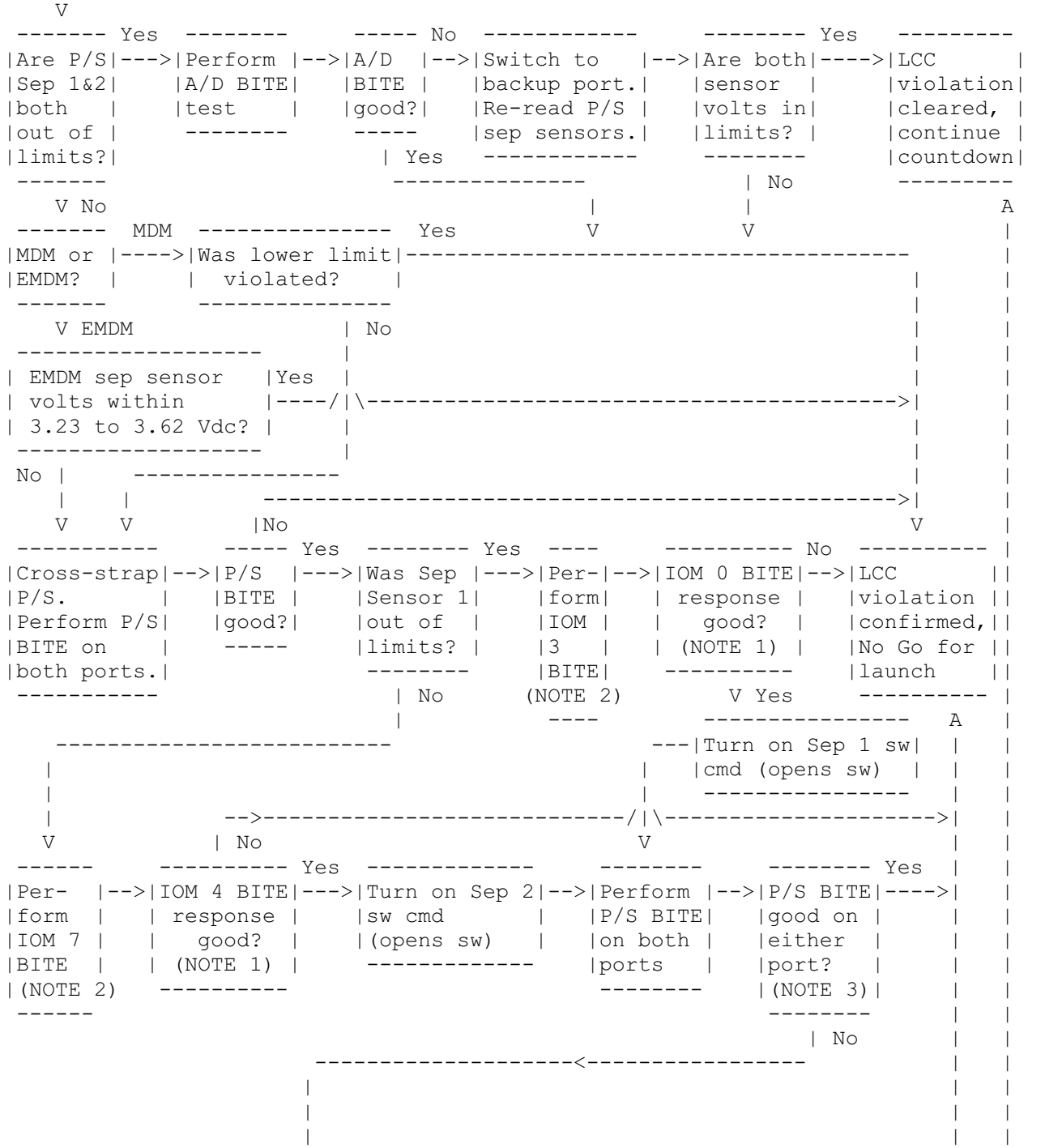
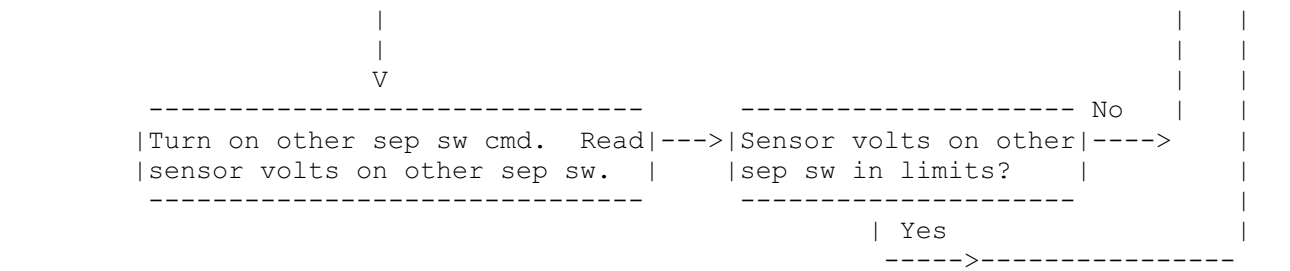


Figure 13-03 Fwd MDM Power Separation Flow Diagram

SUPPORTING DATA:



NOTE 1. For IOM 0 or 4 (DOL) BITE, good response is verified by the absence of any GPC I/O errors related to the BITE command.
NOTE 2. IOM 3 and 7 (AID/DCID) BITE for information only.
NOTE 3. "P/S BITE GOOD", verify by BSR = 0023 (HEX), indicates separation switch failed to open when commanded. The expected P/S BITE failed values here are as follows:

with Sep 1 switch open, BSR = 0003 (HEX) for MDM;
BSR = 200F (HEX) for EMDM.

with Sep 2 switch open, BSR = 0002 (HEX) for MDM;
BSR = 200E (HEX) for EMDM.

Figure 13-03 Fwd MDM Power Separation Flow Diagram - Concluded

LCC VIOLATION CALL: SRB Igniter PIC Cap Voltage Anomaly | EMERG COND: Yellow

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B55V1603C	LH Voltage Ign PIC Cap A		NA	1.5	Vdc	CI
B55V1604C	LH Voltage Ign PIC Cap B		NA	1.5	Vdc	CI
B55V2603C	RH Voltage Ign PIC Cap A		NA	1.5	Vdc	CI
B55V2604C	RH Voltage Ign PIC Cap B		NA	1.5	Vdc	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 Hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY:

(2) The ignition Pyrotechnic Initiator Controllers (PICs) supply voltage to detonate the Shuttle Standard Initiator (SSI). This redline ensures that the PICs are not prematurely charged. The Shuttle Integrated Avionics Panel has defined the PIC low voltage at 1.5 V maximum. The total end-to-end instrumentation error has been factored into this redline.

CONSEQUENCES OF EXCEEDING REDLINE:

(3) Possible premature detonation of SSI (multiple failures required).

CAUSES OF EXCEEDING REDLINE:

(4) Sneak circuit.
(5) Circuit failure.
(6) Premature PIC Arm commands.
(7) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1 for left booster, 2 for right booster									
UNITS-->	Vdc								
B55Vn603C	.0815	.0002	40.75						
B55Vn604C	.0815	.0002	40.75						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO JSC 11174 SHEET 10.2 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS72-948099 SHEET 24 ZONE B4

ELEMENT: SRB SUBSYSTEM: SRB E&I

LCC VIOLATION CALL: SRB Igniter PICs Properly Charged Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B55V1603C	LH Voltage Ign PIC Cap A		35.7	40.5	Vdc	CI
B55V1604C	LH Voltage Ign PIC Cap B		35.7	40.5	Vdc	CI
B55V2603C	RH Voltage Ign PIC Cap A		35.7	40.5	Vdc	CI
B55V2604C	RH Voltage Ign PIC Cap B		35.7	40.5	Vdc	CI

TIME PERIOD:

(1) From Three Seconds After Ignition PICs Arm Command (T-18 seconds) Until Ignition PICs Fire Command (T-0)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) Flight software (RSLS) monitors minimum voltage only.

REDLINE DERIVATION: CRITICALITY:

(3) The ignition Pyrotechnic Initiator Controllers (PICs) supply the voltage to detonate the Shuttle Standard Initiators (SSIs). This redline ensures that the PICs are properly charged to be functional. The Shuttle Integrated Avionics Panel has defined these values as the PIC pass/fail criteria. These will be verified by onboard Orbiter hardware/software. The total end-to-end instrumentation error has been factored into this redline.

CONSEQUENCES OF EXCEEDING REDLINE:

(4) Inability to ignite SRM.

CAUSES OF EXCEEDING REDLINE:

(5) Circuit failure.
(6) Low voltage.
(7) PIC failure.
(8) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1 for left booster, 2 for right booster									
UNITS-->	Vdc								
B55Vn603C	.0815	.0002	40.75						
B55Vn604C	.0815	.0002	40.75						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO JSC 11174 SHEET 10.2 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS72-948099 SHEET 24 ZONE B4

ELEMENT: SRB SUBSYSTEM: SRB E&I

LCC VIOLATION CALL: SRM Ignition Fire 2 Test Power ON Command Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B55X1916X	LH Event Ign A F2 Test Pwr ON Cmd		OFF	NA	Event	DI
B55X2916X	RH Event Ign A F2 Test Pwr ON Cmd		OFF	NA	Event	DI
B55X1917X	LH Event Ign B F2 Test Pwr ON Cmd		OFF	NA	Event	DI
B55X2917X	RH Event Ign B F2 Test Pwr ON Cmd		OFF	NA	Event	DI

TIME PERIOD:

(1) Verify at approximately T-50 seconds after Fwd MDM Lockout (T-55 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) Ignition Systems A and B are totally redundant.
(3) These measurements are not in telemetry. Must perform launch data bus read to verify.

REDLINE DERIVATION: CRITICALITY:

(4) These redlines verify that the ignition Fire 2 test power ON commands are OFF after locking out the forward MDM.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Create a race condition between Fire 1 and Fire 2 commands that would cause loss of system redundancy if Fire 2 appears first at the PIC input.

CAUSES OF EXCEEDING REDLINE:

(6) Shorted transistor in normally open switch.
(7) MDM output fails high.
(8) MDM output inadvertently commanded high.
(9) Instrumentation malfunction.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS72-946099 SHEET 26 ZONE H14

ELEMENT: SRB SUBSYSTEM: SRB E&I

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SECTION 14

BOOSTER SEPARATION SUBSYSTEM

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SECTION 14: BOOSTER SEPARATION SUBSYSTEM

SSID No.	Description/Violation Call	Page
BSEP-01	SRB Separation PIC's Cap Voltage Anomaly	14-01.1
BSEP-02	SRB Aft BRC Separation Bolt PIC Cap Voltage (REQUIREMENT DELETED)	14-02.1
BSEP-03	SRB Forward Separation Motor PIC Cap Voltage (REQUIREMENT DELETED)	14-03.1
BSEP-04	SRB Aft Separation Motor PIC Cap Voltage (REQUIREMENT DELETED)	14-04.1
BSEP-05	Separation Fire 2 Test Power ON Command Anomaly	14-05.1
BSEP-06	SRB Separation Auto Command Anomaly	14-06.1

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LCC VIOLATION CALL: SRB Separation PIC's Cap Voltage Anomaly | EMERG COND: Yellow (4)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B55V1605C	LH Voltage Fwd Thr Pin PIC Cap A		NA	1.5	Vdc	CI
B55V1607C	LH Voltage Aft Upr Brc PIC Cap A		NA	1.5	Vdc	CI
B55V1609C	LH Voltage Aft Mid Brc PIC Cap A		NA	1.5	Vdc	CI
B55V1611C	LH Voltage Aft Lwr Brc PIC Cap A		NA	1.5	Vdc	CI
B55V1613C	LH Voltage Fwd Sepn Mot PIC Cap A		NA	1.5	Vdc	CI
B55V1615C	LH Voltage Aft Sepn Mot PIC Cap A		NA	1.5	Vdc	CI
B55V1606C	LH Voltage Fwd Thr Pin PIC Cap B		NA	1.5	Vdc	CI
B55V1608C	LH Voltage Aft Upr Brc PIC Cap B		NA	1.5	Vdc	CI
B55V1610C	LH Voltage Aft Mid Brc PIC Cap B		NA	1.5	Vdc	CI
B55V1612C	LH Voltage Aft Lwr Brc PIC Cap B		NA	1.5	Vdc	CI
B55V1614C	LH Voltage Fwd Sepn Mot PIC Cap B		NA	1.5	Vdc	CI
B55V1616C	LH Voltage Aft Sepn Mot PIC Cap B		NA	1.5	Vdc	CI
B55V2605C	RH Voltage Fwd Thr Pin PIC Cap A		NA	1.5	Vdc	CI
B55V2607C	RH Voltage Aft Upr Brc PIC Cap A		NA	1.5	Vdc	CI
B55V2609C	RH Voltage Aft Mid Brc PIC Cap A		NA	1.5	Vdc	CI
B55V2611C	RH Voltage Aft Lwr Brc PIC Cap A		NA	1.5	Vdc	CI
B55V2613C	RH Voltage Fwd Sepn Mot PIC Cap A		NA	1.5	Vdc	CI
B55V2615C	RH Voltage Aft Sepn Mot PIC Cap A		NA	1.5	Vdc	CI
B55V2606C	RH Voltage Fwd Thr Pin PIC Cap B		NA	1.5	Vdc	CI
B55V2608C	RH Voltage Aft Upr Brc PIC Cap B		NA	1.5	Vdc	CI
B55V2610C	RH Voltage Aft Mid Brc PIC Cap B		NA	1.5	Vdc	CI
B55V2612C	RH Voltage Aft Lwr Brc PIC Cap B		NA	1.5	Vdc	CI
B55V2614C	RH Voltage Fwd Sepn Mot PIC Cap B		NA	1.5	Vdc	CI
B55V2616C	RH Voltage Aft Sepn Mot PIC Cap B		NA	1.5	Vdc	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) Determine if any of the five other Separation PICs on bus A or B, forward and aft, also violated the redline. If all six PICs on one system violated their redlines, LCC violation confirmed, No Go for launch.
   A. If one or more PICs on the failed system (left hand A, left hand B, right hand A, or right hand B) did not violate their redline perform an MDM DCID BITE test. If the DCID BITE test confirms a failed measurement channel corresponding to the failed PIC(s) and confirms normal measurement channel operation for the PIC(s) which did not violate the redline, LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

B. If the DCID BITE test does not confirm failed and operational measurement channels corresponding to the failed PIC(s) and the PIC(s) which did not violate the redline, LCC violation confirmed, No Go for launch.

NOTES:

REDLINE DERIVATION: CRITICALITY:

(3) The Shuttle Integrated Avionics Panel has defined the Pyrotechnic Initiator Controller (PIC) low voltage as 1.5 V maximum.
(4) The separation system PICs supply the voltage to initiate the NASA Standard Initiator (NSI) pressure cartridges that shear the separation bolts and ignite the Booster Separation Motors (BSMs). The function of this redline is to ensure that the PICs are not prematurely charged.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Remote possibility of premature separation (multiple failures required).

CAUSES OF EXCEEDING REDLINE:

(6) Circuit failure.
(7) Premature arm commands.
(8) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1 for left booster, 2 for right booster									
UNITS-->	Vdc								
B55Vn605C	.0815	0	40.75						
B55Vn607C	.0815	0	40.75						
B55Vn609C	.0815	0	40.75						
B55Vn611C	.0815	0	40.75						
B55Vn613C	.0815	0	40.75						
B55Vn615C	.0815	0	40.75						
B55Vn606C	.0815	0	40.75						
B55Vn608C	.0815	0	40.75						
B55Vn610C	.0815	0	40.75						
B55Vn612C	.0815	0	40.75						
B55Vn614C	.0815	0	40.75						
B55Vn616C	.0815	0	40.75						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO JSC 11174	SHEET 10.2	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS2-948099	SHEET 30	ZONE G5

ELEMENT: SRB SUBSYSTEM: SEPARATION

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SRB Aft BRC Separation Bolt PIC Cap Voltage

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SRB Forward Separation Motor PIC Cap Voltage

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SRB Aft Separation Motor PIC Cap Voltage

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LCC VIOLATION CALL: Separation Fire 2 Test Power ON Command Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B55X1914X	LH Event Sep A F2 Test Pwr ON Cmd		OFF	NA	Event	DI
B55X2914X	RH Event Sep A F2 Test Pwr ON Cmd		OFF	NA	Event	DI
B55X1915X	LH Event Sep B F2 Test Pwr On Cmd		OFF	NA	Event	DI
B55X2915X	RH Event Sep B F2 Test Pwr ON Cmd		OFF	NA	Event	DI

TIME PERIOD:

(1) Verify at approximately T-50 seconds, after Fwd MDM Lockout (T-55 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) The measurements are not in telemetry. Must perform Launch Data Bus read to verify.
(3) Separation systems A and B are totally redundant.

REDLINE DERIVATION: CRITICALITY:

(4) These redlines verify that the Separation Fire 2 Test Power ON commands are OFF.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Creates a race condition between Fire 1 and Fire 2 commands that would cause loss of system redundancy if Fire 2 command appears first at the PIC input.

CAUSES OF EXCEEDING REDLINE:

(6) Shorted transistor in normally open switch.
(7) MDM output fails high.
(8) MDM output inadvertently commanded high.
(9) Instrumentation malfunction.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS72-948099 SHEET 30 ZONE B19

ELEMENT: SRB SUBSYSTEM: Separation

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LCC VIOLATION CALL: SRB Separation Auto Command Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V90X7570X	Sel SRB Separation Auto Cmd	(2)	ON	NA	Event	CI

TIME PERIOD:

(1) From Ops 101 Transition (T-19 minutes) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) The SRB separation switch should be enabled for the AUTO mode for launch.
(3) Required for ground insight into state of the SRB separation switch.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) Measurement available in downlist format 21 only.
(5) Intent of this LCC is to identify the requirement for the measurement to be present for launch.

REDLINE DERIVATION: CRITICALITY: 1R

(6) The auto function is required for launch for the SRB separation switch.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) The auto function of the switch will be impaired. The auto function is an automatic SRB separation. A delayed SRB separation may occur which will impact vehicle performance.

CAUSES OF EXCEEDING REDLINE:

(8) Switch contact short.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET 1 of 3 ZONE
DWG NO 10.1 SHEET 2 of 4 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: SEPARATION

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SECTION 15

BOOSTER RECOVERY SUBSYSTEM

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SECTION 15: BOOSTER RECOVERY SUBSYSTEM

SSID No.	Description/Violation Call	Page
BREC-01	SRB Main Chute Disconnect PIC Voltage Anomaly (REQUIREMENT DELETED)	15-01.1
BREC-02	SRB Recovery System PIC Cap Voltage Anomaly	15-02.1
BREC-03	SRB Nose Cap Release PIC Cap Voltage (REQUIREMENT DELETED)	15-03.1
BREC-04	SRB Frustum Release PIC Cap Voltage (REQUIREMENT DELETED)	15-04.1
BREC-05	Recovery System Reset Command Event Anomaly	15-05.1

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SRB Main Chute Disconnect PIC Voltage Anomaly

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LCC VIOLATION CALL: SRB Recovery System PIC Cap Voltage Anomaly | EMERG COND: Yellow (4)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B55V1617C	LH Voltage Nose Cap Rlse PIC Cap		NA	1.5	Vdc	CI
B55V1618C	LH Voltage Frustum Rlse PIC Cap		NA	1.5	Vdc	CI
B55V1619C	LH Voltage Noz Ext Sev PIC Cap		NA	1.5	Vdc	CI
B55V2617C	RH Voltage Nose Cap Rlse PIC Cap		NA	1.5	Vdc	CI
B55V2618C	RH Voltage Frustum Rlse PIC Cap		NA	1.5	Vdc	CI
B55V2619C	RH Voltage Noz Ext Sev PIC Cap		NA	1.5	Vdc	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) See Figure 15-01 SRB Recovery System PIC Cap Voltage Flow Diagram for a contingency procedure.

NOTES:

REDLINE DERIVATION: CRITICALITY:

(3) The Shuttle Integrated Avionics Panel has defined the PIC low voltage as 1.5 V maximum.
(4) These PICs supply the voltage to initiate the NASA Standard Detonator (NSD) which ignites the Linear-Shaped Charges (LSC) that sever the nozzle extension and effect nose cap jettison and frustum separation. These redlines ensure that the PICs are not prematurely charged.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Remote possibility of premature nozzle severance, nose cap jettison, and frustum separation (multiple failures required).

CAUSES OF EXCEEDING REDLINE:

(6) Instrumentation failure.
(7) Premature closure of two normally open switches (recovery power ON and recovery system armed).

MEASUREMENT INFORMATION TABLE:

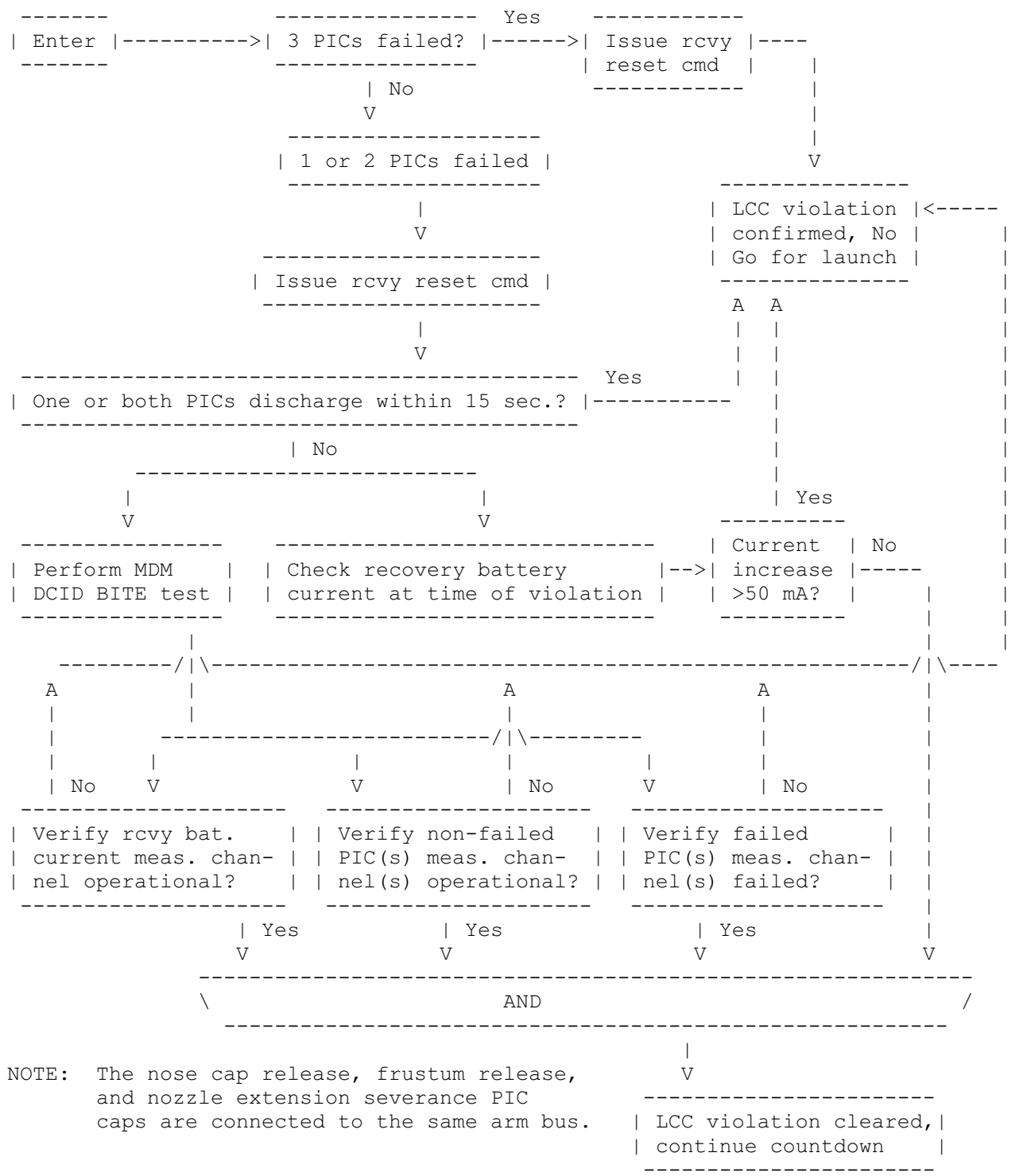
MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1 for left booster, 2 for right booster									
UNITS-->	Vdc								
B55Vn617C	.0815	0	40.75						
B55Vn618C	.0815	0	40.75						
B55Vn619C	.0815	0	40.75						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO JSC 11174 SHEET 5.4 ZONE P4
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS72-948099 SHEET 38 ZONE 013

ELEMENT: SRB SUBSYSTEM: Recovery

SUPPORTING DATA:



NOTE: The nose cap release, frustum release, and nozzle extension severance PIC caps are connected to the same arm bus.

Figure 15-01 SRB Recovery System PIC Cap Voltage Flow Diagram

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SRB Nose Cap Release PIC Cap Voltage

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SRB Frustum Release PIC Cap Voltage

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LCC VIOLATION CALL: Recovery System Reset Command Event Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B52X1907X	LH Ev Recovery Sys Reset Cmd		OFF	NA	Event	DI
B52X2907X	RH Ev Recovery Sys Reset Cmd		OFF	NA	Event	DI

TIME PERIOD:

(1) Verify at approximately T-50 seconds after Fwd MDM Lockout (T-55 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) These measurements are not in telemetry. Must perform launch data bus read to verify.

REDLINE DERIVATION: CRITICALITY:

(3) These redlines verify that the recovery system reset commands are OFF after locking out the forward MDM.

CONSEQUENCES OF EXCEEDING REDLINE:

(4) Inability to deploy the SRB recovery subsystem because of power being inhibited from the recovery system logic resulting in failure to recover an SRB.

CAUSES OF EXCEEDING REDLINE:

(5) MDM output fails high.
(6) MDM output inadvertently commanded high.
(7) Instrumentation malfunction.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SRB SUBSYSTEM: RECOVERY

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SECTION 17

EXTERNAL TANK SUBSYSTEMS

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SECTION 17: EXTERNAL TANK SUBSYSTEMS

SSID No.	Description/Violation Call	Page
ET-01	ET Nose Cone Temperature Anomaly	17-01.1
ET-02	ET Nose Cone Purge Termination Anomaly	17-02.1
ET-03	ET LO2 Helium Injection Termination Anomaly	17-03.1
ET-04	External Tank LH2 Prepressurization Cycle Anomaly	17-04.1
ET-05	ET LH2 Ullage Pressure/Transducer Anomaly	17-05.1
ET-06	ET LO2 Ullage Pressure/Transducer Anomaly	17-06.1
ET-07	External Tank Intertank Temperature Anomaly	17-07.1
ET-08	ET Intertank Purge Termination Anomaly	17-08.1
ET-09	ET LH2 Flight Level Anomaly	17-09.1
ET-10	ET LO2 Flight Level Anomaly	17-10.1
ET-11	External Tank Tumble System Armed Indication Anomaly (REQUIREMENT DELETED)	17-11.1
ET-12	ET Bipod Heater System Deadfacing Anomaly	17-12.1
ET-13	ET Bipod Slot Temp Anomaly	17-13.1
ET-14	ET Bipod Web Temp Anomaly	17-14.1
ET-15	ET Camera System Deadfacing Anomaly	17-15.1
ET-16	ET LO2 Feedline Bellows Heater Current Anomaly	17-16.1
ET-17	ET LO2 Feedline Bellows Heater System Deadfacing Anomaly	17-17.1
ET-FG01	Figure 17-01 Contingency ET Nose Cone Heated Purge (Heater Outlet) Temperature Requirements	17-FG01.1
ET-FG02	Figure 17-02 ET Intertank Purge Heater Outlet Temperature	17-FG02.1

SECTION 17: EXTERNAL TANK SUBSYSTEMS (CONTINUED)

SSID No.	Description/Violation Call	Page
ET-FG03	Figure 17-03 ET GH2 Prepress Cycle Count Definition	17-FG03.1

LCC VIOLATION CALL: ET Nose Cone Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
T41T1820H	Nose Cone Gas Temp No. 1	(2,3)	5	137	deg F	CI
T41T1821H	Nose Cone Gas Temp No. 2	(2,3)	5	137	deg F	CI
GLOT4104A	A106532 Pri NC Htd Prg Temp	(2,4)	(6)	(6)	deg F	BU
GLOT4604A	A106533 Sec NC Htd Prg Temp	(2,4)	(6)	(6)	deg F	BU

TIME PERIOD:

(1) From Prior to Start of LO2 Transfer Line Chilldown (T-6 hours) to ET Nose Cone Purge termination (T-75 seconds)

REQUIREMENTS: FIGURES/TABLES: Figure 17-01

(2) One of two measurements acceptable for confirmed instrumentation failure only. (5)
(3) For readings below 45 degrees F, see Appendix F (SSID: ICE-01) for potential ice formation at nose cone fairing exit.
(4) For confirmed instrumentation failure of both Nose Cone Gas Temp No. 1 and 2 measurements, switch to backup measurements. (5,6)

PREPLANNED CONTINGENCY PROCEDURE:

(5) If measurement is determined to be providing invalid data, instrumentation failure is confirmed. LCC violation cleared, continue countdown.
(6) Reference OMI S1003 for the following contingency procedure for failure of both Nose Cone Gas Temp No. 1 and 2 measurements:
    (A) If both measurements fail prior to topping, and a previous tanking for this ET with a nominal nose cone heated purge performance has not taken place, stop flow. LCC violation confirmed, No Go for launch.
    (B) If both measurements fail prior to topping, and a previous tanking for this ET has taken place with a nominal nose cone heated purge performance, switch to Nose Cone Heated Purge Temperature (Heater Outlet) Control, and use Figure 17-01.
    (C) If both measurements fail after start of topping, switch to Nose Cone Heated Purge Temperature Control with a setpoint of 285 deg F. The operational maximum temperature for the Nose Cone Heated Purge (Heater Outlet) is 350 deg F (ref. OMRSD S00FB0.330).
    (D) Minimum and maximum temperature limits will be determined day of launch based on ambient conditions and temperature data from either a previous loading of this ET or being complete through start of LO2 topping to prevent violation of the Nose Cone temperature limits.

NOTES:

(7) Primary heater controller controls to only primary temperature measurements. Secondary heater controller controls to only secondary temperature measurements.

REDLINE DERIVATION: CRITICALITY: 1R

(8) Redlines have been established for the following reasons:
A. Minimum
1. The LO2 ullage pressure transducers can operate to -30 deg F without violating the operating pressure band accuracy requirements. The 5 deg F Nose Cone compartment gas temperature will protect the transducer -30 deg F minimum temperature limit.
B. Maximum
1. LO2 ullage pressure transducers are calibrated to 140 deg F.

(9) Redline Development:

	Min	Max	
Basic Redline	0	140	deg F
Instrumentation System Error	+5	-3	
Redline	5	137	deg F

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Inaccurate ullage pressure readings.

CAUSES OF EXCEEDING REDLINE:

(11) Improper purge flow, pressure, and temperature caused by clogged filter, closed valve (A106425 NC Prg Redundant SOV Cld), or heater malfunction.
(12) Temperature sensor or electrical failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	deg.F								
T41T1820H	0.648	-4	158						
T41T1821H	0.648	-4	158						
GLOT4104A	1.8	50	500						
GLOT4604A	1.8	50	500						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO NA SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: External Tank SUBSYSTEM: LO2

LCC VIOLATION CALL: ET Nose Cone Purge Termination Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GLOP4195A	A106437 Pri NC Ht GN2 Out Pg Press	(2)	NA	1800	psig	DI
GLOP4695A	A106438 Sec NC Ht GN2 Out Pg Press	(2)	NA	1800	psig	DI

TIME PERIOD:

(1) Verify after T-50 seconds and prior to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 measurements acceptable for confirmed instrumentation failure. (3,4)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Reference OMI S1003 for a Preplanned Contingency Procedure for ET Nose Cone Heated GN2 Purge Out Pressure instrumentation failure. This Procedure uses backup measurements (Nose Cone Purge Valve Closed Indications) to confirm termination of Nose Cone Heated GN2 Purge.
(4) The following valve indicators are backups to output pressure. Closed indicators must indicate ON.
GLOX4103E A106424 Pri NC Prg Vlv Cld
GLOX4603E A106426 Sec NC Prg Vlv Cld
GLOX4193E A106425 NC Prg Redundant SOV Cld

NOTES:

(5) While nose cone purge is flowing, only one of the purge shutoff valves is open (primary or secondary). The other valve is closed (energized).

REDLINE DERIVATION: CRITICALITY: 1R

(6) This redline verifies that the nose cone purge is terminated prior to Ground Umbilical Carrier Plate (GUCP) separation to prevent ET TPS damage due to high velocity gas impingement.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Possible ET intertank structural failure during ascent due to TPS removal.

CAUSES OF EXCEEDING REDLINE:

(8) Either the primary or secondary pneumatic shutoff valve and the redundant shutoff valve fails to close. (Valves are normally open.)
(9) Failure of LPS to terminate purge.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	psig								
GLOP4195A	20	0	5000						
GLOP4695A	20	0	5000						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO NA SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: External Tank SUBSYSTEM: LO2

LCC VIOLATION CALL: ET LO2 Helium Injection Termination Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GLOP4144A	A86927 Pri He Bub Diff Press	2	NA	0.1 (2)	psid	CI
GLOP4644A	A140411 Sec He Bub Diff Press	of	NA	0.1 (2)	psid	CI
GLOP4134A	A78419 He Bub Output Press	3	NA	125 (2)	psig	CI
GLOX4143E	A78412 He Bub Pri Cntl Vlv Open		NA	OFF	Event	BU
GLOX4643E	A78411 He Bub Sec Cntl Vlv Open		NA	OFF	Event	BU

TIME PERIOD:

(1) From T-200 seconds to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) For redline exceedence or confirmed loss of two measurements, use remaining measurement plus backup measurements. (3)(4)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Instrumentation failure is confirmed for a measurement indicating off scale high or low, exhibiting a step function change or functioning erratically. LCC violation cleared, continue countdown.

(4) For indication of Helium Bubbling Reinitiation after Termination, perform the following (ref. S1003 Inadvertent He Bubbling Reactivation After Termination During Terminal Count Seq.):
- Configure the A78410 Helium Bubbling Secondary Select Control Valve (GLOX4633E) to isolate the failed component.
- Verify 2 of 3 pressures indicate Helium Bubbling has terminated.
- Confirm termination for 159 seconds prior to RSLS Start.

LCC violation cleared, continue countdown.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1

(5) a. SSID Intent Summary - The intent of this SSID is to ensure that helium injected into the LO2 Feed Line will have exited the Feed Line and entered the tank prior to engine start. Excessive helium in the LO2 Feed Lines could cause SSME pumps to overspeed with subsequent engine cutoff and possible engine damage. Helium is injected into the LO2 Feed Line during LO2 Load to prevent the formation of Taylor bubbles and to provide subcooling of the liquid oxygen. The helium is supplied through a remotely operated primary control valve or a remotely operated secondary control valve. Additionally, a downstream remotely operated secondary select valve is used in conjunction with the primary or secondary control valve to regulate helium flow. Visibility of flow is

REDLINE DERIVATION: (Continued)

provided by two delta pressure transducers upstream of the valves and by a pressure transducer downstream of the valves. The system is two fault tolerant.

b. Voting Logic - Helium injection termination is monitored by a primary delta pressure transducer, a secondary delta pressure transducer and an output pressure transducer. If one measurement exceeds the redline limits while the other two remain within limits, it is most likely an instrumentation failure. The remaining two measurements will still provide adequate insight to verify termination of helium injection.

c. Maximum Redline Development - Space Shuttle Orbiter Vehicle/Main Engine ICD-13M15000 paragraph 4.2.2. states that the maximum helium flow rate from the LO2 feed line into the engine low pressure pump shall not exceed 0.032 lb/sec. Additionally, the maximum helium flow rate from the engine accumulator into the LO2 feed line shall not exceed 0.027 lb/sec. Therefore, the resultant 0.005 lb/sec (0.032 lb/sec - 0.027 lb/sec) of helium can be allocated for helium bubbling flow.

Based on the Lockheed-Martin equation for helium bubbling flow rate with worst case 496 degree Rankine helium at 800 psig pressure, a 0.005 lb/sec flow rate yields a delta pressure of 0.230 psid.

For GLOP4144A and GLOP4644A:

Basic Redline	0.230	psid
Instrumentation Error	-0.07	psid

Technical Redline	0.160	psid

Actual Redline of 0.1 psid protects for a 0.003 lb/sec flow rate thus providing conservatism.

Empirical data generated through hardware testing post STS-117 indicated a minimum output pressure value of approximately 190 psig was required to achieve a delta pressure of approximately 0.1 psid.

For GLOP4134A:

Basic Redline	190	psig
Instrumentation Error	-30	psig

Technical Redline	160	psig

The empirical data generated was based on GSE hardware configuration, facility pneumatic regulator setting and ambient temperatures on the day of testing.

Actual Redline of 125 psig provides additional conservatism to account for system variability.

The backup measurement redlines are used as an indication of valve positioning.

REDLINE DERIVATION: (Continued)

d. Time Period - Verification of helium injection termination begins at T-200 seconds. This start time allows sufficient time for GSE measurements to stabilize after helium injection termination. It also ensures that 3 minutes minimum time has elapsed from purge termination to SSME start. Analysis has shown that a minimum of 3 minutes time is required for helium to exit the main feedline and enter the tank. Verification to the end time at T-31 seconds provides protection against inadvertent purge reactivation during this time interval.

e. Requirements - Helium injection must be terminated a minimum of 3 minutes prior to SSME Start. The maximum pressure redlines in the Measurement Description Table are an indication that this has occurred. In the case of instrumentation failure on two of these measurements the Helium Bubbling Control Valve position indicators may be used as a backup.

f. Preplanned Contingency Procedure - If instrumentation failure is confirmed or maximum limit exceeded on 2 of 3 primary pressure measurements, the position indicators of the primary and secondary helium bubbling control valves along with the remaining pressure measurement will give a reliable indication of helium injection termination. In the case where a control valve does not close or leaks, the valve may be isolated using the secondary select control valve. If isolation is successful launch may proceed as long as 3 minutes remain prior to SSME Start.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Possible failure of engine(s) because of helium gas ingestion.
(7) Reference hazard report IMPS-03 and ISPR-02.

CAUSES OF EXCEEDING REDLINE:

(8) Helium inject solenoid valve leaks or fails to close.
(9) Failure of LPS to terminate injection.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
UNITS-->	psid								
GLOP4144A	0.008	0	2.0						
GLOP4644A	0.008	0	2.0						
UNITS-->	psig								
GLOP4134A	6.0	0	1500						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO NA	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: External Tank SUBSYSTEM: LO2

LCC VIOLATION CALL: External Tank LH2 Prepressurization Cycle Anomaly | EMERG COND: Yellow (5)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GLHK4521ER	HRS A75616 ET Prs Pr Ctl Vlv O Cmd	1 of 2	NA	(2)	Event	DI
GLHK4531ER	HRS A75617 ET Pr Sec Ctl Vlv O Cmd	2	NA	(2)	Event	DI

TIME PERIOD:

(1) Verify prior to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES: Figure 17-03

(2) For 0.5 second prepress pulses, maximum of 13 command cycles during prepressurization.
A. Start counting command cycles after initial pressurization.
B. Stop counting command cycles at T-43 seconds.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 1

(3) a. SSID Intent Summary - Mitigates the potential for excessive in-flight GH2 leakage through the vent valve, flanges, and pressurization lines. The system is two fault tolerant.

b. Voting Logic - Counts the number of GH2 prepress 0.5 second pulses/ command cycles (a pulse is a single command cycle for the prepress valves when commanded open and then closed) and verifies less than 14. Verification may be accomplished using either primary or secondary control valve open commands.

c. Minimum and Maximum Redline Development - The maximum redline value is based on analysis of the STS-91 SLWT Tanking Test that predicted 13 command cycles or less when 0.5 second prepress pulses are used. The leak rate analysis was further refined to account for variation in ambient temperature, helium supply pressure and prepress valve timing. The analysis confirmed that the maximum cycle of 13 is still valid. The ambient temperature is restricted by LCC WEA-01, the helium supply pressure is controlled procedurally and the valve timing is controlled by File II OMRSD S00FA0.165. A minimum redline limit is not required.

d. Time Effectivity - The start time for the pulse count begins after the LH2 tank ullage pressure reaches the control band during LH2 terminal count and the prepress valves go closed. The end time of T-43 seconds establishes a fixed period of time of prepress pulses (helium mass). This also provides enough time to calculate the pulse count and notify

REDLINE DERIVATION: (Continued)

GLS prior to Go for RSLS.

e. Requirements - The number of times the LH2 prepress valves are pulsed (open for 0.5 seconds and then closed) is used to account for the mass of helium going into the ET LH2 tank ullage vs. the expected ullage pressure drop due to: 1) LH2 liquid surface and tank wall thermal cooling effects, and 2) system leakage. The predicted maximum leak rate (0.16 lb/s) occurs when the prepress valve timing is at its maximum (0.56 seconds per File II OMRSD S00FA0.165) and the ambient temperature is at the LCC WEA-01 minimum (36 degrees F). At this worst case condition the number of prepress pulses would be much less than nominal (5 cycles vs. 9 nominal) and a leak up to the 13 limit is assumed to be due to system leakage (5 prepress cycles plus 8 cycles due to leakage).

f. Preplanned Contingency Procedures - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(4) Possible failure to maintain pressurization control authority during ascent.
(5) Possible reduction in LH2 tank structural safety margin (factor of safety) in collapse mode.
(6) Early engine shutdown because of loss of Net Positive Suction Pressure.
(7) Possible in-flight relief and loss of usable propellant.
(8) Possible adverse structural heating resulting from early in-flight relief.
(9) Reference integrated hazard reports IMPS-05, IMPS-06, IMPS-09, ISPR-02 and ISPR-03.

CAUSES OF EXCEEDING REDLINE:

(10) Leakage in prepressurization system and/or LH2 tank.
(11) Malfunction in pressurization system (software and/or hardware).

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO NA SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: External Tank SUBSYSTEM: LH2

LCC VIOLATION CALL: ET LH2 Ullage Pressure/Transducer Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
T41P1700C	ET-LH2 Ullage Press No 1	(2)	45.6	47.5	psia	CI
T41P1701C	ET-LH2 Ullage Press No 2	(2)	45.6	47.5	psia	CI
T41P1702C	ET-LH2 Ullage Press No 3	(2)	45.6	47.5	psia	CI
Spare	ET-LH2 Ullage Press No 4	(2,3)	45.6	47.5	psia	BU

TIME PERIOD:

(1) From T-75 seconds to Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) A single transducer violating the maximum limit of 47.5 psia will be assumed biased high as long as the remaining two transducers indicate between 45.6 and 47.5 psia. The new maximum limit for the single biased high transducer will be changed to 48.4 psia.

(3) A transducer violating the redlines in effect will be assumed failed. The fourth transducer is a spare and will be utilized in the event of a failure of transducer 1, 2, or 3. Switching to the spare for a failed transducer will take place unless the spare has been switched previously. The spare transducer assumes the MSID of the transducer it is replacing. Revert to initial maximum limit of 47.5 psia after switching that transducer, thus allowing the bias high to subsequently be employed, if necessary.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) Refer to OMRSD File II, Volume 1, requirement S00FM0.400 for specifics of the GH2 prepress mechanization.

REDLINE DERIVATION: CRITICALITY: 1R

(5) a. SSID Intent Summary - Sufficient ullage pressure is required to meet engine start conditions, ensure tank structural margins are maintained and preclude tank venting through the relief valve.

b. Voting Logic - NA

c. Redline Development - The redlines were established to verify the three transducers are functional, ensure proper pressure control for Orbiter flow control valves, and to ensure acceptable ullage pressure in the event of a failure of one flow control valve system after the end of monitoring.

REDLINE DERIVATION: (Continued)

The minimum and maximum redline value was derived as follows:

Minimum LCC value	45.6
Transducer Accuracy	+ 0.9
Prepress trip point	46.5
Maximum pressure rise per pulse	+ 1.0
Maximum LCC value	47.5

The minimum redline protects ET structural stability safety factors and assures adequate Net Positive Suction Pressure and nominal engine start performance. The maximum redline protects against in-flight relief, prevents a violation of structural proof tests, maintains structural factors of safety and protects the ET LH2 tank minimum cracking pressure (35.8 psig) to preclude GH2 venting during prepress. Instrumentation error allowance is accounted for by the requirement that allows a single transducer to indicate up to 48.4 psia.
This value provides 0.5 psi margin to inadvertent GH2 venting based on the following derivation:

Minimum Cracking Pressure	35.8 psig
Allowance for Vibrational and Thermal Effects	-1.5 psi
	34.3 psig
Conversion of Atmospheric Pressure	+14.7 psi
	49.0 psia
Correction for GH2 Relief Valve Elevation	-0.1 psi
	48.9 psia
Maximum LCC Pressure	-48.4 psia
Margin	0.5 psi

d. Time Period - The beginning of the monitoring period was chosen to allow sufficient time from start of prepress (T-1:46) for the ullage pressure to increase within limits. The end of the monitoring period was chosen to ensure the ullage pressure is in limits, thus ensuring engine start conditions are met prior to engine Start Enable (T-9.5 sec).

e. Requirements - Allows for an increased maximum limit in the event of a biased transducer, because the remaining two good transducers are sufficient to control proper prepress cycling. A spare transducer allows for a switch to replace a failed transducer and maintain three ullage pressure measurements.

f. Preplanned Contingency Procedures - NA

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Possible failure to maintain pressure control authority during ascent.
(7) Possible reduction of LH2 tank structural safety margin (factor of safety).
(8) Early engine shutdown because of loss of Net Positive Suction Pressure.
(9) Possible in-flight relief and loss of usable propellant.
(10) Possible adverse structural heating from early in-flight relief.
(11) Possible failure to obtain ENGINE READY.
(12) Reduced High Pressure Fuel Turbo Pump (HPFTP) reuse due to excessive temperature spike during start transient.

CAUSES OF EXCEEDING REDLINE:

(13) Vent valve leakage.
(14) Supply line leakage.
(15) Supply line or filter blockage.
(16) Sensor line leakage.
(17) Orbiter electronics or ET instrumentation failure.
(18) Failure of helium prepress valve to OPEN/CLOSE.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	psia								
T41P1700C	0.08	12	52					28.0	48.9
T41P1701C	0.08	12	52					28.0	48.9
T41P1702C	0.08	12	52					28.0	48.9

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.10 SHEET 1 ZONE D6
DWG NO 10.12 SHEET 1 ZONE Q8
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: External Tank SUBSYSTEM: LH2

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LCC VIOLATION CALL: ET LO2 Ullage Pressure/Transducer Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
T41P1750C	ET-LO2 Ullage Press No 1	2 of 3	19.3(2)	22.5	psig	CI
T41P1751C	ET-LO2 Ullage Press No 2		19.3(2)	22.5	psig	CI
T41P1752C	ET-LO2 Ullage Press No 3		19.3(2)	22.5	psig	CI

TIME PERIOD:

(1) From T-133 seconds to Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) A transducer violating the redlines is assumed failed.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) After the initial pressurization cycle, a one second prepressurization pulse is initiated each time any two transducers register below 20.5 psig.

REDLINE DERIVATION: CRITICALITY: 1R

(4) The minimum and the maximum redline values include instrumentation error.
(5) Redlines have been established for the following reasons:
   A. Ensures ullage pressure is within LO2 ET structural design limits during prepress.
   B. Assures system pressure is adequate for nominal engine start sequence/ performance.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Possible reduction in LO2 tank structural safety margins (factor of safety/ proof factor).
(7) Possible failure to obtain ENGINE READY.

CAUSES OF EXCEEDING REDLINE:

(8) Leakage in LO2 tank.
(9) Leakage in pressurization system.
(10) Clogged orifice or filter.
(11) Orbiter electronics or ET instrumentation failure.
(12) Failure of helium prepress valve to OPEN/CLOSE.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	psig								
T41P1750C	0.06	0	30					0	29
T41P1751C	0.06	0	30					0	29
T41P1752C	0.06	0	30					0	29

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.10 SHEET 1 ZONE J4
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: External Tank SUBSYSTEM: LO2

LCC VIOLATION CALL: External Tank Intertank Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
T41T1810H	Intertank Compt Gas Temp 1	(2,3)	37(4)	84(4)	deg F	CI
T41T1811H	Intertank Compt Gas Temp 2	(2,3)	37(4)	84(4)	deg F	CI
GLHT5736A	A130350 ET/IT GN2 Purge Pri Temp	(2)	(7)	(7)	deg F	BU
GLHT5737A	A130351 ET/IT GN2 Purge Sec Temp	(2)	(7)	(7)	deg F	BU

TIME PERIOD:

(1) From T-1 Hour to T-3 Minutes

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 measurements acceptable for confirmed instrumentation failure. (5)
(3) For confirmed loss of both ET Intertank compartment gas temperature measurements, switch to backup instrumentation (Intertank heater outlet purge temperatures). (6,7)
(4) The maximum redline may be exceeded for up to 5 minutes, and the minimum may be violated for up to 15 minutes.

PREPLANNED CONTINGENCY PROCEDURE:

(5) If measurement is determined to be providing invalid data, instrumentation failure is confirmed. LCC violation cleared, continue countdown.
(6) For loss of both ET Intertank compartment gas temperature measurements, switch control to backup measurements (Intertank heater outlet purge temperatures) based on loading data for this ET. Reference OMI S1004 for a preplanned contingency procedure. LCC violation cleared, continue countdown.
(7) Minimum and maximum temperature limits will be determined day of launch based on ambient conditions and temperature data during replenish prior to the loss of both Intertank compartment temperature sensors to prevent violation of the Intertank compartment temperature limits.

NOTES:

(8) Primary heater controller controls to only primary temperature measurements. Secondary heater controller controls to only secondary temperature measurements.

REDLINE DERIVATION: CRITICALITY: 1R

(9) Redline development:

	Min	Max
Basic Redline	32 deg F	87 deg F
Instrumentation System Error	+5 deg F	-3 deg F
Redline	37 deg F	84 deg F

REDLINE DERIVATION: (Continued)

(10) Redlines have been established for the following reasons:
A. Minimum
1. Protect electrical instrumentation in Intertank.
2. Prevent ice/frost formation.
B. Maximum
1. Prevent excessive thermal stress at Intertank structural splices at lift-off.
2. Prevents excessive heat leak to LO2.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Ice/frost formation.
(12) Negative structural margin during lift-off.
(13) ET instrumentation failure.

CAUSES OF EXCEEDING REDLINE:

(14) Improper purge flow, pressure, and temperature caused by clogged filter, closed valve, or heater malfunction.
(15) Temperature sensor or electrical failure.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
UNITS-->	deg.F								
T41T1810H	.648	-4	158						
T41T1811H	.648	-4	158						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO NA SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: External Tank SUBSYSTEM: LH2

LCC VIOLATION CALL: ET Intertank Purge Termination Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GLHP5734A	A78160 ET/IT GN2 Pri Prg O/Put Prs		NA	1800	psig	DI
GLHP5735A	A78161 ET/IT GN2 Sc Pg Out Prss		NA	1800	psig	DI

TIME PERIOD:

(1) Verify between T-50 seconds and Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 measurements acceptable for confirmed instrumentation failure.

PREPLANNED CONTINGENCY PROCEDURE:

(3) Reference OMI S1004 for a Preplanned Contingency Procedure for ET Intertank GN2 Purge Output Pressure instrumentation failure. This procedure utilizes the following alternate means (i.e., purge system configuration) to confirm that termination of the ET intertank purge has occurred.

GLHK5701ER HRS A78152 ET/IT GN2 P Enb S/Off C - ON
GLHK5731ER HRS A78152 ET/IT GN2 PRG O/P-S/F C - ON
GLHX5733E A78147 ET/IT GN2 Prg O/Pt Vlv Cl I - ON
OR
GLHK5801ER HRS A78150 ET/IT GN2 Pg Clsd Enb C - ON
GLHK5721ER HRS A78150 ET/IT GN2 Prg Clsd Cmd - ON
GLHX5723E A78145 ET/IT Prg Vlv Cl Ind - ON

NOTES:

(4) A78147 high-flow purge (110 #/minute nominal) is terminated at T-93 seconds. A78146 reduced flow purge (36 #/minute nominal) is terminated at T-30 seconds. Reduced purge ensures minimal Oxygen intrusion into the Intertank during a Hold at T-31 seconds thereby preventing an excessive Oxygen concentration in the intertank during flight. Termination of reduced flow purge is not required prior to lift-off.

REDLINE DERIVATION: CRITICALITY: 1R

(5) This requirement verifies that the ET intertank heated high-flow purge is terminated prior to Ground Umbilical Carrier Plate (GUCP) separation to prevent External Tank TPS damage due to high velocity gas impingement.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Possible ET intertank structural failure during ascent due to TPS removal.

CAUSES OF EXCEEDING REDLINE:

(7) Failure of LPS to terminate heated high-flow purge.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	psig								
GLHP5734A	20	0	5000						
GLHP5735A	20	0	5000						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO NA SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: External Tank SUBSYSTEM: LH2

LCC VIOLATION CALL: ET LH2 Flight Level Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
D41T1720A	ET-LH2 100 Pct Liq Lvl Snr 2 - Sec (100% Plus Liquid Level Sensor)		NA	15	% wet	DI
D41T1717A	ET-LH2 100 Pct Liq Lvl Snr 1 - Sec (100% Minus Liquid Level Sensor)		40	NA	% wet	DI
	OR					
D41T1718A	ET-LH2 100 Pct Liq Lvl Snr 1 - Pri (100% Liquid Level Sen 1)	1 of 2	10	70	% wet	DI
D41T1719A	ET-LH2 100 Pct Liq Lvl Snr 2 - Pri (100% Liquid Level Sen 2)		10	70	% wet	DI

TIME PERIOD:

(1) Verify at Termination of LH2 Replenish (T-1 minute 57 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) Loading accuracy using Plus/Minus sensors is 0.37%.
Loading accuracy using 100% sensors is 0.35%.
(3) Probability of redline violation is greater if the 100% sensors are used.

REDLINE DERIVATION: CRITICALITY: 1R

(4) These sensors indicate that the ET LH2 flight level is loaded at termination of replenish.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Early SSME shutdown due to low liquid level cutoff.

CAUSES OF EXCEEDING REDLINE:

(6) Level transducer sensing element shorted or failed electrically open - wet indication.
(7) Excessive wire harness or connector resistance.
(8) Orbiter signal conditioner failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	% wet								
D41T1720A	0.4	0	100						
D41T1717A	0.4	0	100						
D41T1718A	0.4	0	100						
D41T1719A	0.4	0	100						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.10 SHEET 1 ZONE I4, I5
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS72-941099 SHEET 117 ZONE E11

ELEMENT: External Tank SUBSYSTEM: LH2

LCC VIOLATION CALL: ET LO2 Flight Level Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
D41T1767A	ET-LO2 99.85 Pct Sensor Pct Wet		65	NA	% wet	DI
D41T1770A	ET-LO2 100.15 Pct Sensor Pct Wet		NA	35	% wet	DI
	OR					
D41T1768A	ET-LO2 100 Pct Snsr No 1 Pct Wet	1	15	75	% wet	DI
D41T1769A	ET-LO2 100 Pct Snsr No 2 Pct Wet	of	15	75	% wet	DI
D41T1770A	ET-LO2 100.15 Pct Sensor Pct Wet	3	15	75	% wet	DI

TIME PERIOD:

(1) Verify near LO2 Replenish Termination but prior to Go for APU Start (T-5 minutes)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) Loading accuracy using 99.85% and 100.15% sensors is 0.43%.
Loading accuracy using 100% or 100.15% sensors is 0.42%.

(3) a. The most likely failure mode of any liquid level sensor circuit is to the wet state. ET liquid level percent wet values are derived from corresponding ET liquid level discrete (WET/DRY) values. These calculations are performed in a LPS Front End Processor.
b. A delta greater than 30% between the 100% No. 1 and No. 2 sensors indicates a potential liquid level sensor failure. The sensor indicating the higher percent wet is suspect.

(4) ET propellant liquid level is one of the critical parameters required to verify flight mass.

(5) From the start of LO2 Replenish until the start of LO2 Terminal Countdown sequence (Replenish Termination), ET LO2 liquid level is controlled by the 100% No. 1 sensor. If this sensor fails, it is bypassed in the loading software and the 100% No. 2 sensor assumes control. If the 100% No. 2 sensor should subsequently fail, it will be bypassed and the 100.15% sensor will assume control. If the 100.15% sensor should subsequently fail, LCC liquid level verification is no longer possible. Target ET LO2 liquid level during this time period is 50% wet on the controlling sensor.

REDLINE DERIVATION: CRITICALITY: 1R

(6) a. SSID Intent Summary - These sensors indicating within the limits specified by this requirement verify that the ET LO2 tank is loaded to the required liquid level "near LO2 Replenish Termination and prior to Go for APU Start". The system is dual fault tolerance for loss of sensors.

REDLINE DERIVATION: (Continued)

b. Voting Logic - LCC definition of LO2 flight level is: 1) Greater than or equal to 65% wet on the 99.85% sensor and less than or equal to 35% wet on the 100.15% sensor OR 2) 1 of 3 of the group of sensors consisting of the 100% No. 1, 100% No. 2 and 100.15% sensor indicating between 15% and 75% wet.

c. Minimum and Maximum Redline Development - Minimum and maximum redline values are set to assure that prior to LO2 Replenish Termination, the LO2 within the External Tank is being maintained at a stable level that will satisfy all aspects of mission performance including total LO2 mass on board for SSME operation through MECO and correct initial ullage volume for nominal prepress and repress operations.

d. Time Effectivity - ET LO2 liquid level is maintained through a complex closed loop algorithm implemented by LO2 application software. It is an artifact of this control process that the liquid level will modulate in and out of the limits imposed per this LCC during normal execution of the control loop. Should this modulation result in an excursion outside LCC limits late in the count, a verification performed "near LO2 Replenish Termination but prior to Go for APU Start (T-5 minutes)" allows for the ET liquid level to return to within flight limits prior to final verification with no violation of a specific time check.

e. Requirements - In order to take full advantage of the five sensor array bracketing the nominal elevation for desired ET LO2 liquid level at LO2 Replenish Termination, this LCC provides two methods for acceptable liquid level verification. Method one utilizes the 99.85% sensor at a minimum of 65% wet and the 100.15% sensor at a maximum of 35% wet to establish an acceptable liquid level band. The second method utilizes any one of three sensors comprised of the 100% No. 1, the 100% No. 2 or the 100.15% sensor indicating between 15% and 75% wet. The liquid level band established by the first method is the wider of the two and will return a more consistent verification that the ET LO2 liquid level is within flight limits. While the second band is slightly narrower it has the advantage of allowing acceptable liquid level verification utilizing only one sensor. Controlling to the 100.15% sensor produces a slightly higher but acceptable liquid level band.

f. Preplanned Contingency Procedures - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Premature SSME shutdown due to low LO2 liquid level cutoff.
(8) Reference integrated hazard reports IMPS-03 and IMPS-07.

CAUSES OF EXCEEDING REDLINE:

(9) Out of tolerance ullage pressure due to incorrect ullage volume at LO2 Replenish Termination with potential impacts to SSME performance.

CAUSES OF EXCEEDING REDLINE: (Continued)

(10) Level transducer sensing element shorted or failed electrically open - WET indication.
(11) Excessive wire harness or connector resistance.
(12) Orbiter signal conditioner failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	% wet								
D41T1767A	N/A	0	100						
D41T1768A	N/A	0	100						
D41T1769A	N/A	0	100						
D41T1770A	N/A	0	100						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.10 SHEET 1 ZONE O4, O5
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS72-941099 SHEET 118 ZONE F12

ELEMENT: External Tank SUBSYSTEM: LO2

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External Tank Tumble System Armed Indication Anomaly

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LCC VIOLATION CALL: ET Bipod Heater System Deadfacing Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
G56C7010A	LH BIPOD HTR 1 AC CURRENT A	2	N/A	0.03	Amps	DI
G56C7111A	LH BIPOD HTR 1 AC CURRENT B	OF	N/A	0.03	Amps	DI
G56X7011E	LH BIPOD HTR 1 ON IND	3	OFF	N/A	N/A	DI
G56C7020A	LH BIPOD HTR 2 AC CURRENT A	2	N/A	0.03	Amps	DI
G56C7121A	LH BIPOD HTR 2 AC CURRENT B	OF	N/A	0.03	Amps	DI
G56X7121E	LH BIPOD HTR 2 ON IND	3	OFF	N/A	N/A	DI
G56C7030A	LH BIPOD HTR 3 AC CURRENT A	2	N/A	0.03	Amps	DI
G56C7131A	LH BIPOD HTR 3 AC CURRENT B	OF	N/A	0.03	Amps	DI
G56X7031E	LH BIPOD HTR 3 ON IND	3	OFF	N/A	N/A	DI
G56C7040A	LH BIPOD HTR 4 AC CURRENT A	2	N/A	0.03	Amps	DI
G56C7141A	LH BIPOD HTR 4 AC CURRENT B	OF	N/A	0.03	Amps	DI
G56X7141E	LH BIPOD HTR 4 ON IND	3	OFF	N/A	N/A	DI
T56T7055H	LH BIPOD INBD SLOT TEMP A	3	N/A	2.0	Deg F	DI
T56T7155H	LH BIPOD INBD SLOT TEMP B	OF	N/A	2.0	Deg F	DI
G56X0070E	BIPOD HTR MAIN AC 1 BUS ON IND	4	OFF	N/A	N/A	DI
G56X0171E	BIPOD HTR MAIN AC 2 BUS ON IND		OFF	N/A	N/A	DI
T56T7065H	LH BIPOD OTBD SLOT TEMP A	3	N/A	2.0	Deg F	DI
T56T7165H	LH BIPOD OTBD SLOT TEMP B	OF	N/A	2.0	Deg F	DI
G56X0070E	BIPOD HTR MAIN AC 1 BUS ON IND	4	OFF	N/A	N/A	DI
G56X0171E	BIPOD HTR MAIN AC 2 BUS ON IND		OFF	N/A	N/A	DI
T56T7085H	LH BIPOD AFT WEB TEMP A	2	N/A	1.0	Deg F	DI
G56X0070E	BIPOD HTR MAIN AC 1 BUS ON IND	OF	OFF	N/A	N/A	DI
G56X0171E	BIPOD HTR MAIN AC 2 BUS ON IND	3	OFF	N/A	N/A	DI
T56T7185H	LH BIPOD AFT WEB TEMP B	2	N/A	1.0	Deg F	DI
G56X0070E	BIPOD HTR MAIN AC 1 BUS ON IND	OF	OFF	N/A	N/A	DI
G56X0171E	BIPOD HTR MAIN AC 2 BUS ON IND	3	OFF	N/A	N/A	DI
G56C8010A	RH BIPOD HTR 1 AC CURRENT A	2	N/A	0.03	Amps	DI
G56C8111A	RH BIPOD HTR 1 AC CURRENT B	OF	N/A	0.03	Amps	DI
G56X8011E	RH BIPOD HTR 1 ON IND	3	OFF	N/A	N/A	DI
G56C8020A	RH BIPOD HTR 2 AC CURRENT A	2	N/A	0.03	Amps	DI
G56C8121A	RH BIPOD HTR 2 AC CURRENT B	OF	N/A	0.03	Amps	DI
G56X8121E	RH BIPOD HTR 2 ON IND	3	OFF	N/A	N/A	DI
G56C8030A	RH BIPOD HTR 3 AC CURRENT A	2	N/A	0.03	Amps	DI
G56C8131A	RH BIPOD HTR 3 AC CURRENT B	OF	N/A	0.03	Amps	DI
G56X8031E	RH BIPOD HTR 3 ON IND	3	OFF	N/A	N/A	DI

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
G56C8040A	RH BIPOD HTR 4 AC CURRENT A	2	N/A	0.03	Amps	DI
G56C8141A	RH BIPOD HTR 4 AC CURRENT B	OF	N/A	0.03	Amps	DI
G56X8141E	RH BIPOD HTR 4 ON IND	3	OFF	N/A	N/A	DI
T56T8055H	RH BIPOD INBD SLOT TEMP A	3	N/A	2.0	Deg F	DI
T56T8155H	RH BIPOD INBD SLOT TEMP B	OF	N/A	2.0	Deg F	DI
G56X0070E	BIPOD HTR MAIN AC 1 BUS ON IND	4	OFF	N/A	N/A	DI
G56X0171E	BIPOD HTR MAIN AC 2 BUS ON IND		OFF	N/A	N/A	DI
T56T8065H	RH BIPOD OTBD SLOT TEMP A	3	N/A	2.0	Deg F	DI
T56T8165H	RH BIPOD OTBD SLOT TEMP B	OF	N/A	2.0	Deg F	DI
G56X0070E	BIPOD HTR MAIN AC 1 BUS ON IND	4	OFF	N/A	N/A	DI
G56X0171E	BIPOD HTR MAIN AC 2 BUS ON IND		OFF	N/A	N/A	DI
T56T8085H	RH BIPOD AFT WEB TEMP A	2	N/A	1.0	Deg F	DI
G56X0070E	BIPOD HTR MAIN AC 1 BUS ON IND	OF	OFF	N/A	N/A	DI
G56X0171E	BIPOD HTR MAIN AC 2 BUS ON IND	3	OFF	N/A	N/A	DI
T56T8185H	RH BIPOD AFT WEB TEMP B	2	N/A	1.0	Deg F	DI
G56X0070E	BIPOD HTR MAIN AC 1 BUS ON IND	OF	OFF	N/A	N/A	DI
G56X0171E	BIPOD HTR MAIN AC 2 BUS ON IND	3	OFF	N/A	N/A	DI

TIME PERIOD:

(1) Verify at T-40 seconds.

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) Place console Bipod Heater hardwire safing switches to OFF. If deadface requirements in measurement table above are satisfied, LCC Violation cleared, continue countdown.

NOTES:

REDLINE DERIVATION: CRITICALITY: 3

(3) a. SSID Intent summary - To verify that all power to the Ground Umbilical Carrier Plate (GUCP) interface has been terminated prior to umbilical separation.

b. Voting Logic - The 2 of 3 voting logic presented for the Bipod heater currents and associated heater ON indications accommodates for instrumentation failure while ensuring that the heater is deadfaced. The 3 of 4 and 2 of 3 voting logic presented for the slot and web temperatures and associated AC Bus indications accommodates for instrumentation failure while ensuring that the slot and web temperature

REDLINE DERIVATION: (Continued)

sensors are deadfaced.

c. Redline Development - System accuracy is derived using the Root-Sum-Squared method as follows:

	Slot Temps	Web Temps	AC Current
Baseline Reqmt*	0.0 Deg F	0.0 Deg F	0.0 Amps
Signal conditioner	NA	NA	0.015 Amps
Programmable Logic Controller (PLC) output accuracy	1.25 Deg F	0.62 Deg F	NA
Launch Processing System(LPS) accuracy	1.6 Deg F	0.8 Deg F	0.024 Amps
Total accuracy	2.0 Deg F	1.0 Deg F	0.03 Amps

* NSTS 08080-1 Standard 69 Electrical Circuits - De-energizing Requirement.

d. Time Period - Effectivity chosen based on verifying deadfacing prior to last available hold point at T-31 seconds.

e. Requirements - The requirement for deadfacing is to verify that no power exists to provide the energy to arc during the GUCP electrical connector separation.

f. Preplanned Contingency Requirements - Direction is provided to isolate power via the console safing switches. This removes power to facility AC1 and facility AC2, which provides all power to the Bipod heaters and temperature sensors.

CONSEQUENCES OF EXCEEDING REDLINE:

(4) Potential for spark to ignite hydrogen vapor at Ground Umbilical Carrier Plate during separation at T-0.

CAUSES OF EXCEEDING REDLINE:

(5) Instrumentation failure
(6) Command path failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	Amps								
G56C7010A	0.012	0	3						
G56C7111A	0.012	0	3						
G56C7020A	0.012	0	3						
G56C7121A	0.012	0	3						
G56C7030A	0.012	0	3						
G56C7131A	0.012	0	3						
G56C7040A	0.012	0	3						
G56C7141A	0.012	0	3						
G56C8010A	0.012	0	3						
G56C8111A	0.012	0	3						
G56C8020A	0.012	0	3						
G56C8121A	0.012	0	3						
G56C8030A	0.012	0	3						
G56C8131A	0.012	0	3						
G56C8040A	0.012	0	3						
G56C8141A	0.012	0	3						
UNITS-->	Deg F								
T56T7055H	0.8	0	200						
T56T7155H	0.8	0	200						
T56T7065H	0.8	0	200						
T56T7165H	0.8	0	200						
T56T7085H	0.4	0	100						
T56T7185H	0.4	0	100						
T56T8055H	0.8	0	200						
T56T8155H	0.8	0	200						
T56T8065H	0.8	0	200						
T56T8165H	0.8	0	200						
T56T8085H	0.4	0	100						
T56T8185H	0.4	0	100						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO NA SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO NA SHEET ZONE

ELEMENT: External Tank SUBSYSTEM: ET

LCC VIOLATION CALL: ET Bipod Slot Temp Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
T56T7055H	LH BIPOD INBD SLOT TEMP A	(2)	N/A	(3)	Deg F	CI
T56T7155H	LH BIPOD INBD SLOT TEMP B	(2)	N/A	(3)	Deg F	CI
T56T7065H	LH BIPOD OTBD SLOT TEMP A	(2)	N/A	(3)	Deg F	CI
T56T7165H	LH BIPOD OTBD SLOT TEMP B	(2)	N/A	(3)	Deg F	CI
T56T8055H	RH BIPOD INBD SLOT TEMP A	(2)	N/A	(3)	Deg F	CI
T56T8155H	RH BIPOD INBD SLOT TEMP B	(2)	N/A	(3)	Deg F	CI
T56T8065H	RH BIPOD OTBD SLOT TEMP A	(2)	N/A	(3)	Deg F	CI
T56T8165H	RH BIPOD OTBD SLOT TEMP B	(2)	N/A	(3)	Deg F	CI

TIME PERIOD:

(1) From start of ET LH2 Slow Fill to Term LH2 Replenish (T-1 minute 57 seconds).

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 slot temperature sensor measurements per Bipod inboard or outboard location acceptable for confirmed instrumentation failure.(4)

(3) Maximum slot temp will be as follows:
   A. For LH2 98% Liquid Level Sensors less than 50% wet, the max slot temp is 145 degrees F. Excursions above 145 degrees F, not to exceed 175 degrees F, are acceptable if the total time above the limit is less than 10 minutes.
   B. For LH2 98% Liquid Level Sensors greater than or equal to 50% wet, the max slot temp is 175 degrees F.

PREPLANNED CONTINGENCY PROCEDURE:

(4) If a temperature sensor measurement indicates off scale high or low, exhibits a step function change, indicates erratically, or sensor performance cannot be correlated with heater systems performance on the affected Bipod and opposite Bipod (web temperatures, slot temperatures and heater power levels), then instrumentation failure is confirmed, LCC violation cleared, continue countdown.

(5) If both temperature measurements in the same slot fail and the remaining slot temperature on the same Bipod fitting is within LCC limits, then LCC violation cleared, continue countdown.

NOTES:

(6) Control of the heaters at the lost slot temperature measurement location is maintained at a percentage of the other slot heater power level on the same Bipod fitting (REF OMI S0007.500 & OMRSD S00E00.A15).

REDLINE DERIVATION: CRITICALITY: 3

(7) a. SSID Intent Summary - The intent of this requirement is to define maximum allowable temperatures for the bipod copper plate slot locations in order to protect the Bipod phenolic isolator and associated Thermal Protection System (TPS) closeout from damage as well as preventing the reduction of the Bipod attachment bolt preload.

b. Voting Logic - The 1 of 2 voting logic presented for the maximum Bipod slot temperatures accommodates for instrumentation failure while ensuring the minimum visibility required to satisfy the temperature requirements.

c. Redline Development - System accuracy of Bipod slot temperature measurements is derived using the Root-Sum-Squared method as follows:

	Slot Temps
Resistance Temperature Device (RTD) accuracy	3.9 Deg F
RTD Signal conditioner accuracy	0.8 Deg F
Programmable Logic Controller (PLC) output accuracy	1.25 Deg F
Launch Processing System (LPS) accuracy	1.6 Deg F
Total system accuracy	4.5 Deg F

The maximum redline values protect the Thermal Protection System Bondline temperature limit of 200 Deg F. There are also dual limits of 150 Deg F and 180 Deg F dependent on LH2 liquid level for the thermal isolator material associated with loss of bolt preload due to repeated thermal cycling. The redlines were derived as follows:

	Inboard Temps & Outboard Temps	
For LH2 98% Liquid Level Sensors	< 50% Wet	> or = 50% Wet
Thermal Isolator limit	150 Deg F	180 Deg F
Total system accuracy	- 4.5 Deg F	- 4.5 Deg F
Maximum LCC value	145 Deg F	175 Deg F

d. Time Period - Effectivity start time chosen at start of LH2 Slow Fill in order to establish LCC monitoring in parallel with ET Bipod Heater System activation. Effectivity ending time chosen as Term LH2 Replenish based on last hold point just prior to deadfacing of sensor data at T-1 minute 52 seconds.

e. Requirements - Requirement (2) specifies the loss of valid information from a sensor or its associated data path is acceptable for one of the two sensor measurements (1 sensor - The output of each slot temperature sensor signal conditioner is routed through 2 redundant Hardware Interface Modules (HIMs) - requires 2 unique Function Designators) and directs use of a preplanned contingency procedure for use in evaluating the validity of sensor data. Requirement (3) specifies dual maximum slot temperature limits that are dependent on ET LH2 tank liquid level to prevent excessive Bipod fitting attachment bolt preload loss that

REDLINE DERIVATION: (Continued)

could result in unacceptable joint relaxation, as determined by test data. For LH2 98% liquid levels less than 50% wet, the maximum slot temperature limit is reduced to 145 degrees F to lower the amount of heat input to the fitting without a cryogenic backface at the fitting location. Excursions above this limit are acceptable for up to 10 minutes based on test data that shows no loss of attachment bolt preload. For LH2 98% liquid levels equal to or greater than 50% wet, the maximum slot temperature limit is increased to 175 degrees F due to the active cryogenic cooling of the structural mass beneath the Bipod fittings.

f. Preplanned Contingency Procedure - Provides direction for evaluating the validity of data from a sensor and its associated data path by standard criteria (off scale high/low, step function, erratic behavior) plus by comparison with temperature and heater data on the same and opposite Bipod.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Bipod closeout Thermal Protection System bondline over-temperature condition and subsequent debris generation.
(9) Reduction of the Bipod attachment bolt preload.

CAUSES OF EXCEEDING REDLINE:

(10) Instrumentation failure.
(11) Heater power anomaly.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
UNITS-->	Deg F								
T56T7055H	0.8	0	200						
T56T7155H	0.8	0	200						
T56T7065H	0.8	0	200						
T56T7165H	0.8	0	200						
T56T8055H	0.8	0	200						
T56T8155H	0.8	0	200						
T56T8065H	0.8	0	200						
T56T8165H	0.8	0	200						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO NA	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO NA	SHEET	ZONE

ELEMENT: External Tank SUBSYSTEM: ET

LCC VIOLATION CALL: ET Bipod Web Temp Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
T56T7085H	LH BIPOD AFT WEB TEMP A	(2,3)	8	N/A	Deg F	CI
T56T7185H	LH BIPOD AFT WEB TEMP B	(2,3)	8	N/A	Deg F	CI
T56T8085H	RH BIPOD AFT WEB TEMP A	(2,3)	8	N/A	Deg F	CI
T56T8185H	RH BIPOD AFT WEB TEMP B	(2,3)	8	N/A	Deg F	CI

TIME PERIOD:

(1) From start of ET LH2 Slow Fill to Go for APU Start (T-5 minutes and counting).

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 web temperature measurements per Bipod attach fitting acceptable for confirmed instrumentation failure. (4)
(3) Temperature excursions below the minimum redline limit do not represent LCC violations unless:
    a) The Web temperature anomaly is still present when the count reaches T-5 minutes.(5)
    b) The duration of the excursion exceeds 15 minutes.(6)

PREPLANNED CONTINGENCY PROCEDURE:

(4) If temperature measurement indicates off scale high or low, exhibits a step function change, indicates erratically, or measurement performance cannot be correlated with heater system performance on the affected Bipod and opposite bipod (web temps, slot temps and heater power levels), then instrumentation failure is confirmed. For first confirmed instrumentation failure prior to T- 5 minutes and counting, or for first or second confirmed instrumentation failure after T-5 minutes and counting, LCC violation cleared, continue countdown.
(5) The LCC violation can only be cleared by holding at T-5 minutes to verify that the Bipod fitting web temperature(s) recover to within redline limits prior to HH:MM:SS GMT, where HH:MM:SS GMT represents 15 minutes after the beginning of the temperature excursion. If the excursion ends before the time determined above, then LCC violation cleared, continue countdown.
(6) An excursion below minimum limit for up to 90 minutes is acceptable if the the temperature returns and stays above the minimum for at least 20 minutes to eliminate any frost/ice that may have formed. Once satisfied, then LCC violation cleared, continue countdown.

NOTES:

REDLINE DERIVATION: CRITICALITY: 3

(7) a. SSID Intent Summary - This requirement prevents the Bipod fitting from forming ice. It also allows for 15 minute excursions below the limit

REDLINE DERIVATION: (Continued)

without forming ice and accounts for longer time periods out of limits that will eliminate ice formed.

b. Voting Logic - The 1 of 2 voting logic presented for the minimum Bipod web temperatures accommodates for instrumentation failure while ensuring the minimum visibility required to satisfy the temperature requirements.

c. Redline Development - The limits were developed as part of Return to Flight Bipod Certification testing to prevent the formation of ice on the Bipod Fittings. Total system accuracy is derived using the Root-Sum-Squared method as follows:

	Web Temps
Resistance Temperature Device (RTD) accuracy	2.7 Deg F
Programmable Logic Controller (PLC) output accuracy	0.62 Deg F
RTD Signal conditioner accuracy	0.8 Deg F
Launch Processing System (LPS) accuracy	0.8 Deg F
Total accuracy	3.0 Deg F

The minimum redline values were derived as follows:

	Web Temps
Minimum Temperature at Freezing Threshold *	- 5 Deg F
Total accuracy	+ 3 Deg F
Margin	+ 10 Deg F
LCC Minimum limit	8 Deg F

* The LCC lower limit - Extensive thermal testing at cold ambient temperature conditions has shown that under steady state conditions, the uninsulated exposed portions of the bipod fitting web area remain just above the freezing threshold when the web temperature sensors are at -5 degrees F (web sensors are bonded 0.25 inches below the top edge of the foam).

d. Time Period - Effectivity start time chosen as start of LH2 Slow Fill in order to establish LCC monitoring in parallel with ET Bipod Heater steady state operations. Effectivity ending time of GLS Go for APU Start selected because this is the appropriate hold point prior to heater/sensor deadfacing and further monitoring is not required since ice will not form prior to launch, which will occur within 15 minutes (worst case). Bipod deadfacing of sensor data occurs at T-1 minute 52 seconds.

e. Requirements - Requirement (2) specifies that loss of valid information from a measurement or its associated data path is acceptable for one of the two measurements prior to GLS Go for APU Start(T-5 minutes). Requirement (3) specifies that excursions below the minimum redline limit are acceptable provided they do not exceed 15 minutes and can be verified that the temperature recovered above minimum limit prior to

REDLINE DERIVATION: (Continued)

GLS Go for APU Start (T-5 minutes and counting). This requirement is based on thermal testing which indicated that under worst case environmental conditions and if all heater power is lost, icing will not occur on the Bipod fitting within 15 minutes of the heater power loss. Excursions below the lower limit for up to 90 minutes are acceptable as long as the temperature returns and remains above the lower limit for 20 minutes minimum to provide enough heat to melt any ice that formed on the Bipod fitting.

f. Preplanned Contingency Procedure - Contingency (4) provides direction for evaluating the validity of data from a measurement and its associated data path by standard criteria (off scale high/low, step function, erratic behavior) plus by comparison with temperature and heater data on the same and opposite bipods.
Contingency (5) provides direction that if an excursion below the minimum redline occurs, but has not returned to above the minimum limit prior to T-5 minutes then request a hold. The need to hold verifies that the temperature recovers to within limits within the allowed 15 minute duration. This contingency is based on thermal testing which indicated that under worst case environmental conditions and if all heater power is lost, icing will not occur on the Bipod fitting within 15 minutes of the power loss.
Contingency (6) specifies time required to be above minimum temperature limit to ensure ice/frost has dissipated for temperature excursions up to 90 minutes. This requirement is based on thermal testing which indicated that under worst case environmental conditions and all heater power is lost for up to 90 minutes, ice/frost will be completely dissipated if power is restored and temperatures return above minimum limits for at least 20 minutes.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Ice formation on exposed ET Bipod Fitting and subsequent debris generation.

CAUSES OF EXCEEDING REDLINE:

(9) Instrumentation failure.
(10) Heater power anomaly.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	Deg F								
T56T7085H	0.4	0	100						
T56T7185H	0.4	0	100						
T56T8085H	0.4	0	100						
T56T8185H	0.4	0	100						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO NA SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO NA SHEET ZONE

ELEMENT: ET SUBSYSTEM: ET

LCC VIOLATION CALL: ET Camera System Deadfacing Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
G76X6030E	ET CAMERA AC 1 ON IND	2	OFF	N/A	N/A	DI
G76V6051A	ET CAMERA CMD VOLTAGE PRI	of 3	- 0.9	+ 0.9	Volts	DI
G76V6151A	ET CAMERA CMD VOLTAGE SEC	(2)	- 0.9	+ 0.9	Volts	DI
G76X6130E	ET CAMERA AC 2 ON IND	2	OFF	N/A	N/A	DI
G76V6051A	ET CAMERA CMD VOLTAGE PRI	of 3	- 0.9	+ 0.9	Volts	DI
G76V6151A	ET CAMERA CMD VOLTAGE SEC	(2)	- 0.9	+ 0.9	Volts	DI

TIME PERIOD:

(1) Verify after ET Camera System Deadfacing (T-2 minutes 30 seconds) and prior to Go For RSLS Start (T-31 seconds).

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) Re-issue ET Camera deadfacing commands, if deadfacing redline limits can be verified per the table above, then LCC violation cleared, continue countdown. (Ref. OMI S0007.500)

NOTES:

REDLINE DERIVATION: CRITICALITY: 3

(3) a. SSID Intent Summary - To ensure that all ET Camera System command power to the Ground Umbilical Carrier Plate (GUCP) interface has been terminated prior to umbilical separation.

b. Voting Logic - The dual 2 of 3 voting logic scheme takes into account the operation of the primary (G76X6030E) or redundant (G76X6130E) power supplies. The logic presented for the maximum ET Camera DC Command Voltages and AC ON indications accommodates potential instrumentation and discrete failures while ensuring the minimum visibility required to satisfy the deadfacing requirements is maintained.

c. Redline Development - System accuracy for DC Power Command Voltage is derived using Root-Sum-Squared method as follows:

	MIN	MAX
Baseline Reqmt*	0 Volts	0 Volts
Voltage Tranducer accuracy	- 0.35 Volts	+ 0.35 Volts
Launch Processing System(LPS) accuracy	- 0.8 Volts	+ 0.8 Volts
(Includes +/- 2 bit LPS error)		
Total Range	- 0.87 Volts	+ 0.87 Volts

REDLINE DERIVATION: (Continued)

* NSTS 08080-1, Standard 69, Electrical Circuits - De-energizing Requirement.

d. Time Period - Effectivity chosen based on ET Camera System command deadfacing at T-2 minutes 30 seconds and the next available hold point at T-31 seconds. The deadface verification will take into account the ET Camera System command and response latencies to ensure that the check does not catch the output voltage while it is decreasing.

e. Requirements - The 2 of 3 voting logic presented for the ET Camera momentary DC command voltage and associated AC bus indications accommodates instrumentation failure while ensuring that all power to the ET Camera System is deadfaced.

f. Preplanned Contingency Requirements - Direction is provided to isolate ET Camera System command power by re-issuing the facility AC1 and facility AC2 power off commands to remove power from the ET Camera System command DC power supplies.

CONSEQUENCES OF EXCEEDING REDLINE:

(4) Potential for gaseous Hydrogen exposure to possible electrical arcing and fire during Ground Umbilical Carrier Plate separation from the ET at T-0.

CAUSES OF EXCEEDING REDLINE:

(5) Instrumentation failure.
(6) Command Path failure.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
UNITS-->	Volts								
G76V6051A	0.4	-50	50						
G76V6151A	0.4	-50	50						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO NA SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO NA SHEET ZONE

ELEMENT: External Tank SUBSYSTEM: ET

LCC VIOLATION CALL: ET LO2 Feedline Bellows Heater Current Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
G56C2010A	BELLOWS STA 1106 PRI HTR AC CUR A	(2,3)	2.2	2.6	AMPS	CI
G56C2011A	BELLOWS STA 1106 PRI HTR AC CUR B	(2,3)	2.2	2.6	AMPS	CI
	OR					
G56C2110A	BELLOWS STA 1106 SEC HTR AC CUR A	(2,3)	2.2	2.6	AMPS	CI
G56C2111A	BELLOWS STA 1106 SEC HTR AC CUR B	(2,3)	2.2	2.6	AMPS	CI

TIME PERIOD:

(1) Start of LO2 Replenish to Go For GLS Start (T-9 minutes and counting).

REQUIREMENTS: FIGURES/TABLES:

(2) One of two measurements acceptable on the active system for confirmed instrumentation failure only. (4)
(3) Either Primary or Secondary heater may be utilized during Bellows Heater System operation. (5)

PREPLANNED CONTINGENCY PROCEDURE:

(4) For current measurement exhibiting a step function, off-scale-high or off-scale-low or exhibiting erratic behavior while the associated current measurement and associated voltage measurement data remained nominal, instrumentation failure is confirmed. LCC violation cleared, continue countdown.
(5) If both current measurements for one heater fail, switch to secondary heater and verify functionality (ref. OMRSD S00FD0.100). LCC violation cleared, continue countdown.

NOTES:

(6) Primary heater controller provides controlling function to only primary current measurements. Secondary heater controller provides controlling function to only secondary current measurements.
(7) Heaters will be activated based on LO2 calculated head pressure pseudo function designator N41H1771A > 52 psi.

REDLINE DERIVATION: CRITICALITY: 3

(8) a. SSID Intent Summary - The intent of the requirement is to prevent ice from forming at the station 1106 Bellows area while ensuring Thermal Protection System (TPS) bond line temp limit not exceeded.
1. Minimum Current Value: 2.2 AMPS
2. Maximum Current Value: 2.6 AMPS

b. Voting Logic - 1 of 2 heater systems. Primary and Secondary Heater Systems are redundant to each other. The Secondary Heater system is activated after a failure of the Primary Heater System.

REDLINE DERIVATION: (Continued)

c. Redline Development - Redline Development:

System accuracy is derived using the Root-Sum-Squared method as follows:

	AC Current
Signal conditioner	0.015 Amps
Launch Processing System (LPS) accuracy	0.024 Amps
Total accuracy	0.03 Amps

	Min	Max
Design limit (ice prevention/bond line protection)	2.17	2.63
Total accuracy	0.03	0.03
LCC Limit	2.2	2.6

d. Time Period - Start effectivity based on the LO2 load being stable and to provide maximum flexibility of heater activation and deactivation during LO2 loading. During LO2 loading, the heaters are activated when the LO2 head pressure is greater than 52 psi and the heaters will be deactivated during LO2 stop flow/revert and with a LO2 head pressure less than 51 psi. Ending effectivity chosen based on last major milestone prior to heater deactivation (Go for GLS Start, at T-9 minutes and counting).

e. Requirements - Requirement (2) specifies the loss of valid information from a sensor or its associated data path is acceptable for one of the two sensor measurements. Requirement (3) specifies that the heater system will operate with either the primary or secondary.

f. Preplanned Contingency Procedure - Provides direction for evaluating the validity of data from a sensor and its associated data path by standard criteria (off scale high/low, step function, erratic behavior). References to switch to the Secondary Heater Power per OMRSD S00FD0.100.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Ice may form on LO2 Bellows Feedline (Sta Xt 1106) area, creating a possible debris source. (lower current limit)
(10) The TPS bondline temperature limit may be exceeded creating a possible debris source. (upper current limit)

CAUSES OF EXCEEDING REDLINE:

(11) Instrumentation Failure
(12) Heater Failure
(13) Power or Control System Failure

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	AMPS								
G56C2010A	0.012	0	3						
G56C2011A	0.012	0	3						
G56C2110A	0.012	0	3						
G56C2111A	0.012	0	3						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO NA SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: External Tank SUBSYSTEM: LO2

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LCC VIOLATION CALL: ET LO2 Feedline Bellows Heater System Deadfacing Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
G56X2010E	BELLOWS STA 1106 PRI HTR ON IND	1 of 2	OFF	N/A	N/A	DI
G56C2010A	BELLOWS STA 1106 PRI HTR AC CUR A	2	N/A	0.03	AMPS	DI
G56X2110E	BELLOWS STA 1106 SEC HTR ON IND	1 of 2	OFF	N/A	N/A	DI
G56C2110A	BELLOWS STA 1106 SEC HTR AC CUR A	2	N/A	0.03	AMPS	DI

TIME PERIOD:

(1) Verify by T-40 seconds.

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) Place console ET heater hardware safing switches to OFF. If deadface requirements in measurement table above are satisfied, LCC Violation cleared, continue countdown.

NOTES:

REDLINE DERIVATION: CRITICALITY: 3

(3) a. SSID Intent Summary - To verify that all power to the Ground Umbilical Carrier Plate (GUCP) interface has been terminated prior to umbilical separation. Deadfacing verifies that no power exists to provide the energy to arc during the GUCP electrical connector separation.

b. Voting Logic - The 1 of 2 voting logic presented for the Bellows Heater current and associated heater ON indications accommodates for one failure while ensuring the minimum visibility required to verify that the heater is deadfaced.

c. Redline Development - System accuracy is derived using the Root-Sum-Squared method as follows:

	AC Current
Baseline Requirement*	0.0 Amps
Signal conditioner	0.015 Amps
Launch Processing System (LPS) accuracy	0.024 Amps
Total accuracy	0.03 Amps

*NSTS 08080-1 Standard 69 Electrical Circuits - De-energizing Requirement.

REDLINE DERIVATION: (Continued)

d. Time Period - Effectivity chosen based on verifying deadfacing prior to last available hold point at T-31 seconds.

e. Requirements - N/A

f. Preplanned Contingency Procedure - Direction is provided to isolate power via the console safing switches. This removes power to facility Power Supply 1 and facility Power Supply 2, which provides all power to the Bellows heaters.

CONSEQUENCES OF EXCEEDING REDLINE:

(4) Potential for spark to ignite hydrogen vapor at Ground Umbilical Carrier Plate during separation at T-0.

CAUSES OF EXCEEDING REDLINE:

(5) Instrumentation failure.
(6) Command path failure.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
UNITS-->	AMPS								
G56C2010A	0.012	0	3						
G56C2110A	0.012	0	3						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO NA SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO NA SHEET ZONE

ELEMENT: ET SUBSYSTEM: ET

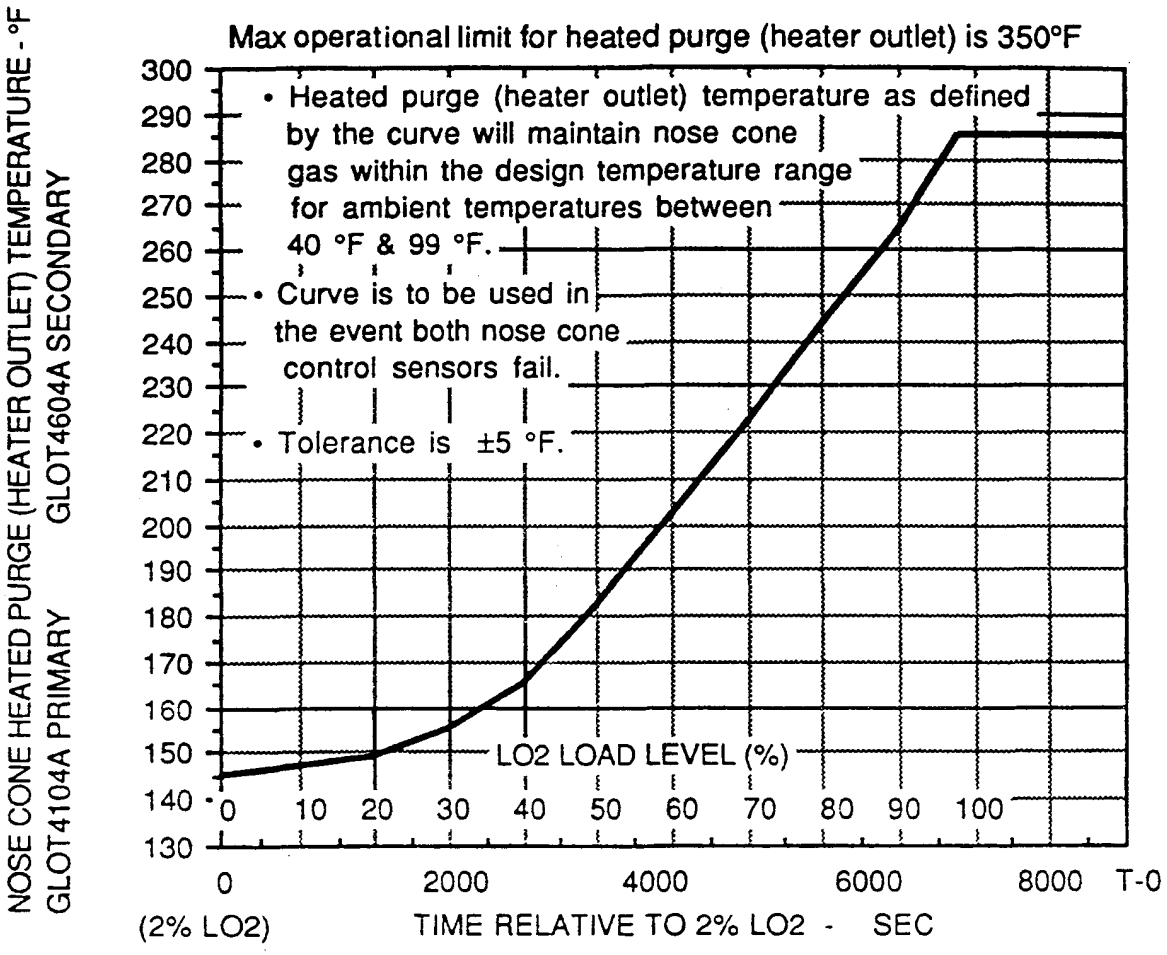

Figure 17-01 Contingency ET Nose Cone Heated Purge (Heater Outlet) Temperature Requirements

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Figure 17-02 ET Intertank Purge Heater Outlet Temperature

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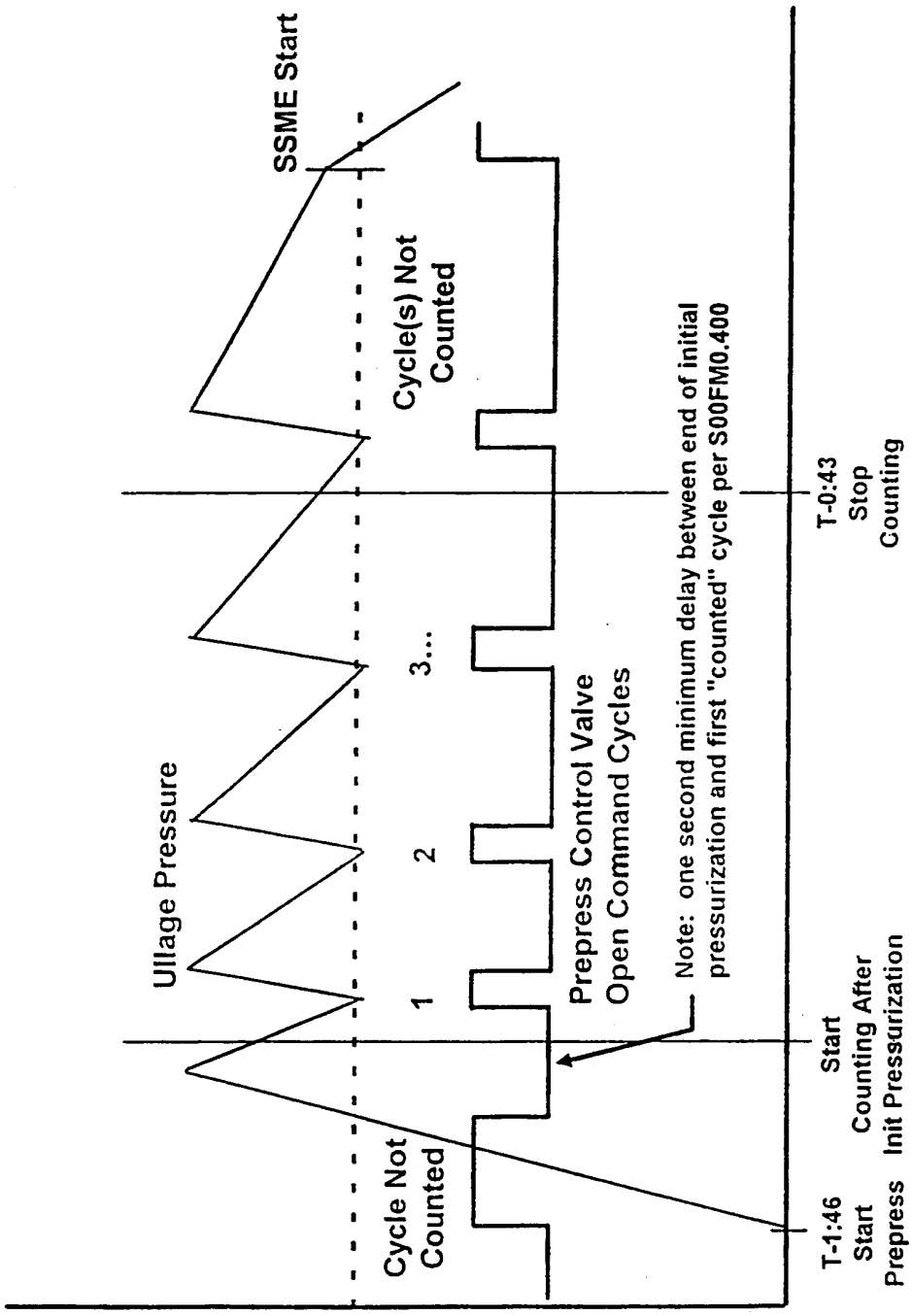

Figure 17-03 ET GH2 Prepress Cycle Count Definition

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SECTION 18

EXTERNAL TANK RANGE SAFETY SUBSYSTEM

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SECTION 18: EXTERNAL TANK RANGE SAFETY SUBSYSTEM

SSID No.	Description/Violation Call	Page
TRSS-01	ET Range Safety System Safe and Arm Device (SAFED) (REQUIREMENT DELETED)	18-01.1
TRSS-02	ET Range Safety System Battery Power (Amp-Hr) (REQUIREMENT DELETED)	18-02.1
TRSS-03	ET Range Safety System Battery Open Circuit Voltage (REQUIREMENT DELETED)	18-03.1
TRSS-04	ET Range Safety System Inhibit Indication (REQUIREMENT DELETED)	18-04.1
TRSS-05	ET Range Safety System Battery Voltage (REQUIREMENT DELETED)	18-05.1
TRSS-06	ET Range Safety System PIC CAP Voltage (REQUIREMENT DELETED)	18-06.1
TRSS-07	ET Range Safety System Decoder Power Indication (REQUIREMENT DELETED)	18-07.1
TRSS-08	ET Range Safety System Battery Current (REQUIREMENT DELETED)	18-08.1
TRSS-09	ET Range Safety System Receiver Signal Strength (REQUIREMENT DELETED)	18-09.1
TRSS-10	ET Range Safety System Arm Command From Decoder (OFF) (REQUIREMENT DELETED)	18-10.1
TRSS-11	ET Range Safety System Fire Command From Decoder (OFF) (REQUIREMENT DELETED)	18-11.1
TRSS-12	ET Range Safety System Safe and Arm Device (SAFED) (REQUIREMENT DELETED)	18-12.1
TRSS-13	ET Range Safety System Safe and Arm Device (ARMED) (REQUIREMENT DELETED)	18-13.1

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SECTION 20

SPACE SHUTTLE MAIN ENGINE

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SECTION 20: SPACE SHUTTLE MAIN ENGINE

SSID No.	Description/Violation Call	Page
SSME-01	SSME OPOV LOX Supply Line Temperature Anomaly	20-01.1
SSME-02	SSME Main Fuel Valve Downstream Temperature Anomaly	20-02.1
SSME-03	SSME HPOTP Intermediate Seal Purge Pressure Anomaly	20-03.1
SSME-04	SSME Anti-Flood Valve Downstream Temperature Anomaly	20-04.1
SSME-05	SSME MCC LOX Dome Temperature Anomaly	20-05.1
SSME-06	SSME Hydraulic System Pressure (REQUIREMENT DELETED)	20-06.1
SSME-07	SSME Phase/Mode Anomaly	20-07.1
SSME-08	SSME Actuator Position Channel Anomaly	20-08.1
SSME-09	SSME Fuel System Purge Pressure Anomaly	20-09.1
SSME-10	SSME HPOTP Intermediate Seal Purge Pressure Anomaly	20-10.1
SSME-11	SSME POGO Precharge Pressure Anomaly	20-11.1
SSME-12	SSME POGO Recirculation Isolation Valve Anomaly	20-12.1
SSME-13	SSME Propellant Bleed Valve Anomaly	20-13.1
SSME-14	SSME Anti-Flood Valve Anomaly	20-14.1
SSME-15	SSME Propellant Valve Hydraulic Temperature Anomaly	20-15.1
SSME-16	SSME Emergency Shutdown Pressure Anomaly	20-16.1
SSME-17	SSME LPFP Discharge Pressure Engine Ready Anomaly	20-17.1
SSME-18	SSME LPFP Discharge Temperature Engine Ready Anomaly	20-18.1

SECTION 20: SPACE SHUTTLE MAIN ENGINE (CONTINUED)

SSID No.	Description/Violation Call	Page
SSME-19	SSME LPOT Discharge Pressure Engine Ready Anomaly	20-19.1
SSME-20	SSME Preburner Pump Discharge Temperature ENGINE READY Anomaly	20-20.1
SSME-21	SSME Preburner Purge Pressure Engine Ready Anomaly	20-21.1
SSME-22	SSME Emergency Shutdown Pressure ENGINE READY Anomaly	20-22.1
SSME-23	SSME MOV/MFV Hydraulic Temperature ENGINE READY Anomaly	20-23.1
SSME-24	SSME HPFT Discharge Temperature Qualification Anomaly	20-24.1
SSME-25	SSME HPOT Discharge Temperature Qualification Anomaly	20-25.1
SSME-26	SSME HPOT Intermediate Seal Purge Pressure Qualification Anomaly	20-26.1
SSME-27	SSME HPOT Secondary Seal Cavity Pressure Qualification Anomaly (REQUIREMENT DELETED)	20-27.1
SSME-28	SSME HPFT Coolant Liner Pressure Qualification Anomaly (REQUIREMENT DELETED)	20-28.1
SSME-29	SSME Fuel Flow Rate Channel Qualification Anomaly	20-29.1
SSME-30	SSME MCC Pressure Interchannel Qualification Anomaly	20-30.1
SSME-31	SSME MCC Press Channel Qualification Anomaly	20-31.1
SSME-32	SSME LPFP Discharge Pressure Qualification Anomaly	20-32.1
SSME-33	SSME Preburner Purge Pressure Qualification Anomaly	20-33.1

SECTION 20: SPACE SHUTTLE MAIN ENGINE (CONTINUED)

SSID No.	Description/Violation Call	Page
SSME-34	SSME LPFP Discharge Temperature Qualification Anomaly	20-34.1
SSME-35	SSME Propellant Valve Position Anomaly	20-35.1
SSME-36	ME Shutdown Switch Contact Disagree	20-36.1
SSME-37	MPS Engine Limit Control Auto Switch Anomaly	20-37.1
SSME-38	SSME Preburner Pump Discharge Temperature Sensor Qualification Anomaly	20-38.1
SSME-39	SSME POGO Precharge Pressure Qualification Anomaly	20-39.1
SSME-40	SSME MCC LOX Dome Purge (REQUIREMENT DELETED)	20-40.1
SSME-41	Main Engine TVC Servo Override Command Anomaly (REQUIREMENT DELETED)	20-41.1
SSME-42	SSME Reference Junction Temperature Qualification Anomaly (REQUIREMENT DELETED)	20-42.1
SSME-43	SSME MCC Pc Discriminator Qualification Anomaly	20-43.1
SSME-44	SSME HPFTP Lift-Off Seal Anomaly	20-44.1

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LCC VIOLATION CALL: SSME OPOV LOX Supply Line Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41T1151A	ME-1 OPOV LOX Supply Line Temp #1	(3)	-40	NA	Deg F	CI
E41T1152A	ME-1 OPOV LOX Supply Line Temp #2	(3)	-40	NA	Deg F	CI
E41T2151A	ME-2 OPOV LOX Supply Line Temp #1	(3)	-40	NA	Deg F	CI
E41T2152A	ME-2 OPOV LOX Supply Line Temp #2	(3)	-40	NA	Deg F	CI
E41T3151A	ME-3 OPOV LOX Supply Line Temp #1	(3)	-40	NA	Deg F	CI
E41T3152A	ME-3 OPOV LOX Supply Line Temp #2	(3)	-40	NA	Deg F	CI

TIME PERIOD:

(1) Purge Sequence No. 3 to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Ground monitored.
(3) 1 of 2 measurements acceptable for confirmed instrumentation loss. (4)

PREPLANNED CONTINGENCY PROCEDURE:

(4) Instrumentation failure is defined as a measurement indicating off scale high or low, or indicating erratically. If instrumentation failure is confirmed, LCC violation cleared, continue countdown.
(5) Isolate engine from propellants per OMI S1003 & S1004.

NOTES:

REDLINE DERIVATION: CRITICALITY: 3

(6) Minimum redline violation indicates LOX leakage past SSME Oxidizer Pre-Burner Oxidizer Valve (OPOV) ball seal.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Oxygen will be expelled from the nozzle.
(8) Abnormal thermal conditioning of Oxidizer Pre-Burner (OPB) resulting in early OPB prime during start phase. Early OPB prime may result in shutdown during start.

CAUSES OF EXCEEDING REDLINE:

(9) Defective OPOV seal, ball seal surface, or contaminant between seal and ball.
(10) OPOV malfunction.
(11) Transducer malfunction.
(12) Harness malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.F								
E41Tn151A	2.511	-334.98	293.68						
E41Tn152A	3.305	-335.57	490.65						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET 1 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: SSME Main Fuel Valve Downstream Temperature Anomaly | EMERG COND: Yellow (7)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41T1153A	ME-1 MFV Downstream Temp #1	(2)	-130	NA	Deg F	CI
E41T1154A	ME-1 MFV Downstream Temp #2	(2)	-130	NA	Deg F	CI
E41T2153A	ME-2 MFV Downstream Temp #1	(2)	-130	NA	Deg F	CI
E41T2154A	ME-2 MFV Downstream Temp #2	(2)	-130	NA	Deg F	CI
E41T3153A	ME-3 MFV Downstream Temp #1	(2)	-130	NA	Deg F	CI
E41T3154A	ME-3 MFV Downstream Temp #2	(2)	-130	NA	Deg F	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 measurements per engine acceptable for confirmed instrumentation failure. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) If measurement indicates off-scale high or low, exhibits a step function change, or indicates erratically then instrumentation failure is confirmed. For first instrumentation failure per engine, LCC violation cleared, continue countdown. For second instrumentation failure per engine, LCC violation confirmed, No Go for Launch. (4)

(4) If violation does not meet criteria for confirmed instrumentation failure then immediately perform the emergency safing steps of OMI S1004, "SSME MFV and HPFTP Lift-Off Seal Leakage", to isolate engine from fuel supply. LCC violation confirmed, No Go for launch.

NOTES:

(5) Ground monitored.

REDLINE DERIVATION: CRITICALITY: 1

(6) a. SSID Intent Summary - The Main Fuel Valve (MFV) downstream temperature measurements consist of skin temperature sensors mounted to the outside wall of the downstream duct of the MFV. The measurements are used to detect cryogenic leakage past the MFV by establishing a minimum temperature limit.

b. Voting Logic - NA

c. Redline Development - The minimum limit is based on flight experience. A minimum redline violation is indicative of LH2 leakage past SSME MFV ball seal.

d. Time Period - Prior to T-31 seconds, the limit ensures MFV integrity

REDLINE DERIVATION: (Continued)

during critical MFV leak periods such as LH2 propellant drop, actuator transition to hydraulic power, and LH2 pressurization. After T-31 seconds, the limit is removed since no critical leak periods exist and any MFV leakage would be insignificant compared to the LH2 lead of the SSME start transient.

e. Requirements - The MFV itself is zero-fault tolerant to leakage. The measurement system to detect MFV leakage is one-fault tolerant since there are two measurements per engine and one confirmed instrumentation failure is accepted. The measurements are not needed during Engine Start and Mainstage and therefore redundancy prior to Engine Start is not required. Measurement failure is confirmed by ground systems since the measurements are not routed through the SSME Controller (SSMEC).

f. Preplanned Contingency Procedures - If violation meets criteria for confirmed instrumentation failure and the second measurement on that SSME has not been violated then the violation is cleared. Otherwise emergency procedures are initiated to isolate the engine from the fuel supply since MFV leakage is a criticality category 1 failure requiring immediate action.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) A Yellow condition exists should a violation of the redline occur. Unburned hydrogen will be expelled from the nozzle; there is a potential for fire/explosion.

CAUSES OF EXCEEDING REDLINE:

(8) Defective MFV seal, ball surface, or contaminant between seal and ball.
(9) MFV malfunction.
(10) Transducer malfunction.
(11) Harness malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.F								
E41Tn153A	NonLinear	-427	200.8						
E41Tn154A	3.304	-335.6	490.7						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET 1 ZONE N4
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: SSME HPOTP Intermediate Seal Purge Pressure Anomaly | EMERG COND: Yellow (6)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41P1014D	ME-1 HPOTP IMSL Prg Pr Ch A DW 20		90	NA	psia	CI
E41P1015D	ME-1 HPOTP IMSL Prg Pr Ch B DW 21		90	NA	psia	CI
E41P2014D	ME-2 HPOTP IMSL Prg Pr Ch A DW 20		90	NA	psia	CI
E41P2015D	ME-2 HPOTP IMSL Prg Pr Ch B DW 21		90	NA	psia	CI
E41P3014D	ME-3 HPOTP IMSL Prg Pr Ch A DW 20		90	NA	psia	CI
E41P3015D	ME-3 HPOTP IMSL Prg Pr Ch B DW 21		90	NA	psia	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to PSN4 plus 120 seconds

REQUIREMENTS: FIGURES/TABLES:

(2) Ground monitored.

PREPLANNED CONTINGENCY PROCEDURE:

(3) If redline violation is caused by a loss of GN2 supply pressure to the SSME(s) with no loss of ground facility drain capability, then immediately isolate engines from fuel supply per OMI S1004. GN2 supply pressure loss is confirmed if FPB Pressure (E41Px106D) indicates below 100 psia and OPB Pressure (E41Px059D) indicates below 330 psia.

NOTES:

(4) The SSMEC will post a Report-only FID if the redline is violated between PSN3 and START ENABLE. The hold condition is initiated by a ground call.

SSMEC Logic:

PSN3 to START ENABLE:

Single channel violation: Report-only FID

Dual channel violation: Report-only FID

From PSN4 + 120 seconds to ENGINE START, HPOTP intermediate seal purge LCC requirements are monitored and enforced by the SSMEC. (See SSME-10)

REDLINE DERIVATION: CRITICALITY: 1

(5) Verifies GN2 purge is active.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) A yellow condition exists if redline violation is caused by a loss of GN2 supply pressure. Thrust chamber effluent from allowable fuel system leakage may not be below flammability limits. There is a potential for fire/explosion.

CONSEQUENCES OF EXCEEDING REDLINE: (Continued)

(7) Improper purge flow to HPOTP Seal could result in moisture/ice accumulation and subsequent damage to seal, loss of hot gas/LOX barrier during engine operation.

CAUSES OF EXCEEDING REDLINE:

(8) Lower or higher resistance than normal in seal groups or lines.
(9) Solenoid or PAV malfunction.
(10) Transducer malfunction.
(11) Controller electronics malfunction.
(12) Harness malfunction.
(13) GN2 purge interrupt.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
E41Pn014D	0.325	0	600						
E41Pn015D	0.325	0	600						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET 1 ZONE L8
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: SSME Anti-Flood Valve Downstream Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41T1155A	ME-1 AFV Downstream Temp #1	(3)	-160	NA	Deg F	CI
E41T1156A	ME-1 AFV Downstream Temp #2	(3)	-160	NA	Deg F	CI
E41T2155A	ME-2 AFV Downstream Temp #1	(3)	-160	NA	Deg F	CI
E41T2156A	ME-2 AFV Downstream Temp #2	(3)	-160	NA	Deg F	CI
E41T3155A	ME-3 AFV Downstream Temp #1	(3)	-160	NA	Deg F	CI
E41T3156A	ME-3 AFV Downstream Temp #2	(3)	-160	NA	Deg F	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Ground monitored.
(3) 1 of 2 measurements acceptable for confirmed instrumentation failure. (4)

PREPLANNED CONTINGENCY PROCEDURE:

(4) Instrumentation failure is defined as a measurement indicating off-scale high or low, or indicating erratically.

NOTES:

REDLINE DERIVATION: CRITICALITY: 3

(5) Temperatures below minimum redline indicative of excessive LOX leakage past the antiflood valve.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Flooded heat exchanger could rupture during START phase.

CAUSES OF EXCEEDING REDLINE:

(7) Defect in AFV seat, poppet surface, or contaminant between the seat and poppet.
(8) Excessive pressure in LOX system may open AFV.
(9) Transducer malfunction.
(10) Harness malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.F								
E41Tn155A	2.511	-333.98	293.68						
E41Tn156A	2.511	-333.98	293.68						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET ZONE N/A
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: SSME MCC LOX Dome Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41T1120D	ME-1 MCC LOX Dome Temperature DW12	(1,3)	400	NA	Deg R	CI
E41T1120B	ME-1 MCC LOX Dome Temperature DW12	(2,3)	400	NA	Deg R	CI
E41T2120D	ME-2 MCC LOX Dome Temperature DW12	(1,3)	400	NA	Deg R	CI
E41T2120B	ME-2 MCC LOX Dome Temperature DW12	(2,3)	400	NA	Deg R	CI
E41T3120D	ME-3 MCC LOX Dome Temperature DW12	(1,3)	400	NA	Deg R	CI
E41T3120B	ME-3 MCC LOX Dome Temperature DW12	(2,3)	400	NA	Deg R	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Transition to OPS 1 (T-19 minutes)
(2) From Transition to OPS 1 (T-19 minutes) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(3) If measurement indicates off-scale high or low, exhibits a step function change, or indicates erratically, then instrumentation failure is confirmed. Monitor the Nozzle exit for Main Oxidizer Valve (MOV)leakage. The loss of instrumentation is acceptable only after Cryogenic Tanking provided that no leakage is observed by the Final Inspection Team or when Operational Television (OTV) is utilized to observe for leakage. If no visual evidence of an MOV leak is observed, LCC violation cleared, continue countdown. Otherwise, if instrumentation failure was not confirmed or visual evidence of a leak is observed then perform safing. (4)
(4) Isolate engine(s) from propellants per OMI S1003 and S1004.

NOTES:

(5) Ground monitored.
(6) The MCC LOX Dome Temperature measurement becomes available in the 128 kbit datastream after Transition to OPS 1 (T-19 minutes). If measurement visibility (60 kbit datastream) is lost prior to Transition to OPS 1, monitor the SSMEC Failure Identifier (FID) buffer (Data Word 5) to verify no 400 Deg R minimum violation. A report-only FID will be posted if the measurement violates the minimum limit up to Start Enable (T-9.5 seconds). No action will be taken for a FID occurrence after T-31 seconds.

REDLINE DERIVATION: CRITICALITY: 3

(7) a. SSID Intent Summary - The MCC LOX Dome Temperature sensor is located downstream of the MOV. The measurement is used to detect cryogenic leakage past the MOV by establishing a minimum temperature limit. The measurement is zero-fault tolerant because there is only one measurement

REDLINE DERIVATION: (Continued)

per engine and a single violation of the minimum limit is indicative of MOV leakage unless instrumentation failure is confirmed.

b. Voting Logic - N/A

c. Redline Development - The MCC LOX Dome Temperature sensor is located on the opposite side of the MOV in the LOX Dome. In addition, there is a GN2 purge downstream of the MOV and upstream of the LOX Dome. The minimum limit, therefore, is based on experience and a minimum redline violation is indicative of unacceptable LOX leakage past the MOV ball seal. MOV leakage has been observed during chilldown on hotfire test 901-591 and 902-673 (reference Unsatisfactory Condition Reports A022586 and A034037).

d. Time Period - "B" measurements are not visible until Transition to OPS 1 (T-19 minutes). Prior to T-31 seconds, the limit ensures MOV integrity during critical MOV leak periods such as initial loading of LOX propellant, actuator transition to hydraulic power, and LOX tank pressurization. After T-31 seconds, the limit is no longer required since no critical leak periods exist and any MOV leakage would have an insignificant effect on the Start transient.

e. Requirements - The MCC LOX Temperature measurement is required to be above the minimum limit. Violations are indicative of MOV leakage.

f. Preplanned Contingency Procedures - Visual cues will be used to provide a backup method of detecting MOV leakage if instrumentation failure is confirmed. MOV leakage history indicates that leakage is visible when monitoring the Nozzle exit.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Abnormal thermal conditioning of Main Injector resulting in early MCC prime during start phase. Early MCC prime may result in engine Shutdown during Start.
(9) Oxygen will be expelled from the Nozzle.

CAUSES OF EXCEEDING REDLINE:

(10) Defective MOV seal, ball seal surface, or contaminant between seal and ball.
(11) Valve malfunction.
(12) Transducer malfunction.
(13) Controller electronics malfunction.
(14) Harness malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.R								
E41Tn120D	0.324	110	610						
E41Tn120B	0.324	110	610						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET 1 ZONE N/A
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

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SSME Hydraulic System Pressure

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LCC VIOLATION CALL: SSME Phase/Mode Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41J1512B	ME-1 Phase In Effect	(5)	N/A	N/A	N/A	(5)
E41J2512B	ME-2 Phase In Effect	(5)	N/A	N/A	N/A	(5)
E41J3512B	ME-3 Phase In Effect	(5)	N/A	N/A	N/A	(5)
E41J1513B	ME-1 Operating Mode	(5)	N/A	N/A	N/A	(5)
E41J2513B	ME-2 Operating Mode	(5)	N/A	N/A	N/A	(5)
E41J3513B	ME-3 Operating Mode	(5)	N/A	N/A	N/A	(5)

TIME PERIOD:

(1) Verify at T-240 seconds
(2) From T-235 seconds to T-117 seconds
(3) From T-40 seconds to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(4) Ground monitored.
(5) Verify PSN-3 active at T-240 seconds, Code: DI
Verify PSN-4 active T-235 seconds to T-117 seconds, Code: CI
Verify ENGINE READY T-40 seconds to T-31 seconds, Code: CI

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 3

(6) Software verification of normal purge sequencing and ENGINE READY.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Improper launch countdown sequence.
(8) Failure to achieve ENGINE READY status results in controller rejection of engine start command.

CAUSES OF EXCEEDING REDLINE:

(9) Controller initiated "inhibit" command.
(10) Controller electronics malfunction.
(11) ENGINE READY parameter out of acceptable limits.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO N/A	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: SSME Actuator Position Channel Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41H1024B	ME-1 MFV Actuator Position Ch A		(3)	NA	Pct	CI
E41H1024D	ME-1 MFV Actuator Position Ch A		(3)	NA	Pct	CI
E41H1084D	ME-1 MFV Act Pos Ch B		(3)	NA	Pct	CI
E41H1025B	ME-1 MOV Actuator Position Ch A		(3)	NA	Pct	CI
E41H1025D	ME-1 MOV Actuator Position Ch A		(3)	NA	Pct	CI
E41H1085D	ME-1 MOV Act Pos Ch B		(3)	NA	Pct	CI
E41H1027B	ME-1 FPOV Actuator Position Ch A		(3)	NA	Pct	CI
E41H1027D	ME-1 FPOV Actuator Position Ch A		(3)	NA	Pct	CI
E41H1087D	ME-1 FPOV Act Pos Ch B		(3)	NA	Pct	CI
E41H1028B	ME-1 OPOV Actuator Position Ch A		(3)	NA	Pct	CI
E41H1028D	ME-1 OPOV Actuator Position Ch A		(3)	NA	Pct	CI
E41H1088D	ME-1 OPOV Act Pos Ch B		(3)	NA	Pct	CI
E41H2024B	ME-2 MFV Actuator Position Ch A		(3)	NA	Pct	CI
E41H2024D	ME-2 MFV Actuator Position Ch A		(3)	NA	Pct	CI
E41H2084D	ME-2 MFV Act Pos Ch B		(3)	NA	Pct	CI
E41H2025B	ME-2 MOV Actuator Position Ch A		(3)	NA	Pct	CI
E41H2025D	ME-2 MOV Actuator Position Ch A		(3)	NA	Pct	CI
E41H2085D	ME-2 MOV Act Pos Ch B		(3)	NA	Pct	CI
E41H2027B	ME-2 FPOV Actuator Position Ch A		(3)	NA	Pct	CI
E41H2027D	ME-2 FPOV Actuator Position Ch A		(3)	NA	Pct	CI
E41H2087D	ME-2 FPOV Act Pos Ch B		(3)	NA	Pct	CI
E41H2028B	ME-2 OPOV Actuator Position Ch A		(3)	NA	Pct	CI
E41H2028D	ME-2 OPOV Actuator Position Ch A		(3)	NA	Pct	CI
E41H2088D	ME-2 OPOV Act Pos Ch B		(3)	NA	Pct	CI
E41H3024B	ME-3 MFV Actuator Position Ch A		(3)	NA	Pct	CI
E41H3024D	ME-3 MFV Actuator Position Ch A		(3)	NA	Pct	CI
E41H3084D	ME-3 MFV Act Pos Ch B		(3)	NA	Pct	CI
E41H3025B	ME-3 MOV Actuator Position Ch A		(3)	NA	Pct	CI
E41H3025D	ME-3 MOV Actuator Position Ch A		(3)	NA	Pct	CI
E41H3085D	ME-3 MOV Act Pos Ch B		(3)	NA	Pct	CI
E41H3027B	ME-3 FPOV Actuator Position Ch A		(3)	NA	Pct	CI
E41H3027D	ME-3 FPOV Actuator Position Ch A		(3)	NA	Pct	CI
E41H3087D	ME-3 FPOV Act Pos Ch B		(3)	NA	Pct	CI
E41H3028B	ME-3 OPOV Actuator Position Ch A		(3)	NA	Pct	CI
E41H3028D	ME-3 OPOV Actuator Position Ch A		(3)	NA	Pct	CI
E41H3088D	ME-3 OPOV Act Pos Ch B		(3)	NA	Pct	CI

TIME PERIOD:

(1) Verify at Purge Sequence No. 4 Command

REQUIREMENTS: FIGURES/TABLES:

(2) SSMEC monitored.

REQUIREMENTS: (Continued)

(3) Movement of 0.1% toward the closed position (downshift) on either channel of each actuator is required. Shift calculation based on the difference between the average of the measured position over 2.56 seconds just prior to PSN 4 and the average of the measured position over 2.56 seconds beginning at PSN 4 plus 10.04 seconds.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 3

(4) To verify proper operation of Channel A actuator servo components.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Abnormal SSME actuator response rate or actuator inoperation during start phase.

CAUSES OF EXCEEDING REDLINE:

(6) Failure of fail-safe servoswitch or bypass valve to actuate properly.
(7) Channel A servovalve malfunction.
(8) Transducer malfunction.
(9) Controller electronics malfunction.
(10) Harness malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	pcnt								
E41Hn024B	0.068	-5	105						
E41Hn024D	0.068	-5	105						
E41Hn084D	0.068	-5	105						
E41Hn025B	0.068	-5	105						
E41Hn025D	0.068	-5	105						
E41Hn085D	0.068	-5	105						
E41Hn027B	0.072	-5	105						
E41Hn027D	0.072	-5	105						
E41Hn087D	0.072	-5	105						
E41Hn028B	0.072	-5	105						
E41Hn028D	0.072	-5	105						
E41Hn088D	0.072	-5	105						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.13	SHEET 1	ZONE L5, I7,
	DWG NO	SHEET	ZONE P7, 03
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: SSME SUBSYSTEM: SSME

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LCC VIOLATION CALL: SSME Fuel System Purge Pressure Anomaly | EMERG COND: Yellow (9)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41P1057D	ME-1 Fuel Sys Prg Pr Ch A DW53	1 of	(2)	(2)	psia	CI
E41P1058D	ME-1 Fuel Sys Prg Pr Ch B DW54	2	(2)	(2)	psia	CI
E41P2057D	ME-2 Fuel Sys Prg Pr Ch A DW53	1 of	(2)	(2)	psia	CI
E41P2058D	ME-2 Fuel Sys Prg Pr Ch B DW54	2	(2)	(2)	psia	CI
E41P3057D	ME-3 Fuel Sys Prg Pr Ch A DW53	1 of	(2)	(2)	psia	CI
E41P3058D	ME-3 Fuel Sys Prg Pr Ch B DW54	2	(2)	(2)	psia	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Engine Start (T-6.5 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) From Start of ET Cryo Tanking (T-6 hours) to Start Enable (T-9.5 seconds)
Minimum: 180 psia (3)
Maximum: 300 psia
From Start Enable (T-9.5 seconds) plus 1 second to Engine Start (T-6.5 seconds)
Minimum: None
Maximum: 50 psia

PREPLANNED CONTINGENCY PROCEDURE:

(3) If a loss of Fuel System Purge occurs after GN2 purge termination (T-2 min, 55 seconds) and before Start Enable (T-9.5 seconds), emergency safing is required. Perform appropriate emergency safing steps to reinstate the SSME GN2 purge so that thrust chamber effluent from allowable design leakage is below flammability limits. LCC violation confirmed, No Go for launch.

NOTES:

(4) SSME Controller (SSMEC) monitored.
(5) Purge and ancillary requirement.
(6) Report-only FID (Failure Identifier) issued on first redline violation.
(7) Major Component Failure (MCF) posted and Engine Start inhibited by SSMEC on second redline violation.

REDLINE DERIVATION: CRITICALITY: 1

(8) a. SSID Intent Summary - The SSME Fuel System Purge provides helium to fuel system components prior to Start Enable. The purge is required for the downstream side of the Main Fuel Valve (MFV) to prevent potential leakage from solid nitrogen formation. The purge is required for the fuel system downstream of the MFV to maintain thrust chamber effluent from allowable system leakage below flammable limits. The purge is required for the High Pressure Fuel Turbopump (HPFTP) turbine coolant

REDLINE DERIVATION: (Continued)

tubes to prevent tube blockage from solid nitrogen formation. The purge is terminated at Start Enable to prevent any possible disruption of the SSME Start transient. The SSME Fuel System Purge Pressure measurements are single fault tolerant per engine.

b. Voting Logic - The SSME Fuel System Purge Pressure measurements are single fault tolerant since there are two measurements per engine and failure is accepted. The measurements are not needed during Engine Start and Mainstage and therefore redundancy prior to Engine Start is not required. Failure is determined by the SSMEC.

c. Redline Development - The minimum and maximum limits are based on experience. The minimum limit prior to Start Enable ensures that an adequate helium purge is provided to those fuel system components that require the purge. The maximum limit prior to Start Enable ensures the absence of blockage in the purge lines and verifies nominal operation of the purge. The maximum limit after Start Enable + 1 second ensures that the purge has been terminated prior to SSME Start to prevent any possible disruption of the SSME Start transient.

d. Time Period - The SSME Fuel System Purge is required from the Start of ET Cryo Tanking (T-6 hours) until Start Enable (T-9.5 seconds) when the purge is terminated. Termination of the purge is verified from Start Enable + 1 second until SSME Start (T-6.5 seconds). The time between Start Enable and Engine Start, when neither the GN2 purge nor the Fuel System Purge is active, is short and does not pose any thrust chamber effluent flammability concerns.

e. Requirements - Reference Redline Development paragraph (8)c.

f. Preplanned Contingency Procedures - Loss of the SSME Fuel System Purge after GN2 termination is a Yellow condition requiring immediate action to restore purge. This procedure reinitiates the SSME GN2 purge in order to prevent combustible hydrogen concentrations in the thrust chamber in the absence of the Fuel System Purge.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) A Yellow condition exists should a minimum redline violation occur after the GN2 purge is terminated (T - 2 min, 55 sec). Thrust chamber effluent from allowable fuel system leakage may not be below flammable limits. There is a potential for fire/explosion.
(10) Potential for solid N2 formation on MFV and subsequent MFV leakage.
(11) Potential for solid N2 formation in HPFTP turbine coolant tubes and subsequent turbine blade erosion during hotfire.
(12) Possible disruption of the SSME Start transient if Fuel System Purge is not terminated prior to Engine Start.

CAUSES OF EXCEEDING REDLINE:

(13) Solenoid or Pressure Actuated Valve (PAV) malfunction.
(14) Restriction in purge line.
(15) Transducer malfunction.
(16) Controller electronic malfunction.
(17) Harness malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
E41Pn057D	0.325	0	600						
E41Pn058D	0.325	0	600						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.9 SHEET 1 ZONE K6
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

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LCC VIOLATION CALL: SSME HPOTP Intermediate Seal Purge Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41P1014D	ME-1 HPOT I-SEAL PGE P CH A DW 20		(2)	(2)	psia	CI
E41P1015D	ME-1 HPOT I-SEAL PGE P CH B DW 21		(2)	(2)	psia	CI
E41P2014D	ME-2 HPOT I-SEAL PGE P CH A DW 20		(2)	(2)	psia	CI
E41P2015D	ME-2 HPOT I-SEAL PGE P CH B DW 21		(2)	(2)	psia	CI
E41P3014D	ME-3 HPOT I-SEAL PGE P CH A DW 20		(2)	(2)	psia	CI
E41P3015D	ME-3 HPOT I-SEAL PGE P CH B DW 21		(2)	(2)	psia	CI

TIME PERIOD:

(1) Start of ET Cryo Tanking (T-6 hours) to Engine Start (T-6.5 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Redline dependent on purge condition:
Helium purge OFF (Monitored from Purge Sequence Number 3 (PSN3) plus 130 seconds to Purge Sequence Number 4 (PSN4))
Minimum Redline: None
Maximum Redline: 215
Helium purge ON (Monitored from PSN4 plus 120 seconds to Engine Start)
Minimum Redline: 164
Maximum Redline: 225

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) SSME Controller (SSMEC) monitored.
(4) Purge and ancillary monitoring requirement.
(5) Engine Start inhibited by SSMEC.
(6) During PSN3, if the Intermediate Seal (IMSL) Purge pressure is observed to be greater than 160 psia (ref. STS-78), the High Pressure Oxidizer Turbopump (HPOTP) IMSL Purge Solenoid may be energized, as needed, in an effort to lower the pressure. This will provide helium to the IMSL package and clear any ice build-up. Once energized, the solenoid will remain energized for a period of 120 seconds. Redline monitoring is suspended for 120 seconds each time the solenoid changes state.

REDLINE DERIVATION: CRITICALITY: 3

(7) a. SSID Intent Summary - The HPOTP Intermediate Seal Purge provides a pneumatic barrier between the pump end and the turbine end of the HPOTP. The purge keeps LOX from entering the turbine end of the HPOTP prior to Engine Start. Prior to PSN4, the purge is supplied by GN2. After PSN4, the purge is supplied by helium.

REDLINE DERIVATION: (Continued)

b. Voting Logic - NA
c. Redline Development - The HPOTP Intermediate Seal Purge Pressure limits are based on experience and detailed internal flow models.
   i. The helium purge OFF redline prevents IMSL rings from freezing to the shaft and ensures a gap remains between the rings and the shaft for helium flow past both rings in PSN4. The limit also verifies normal operation of IMSL GN2 purge.
   ii. The helium purge ON minimum redline verifies activation of the helium purge to HPOTP Intermediate Seal and provides margin to the flight redline limit active after Engine Start. The redline limit is 159 psia (minimum) after Engine Start and 140 psia (minimum) after Engine Cutoff.
   iii. The helium purge ON maximum redline ensures the Intermediate Seal has been cleared of ice prior to Engine Start.
d. Time Period - The HPOTP Intermediate Seal Purge is required from the beginning of LO2 chilldown until after SSME Shutdown. Engine Start is specified as the end time because SSME Launch Commit Criteria monitoring ends at Engine Start.
e. Requirements - There are two HPOTP Intermediate Seal measurements per engine (one pressure transducer body with two independent electrical outputs). No failures are accepted prior to Engine Start because the measurements are Pad Abort monitors during SSME Start and Redline monitors during SSME Mainstage. When the helium purge is OFF, GN2 is provided to the HPOTP Intermediate Seal. The helium supply pressure to the IMSL is higher than GN2 supply pressure. Therefore, the limits when the helium purge is ON are higher than when the helium purge is OFF.
f. Preplanned Contingency Procedures - NA

CONSEQUENCES OF EXCEEDING REDLINE:

(8) A maximum violation due to blockage in seal groups or lines would cause low purge flow to critical HPOTP seals and a loss of the LOX-hot gas barrier required during Engine Start and Mainstage. If maximum violation is due to icing of the IMSL rings to the shaft, IMSL hardware damage could occur and/or SSME Start transient performance could be affected during SSME Start.
(9) Violation of minimum redline with helium purge ON would result in violation of the HPOTP Intermediate Seal Purge redline during start phase.

CAUSES OF EXCEEDING REDLINE:

(10) IMSL rings iced to shaft or any other blockage in seal groups or lines.
(11) Leakage or lower than normal resistance in seal groups or lines.
(12) Solenoid or Pressure Actuated Valve (PAV) malfunction.
(13) Transducer malfunction.
(14) Controller electronics malfunction.
(15) Harness malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
E41Pn014D	0.325	0	600						
E41Pn015D	0.325	0	600						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET 1 ZONE L8
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

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LCC VIOLATION CALL: SSME POGO Precharge Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41P1055D	ME-1 POGO Prechg Press Ch A		(2)	(2)	psia	CI
E41P1056D	ME-1 POGO Prechg Press Ch B		(2)	(2)	psia	CI
E41P2055D	ME-2 POGO Prechg Press Ch A		(2)	(2)	psia	CI
E41P2056D	ME-2 POGO Prechg Press Ch B		(2)	(2)	psia	CI
E41P3055D	ME-3 POGO Prechg Press Ch A		(2)	(2)	psia	CI
E41P3056D	ME-3 POGO Prechg Press Ch B		(2)	(2)	psia	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Engine Start

REQUIREMENTS: FIGURES/TABLES:

(2) Redline dependent on Time Period:
For PSN1 to Start Enable (STEN) with helium OFF:
Minimum Redline: None, Maximum Redline: 1425
For STEN +120 milliseconds to STEN +440 milliseconds with helium ON:
Minimum Redline: 600, Maximum Redline: 800
For STEN +640 milliseconds to Engine Start with helium OFF:
Minimum Redline: None, Maximum Redline: 150

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) SSME Controller (SSMEC) monitored.
(4) Purge and ancillary requirement.
(5) Engine Start inhibited by SSMEC.

REDLINE DERIVATION: CRITICALITY: 3

(6) a. SSID Intent Summary - The Pogo Suppression System is intended to dampen LOX system pressure oscillations during mainstage and prevent a potential zero-G High Pressure Oxidizer Turbopump (HPOTP) overspeed condition during shutdown. The system measurements are one-fault tolerant since two sensors per engine exist. However, no failures are accepted between PSN1 and Engine Start since sensor redundancy is required for Pad Abort Limit Monitoring during Engine Start.
b. Voting Logic - N/A
c. Redline Development - Limits are based on experience.
i. PSN1 to STEN redline detects erroneous data during this time frame. The 1425 psia value is based on full scale sensor operating range of 0 to 1600 psia and chosen for consistency with other 1425 psia limits.
ii. STEN +120 milliseconds to STEN +440 milliseconds 600 psia minimum redline verifies sufficient helium pressure supplied to precharge

REDLINE DERIVATION: (Continued)

the Pogo accumulator with helium. The Pogo Accumulator is charged with helium at this time frame to prevent a GOX bubble collapse due to LOX pressure oscillations caused by closing the MPS and SSME bleed valves. The 800 psia maximum redline is in place to supplement precharge failure protection during Engine Start time frame. The maximum limit exists during this time period since software requires the same limits for all helium precharge ON periods.

iii. STEN +640 milliseconds to Engine Start redline verifies helium precharge OFF. The 150 psia max limit provides margin to normal operational pressures without helium activated (average maximum during this timeframe is approximately 125 psia).

d. Time Period - Times are chosen based on precharge ON and OFF events and include a 120 millisecond delay to allow for changes of state.

e. Requirements - Helium precharge of accumulator must occur during specified ON time frames. Helium precharge must be inactive during specified OFF time frames.

f. Preplanned Contingency Procedures - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Failure to charge Pogo Accumulator during STEN (when LOX bleed valve closure causes pressure oscillations in LOX sytem)can result in an undesirable LOX system pressure surge due to GOX bubble collapse. Failure to charge Pogo Accumulator with helium during STEN may also be indicative of a problem in the Pogo Supression System that could continue during later phases of engine operation. If there is a failure to precharge the accumulator later during Engine Start, subsequent GOX flow will be unable to reinitiate the bubble until well into mainstage, leading to a lack of protection against Pogo effect on an engine during a portion of ascent (the Pogo effect is when low frequency LOX flow and associated combustion oscillations lead to vehicle instability from resonating with major structural modes). Failure to charge Pogo Accumulator during Shutdown can result in HPOTP overspeed condition (cavitation due to low LOX Net Positive Suction Pressure without gravity or vehicle acceleration). HPOTP overspeed is Crit 1 (uncontained engine failure and loss of vehicle).

(8) Failure to terminate STEN Pogo helium precharge prior to Start may result in HPOTP overspeed failure due to cavitation during Engine Start phase. HPOTP overspeed is Crit 1 (uncontained engine failure and loss of vehicle).

CAUSES OF EXCEEDING REDLINE:

(9) Helium Precharge Valve malfunction.
(10) Transducer malfunction.
(11) Controller electronics malfunction.
(12) Harness failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
E41Pn055D	0.812	0	1500						
E41Pn056D	0.812	0	1500						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET 1 ZONE F5
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

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LCC VIOLATION CALL: SSME POGO Recirculation Isolation Valve Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41H1180D	ME-1 POGO Recirn Isln V Pos DW 63		(3)	(3)	Pct	CI
E41H2180D	ME-2 POGO Recirn Isln V Pos DW 63		(3)	(3)	Pct	CI
E41H3180D	ME-3 POGO Recirn Isln V Pos DW 63		(3)	(3)	Pct	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to ENGINE START

REQUIREMENTS: FIGURES/TABLES:

(2) SSMEC monitored.
(3) Redlines dependent on whether the valve is commanded OPEN or CLOSED:
Valve CLOSED (PSN3 plus 2 seconds to STEN):
Minimum Redline: None, Maximum Redline: 20
Valve OPEN (STEN plus 2 seconds to ENGINE START):
Minimum Redline: 80, Maximum Redline: None

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) Purge and ancillary requirement.
(5) ENGINE START inhibited by SSMEC.

REDLINE DERIVATION: CRITICALITY: 3

(6) Verifies POGO Recirculation Isolation Valve is CLOSED from PSN3 plus 2 seconds to STEN.
(7) Verifies POGO Recirculation Isolation Valve is OPEN from STEN plus 2 seconds to ENGINE START.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) PSN3 plus 2 seconds to STEN violation: Recirculation Isolation Valve remains open and short-circuits LOX recirculation flow path.
(9) STEN plus 2 seconds to ENGINE START violation: Blocks POGO accumulator recirculation flow path.

CAUSES OF EXCEEDING REDLINE:

(10) POGO recirculation isolation valve malfunction.
(11) PCA malfunction.
(12) Transducer malfunction.
(13) Controller electronics malfunction.
(14) Harness malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	pcnt								
E41Hn180D	1.0	0	100						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET 1 ZONE G5
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: SSME Propellant Bleed Valve Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41H1184D	ME-1 Oxid Bleed Vlv Position DW 65		(3)	(3)	Pct	CI
E41H1185D	ME-1 Fuel Bleed Vlv Position DW 65		(3)	(3)	Pct	CI
E41H2184D	ME-2 Oxid Bleed Vlv Position DW 65		(3)	(3)	Pct	CI
E41H2185D	ME-2 Fuel Bleed Vlv Position DW 65		(3)	(3)	Pct	CI
E41H3184D	ME-3 Oxid Bleed Vlv Position DW 65		(3)	(3)	Pct	CI
E41H3185D	ME-3 Fuel Bleed Vlv Position DW 65		(3)	(3)	Pct	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to ENGINE START

REQUIREMENTS: FIGURES/TABLES:

(2) SSMEC monitored.
(3) Redlines dependent on whether the valves are commanded OPEN or CLOSED:
Valves OPEN (PSN3 plus 2 seconds to STEN):
Minimum Redline: 80, Maximum Redline: None
Valves CLOSED (STEN plus 2 seconds to ENGINE START):
Minimum Redline: None, Maximum Redline: 20

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) Purge and ancillary requirements.
(5) ENGINE START inhibited by SSMEC.

REDLINE DERIVATION: CRITICALITY: 3

(6) Verifies bleed valves are OPEN from PSN3 plus 2 seconds to STEN.
(7) Verifies bleed valves are CLOSED from STEN plus 2 seconds to ENGINE START.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Failure to open bleed valve results in failure to thermally condition the engine.
(9) Possible vehicle line over-pressure if valve fails to close before ENGINE START.

CAUSES OF EXCEEDING REDLINE:

(10) Bleed valve malfunction.
(11) PCA malfunction.
(12) Position indicator malfunction.

CAUSES OF EXCEEDING REDLINE: (Continued)

(13) Controller electronics malfunction.
(14) Harness malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	pcnt								
E41Hn184D	1.0	0	100						
E41Hn185D	1.0	0	100						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET 1 ZONE 04, P6
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: SSME Anti-Flood Valve Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41H1187D	ME-1 Anti-Flood Vlv Posn Ch A DW68		NA	10	Pct	CI
E41H1188D	ME-1 Anti-Flood Vlv Posn Ch B DW68		NA	10	Pct	CI
E41H2187D	ME-2 Anti-Flood Vlv Posn Ch A DW68		NA	10	Pct	CI
E41H2188D	ME-2 Anti-Flood Vlv Posn Ch B DW68		NA	10	Pct	CI
E41H3187D	ME-3 Anti-Flood Vlv Posn Ch A DW68		NA	10	Pct	CI
E41H3188D	ME-3 Anti-Flood Vlv Posn Ch B DW68		NA	10	Pct	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to ENGINE START

REQUIREMENTS: FIGURES/TABLES:

(2) SSMEC monitored.
(3) 2 of 2 required per Engine prior to STEN.
1 of 2 required per Engine after STEN + 1 second.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) Purge and ancillary requirement.
(5) ENGINE START inhibited by SSMEC on first failure before STEN.
(6) ENGINE START inhibited by SSMEC on second failure after STEN + 1 second.

REDLINE DERIVATION: CRITICALITY: 3

(7) Verifies that the anti-flood valve is closed to prevent LOX from entering the heat exchanger before start.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Flooded heat exchanger could rupture during start phase.

CAUSES OF EXCEEDING REDLINE:

(9) Anti-flood valve poppet failing OPEN.
(10) Position indicator failure.
(11) Controller electronics malfunction.
(12) Harness malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	pcnt								
E41Hn187D	1.0	0	100						
E41Hn188D	1.0	0	100						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET 1 ZONE K4
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: SSME Propellant Valve Hydraulic Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41T1109D	ME-1 MOV Hyd Temp Ch A DW 59	1 of	450	NA	Deg R	CI
E41T1110D	ME-1 MOV Hyd Temp Ch B DW 60	2	450	NA	Deg R	CI
E41T1111D	ME-1 MFV Hyd Temp Ch A DW 61	1 of	460	NA	Deg R	CI
E41T1112D	ME-1 MFV Hyd Temp Ch B DW 62	2	460	NA	Deg R	CI
E41T2109D	ME-2 MOV Hyd Temp Ch A DW 59	1 of	450	NA	Deg R	CI
E41T2110D	ME-2 MOV Hyd Temp Ch B DW 60	2	450	NA	Deg R	CI
E41T2111D	ME-2 MFV Hyd Temp Ch A DW 61	1 of	460	NA	Deg R	CI
E41T2112D	ME-2 MFV Hyd Temp Ch B DW 62	2	460	NA	Deg R	CI
E41T3109D	ME-3 MOV Hyd Temp Ch A DW 59	1 of	450	NA	Deg R	CI
E41T3110D	ME-3 MOV Hyd Temp Ch B DW 60	2	450	NA	Deg R	CI
E41T3111D	ME-3 MFV Hyd Temp Ch A DW 61	1 of	460	NA	Deg R	CI
E41T3112D	ME-3 MFV Hyd Temp Ch B DW 62	2	460	NA	Deg R	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to START ENABLE (T-9.5 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) SSMEC monitored.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) Purge and ancillary requirement.
(4) Report-only FID issued on first redline violation.
(5) MCF posted and ENGINE START inhibited by SSMEC on second redline violation.

REDLINE DERIVATION: CRITICALITY: 3

(6) Minimum temperature required to ensure proper hydraulic actuator slew rate during flight.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Extremely low temperature may result in hydraulic fluid freezeup.

CAUSES OF EXCEEDING REDLINE:

(8) Low hydraulic circulation pump performance.
(9) Excessively high return system pressure.
(10) Restriction across SSME hydraulic supply filter or supply system.
(11) Transducer malfunction.
(12) Controller electronics malfunction.
(13) Harness malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.R								
E41Tn109D	0.258	360	760						
E41Tn110D	0.258	360	760						
E41Tn111D	0.258	360	760						
E41Tn112D	0.258	360	760						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.9 SHEET 1 ZONE P2, L2
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: SSME Emergency Shutdown Pressure Anomaly | EMERG COND: Yellow (7)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41P1107D	ME-1 Emerg Sht Dn Press Ch A DW 72		(3)	(3)	psia	CI
E41P1108D	ME-1 Emerg Sht Dn Press Ch B DW 73		(3)	(3)	psia	CI
E41P2107D	ME-2 Emerg Sht Dn Press Ch A DW 72		(3)	(3)	psia	CI
E41P2108D	ME-2 Emerg Sht Dn Press Ch B DW 73		(3)	(3)	psia	CI
E41P3107D	ME-3 Emerg Sht Dn Press Ch A DW 72		(3)	(3)	psia	CI
E41P3108D	ME-3 Emerg Sht Dn Press Ch B DW 73		(3)	(3)	psia	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to START ENABLE (T-9.5 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) SSMEC monitored.
(3) Redline dependent on Time Period:
From PSN3 to PSN4:
Minimum Redline: 600, Maximum Redline: 900
From PSN4 plus 2 seconds to STEN
Minimum Redline: None, Maximum Redline: 50
(4) Verify engine helium supply conditions and monitor propellant valve for leakage.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(5) Purge and ancillary requirement.
(6) ENGINE START inhibited by SSMEC.
(7) Yellow condition exists if pneumatic pressure is not present on the propellant valve actuators during PSN3.

REDLINE DERIVATION: CRITICALITY: 1 (PSN3 to PSN4)
3 (PSN4+2 seconds to STEN)

(8) PSN3 to PSN4 lower redline limit verifies pneumatic closing pressure on propellant valve actuators.
(9) PSN3 to PSN4 upper redline violation indicative of erroneous data.
(10) PSN4 plus 2 seconds to STEN redline limits verify helium pressure is removed from propellant valve actuators.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Failure to provide pneumatic closing pressurant results in potential for propellant valve drift during PSN3.
(12) Failure to vent pneumatic pressure during PSN4 results in pneumatic shutdown if APU shutdown (hydraulic lockup) occurs during ascent.

CAUSES OF EXCEEDING REDLINE:

(13) Emergency shutdown solenoid valve malfunction.
(14) Emergency shutdown PAV malfunction.
(15) Transducer malfunction.
(16) Controller electronics malfunction.
(17) Loss of vehicle helium supply pressure.
(18) Harness malfunction.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
E41Pn107D	0.812	0	1500						
E41Pn108D	0.812	0	1500						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.9 SHEET 1 ZONE R4
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: SSME LPFP Discharge Pressure Engine Ready Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41P1092D	ME-1 LPFP Disch Press Ch A DW 92		53	60	psia	CI
E41P1127D	ME-1 LPFP Disch Press Ch B DW 127		53	60	psia	CI
E41P2092D	ME-2 LPFP Disch Press Ch A DW 92		53	60	psia	CI
E41P2127D	ME-2 LPFP Disch Press Ch B DW 127		53	60	psia	CI
E41P3092D	ME-3 LPFP Disch Press Ch A DW 92		53	60	psia	CI
E41P3127D	ME-3 LPFP Disch Press Ch B DW 127		53	60	psia	CI

TIME PERIOD:

(1) PSN4 (T-4 minutes) plus 10 seconds to Start Enable (T-9.5 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) SSME Controller (SSMEC) monitored.
(3) Engine Ready requirement.
(4) All Engine Ready parameters must be within limits for two continuous seconds to obtain Engine Ready mode. After Engine Ready is achieved, no Engine Ready parameter may leave the redline envelope for more than one continuous second.
(5) Engine Start inhibited by SSMEC. No Failure Identifier (FID) or Inhibit until Engine Ready is obtained and lost or Start Enable command is given without Engine Ready.

REDLINE DERIVATION: CRITICALITY: 3

(6) a. SSID Intent Summary - Low Pressure Fuel Turbopump (LPFTP) Discharge Pressure is a measure of LH2 Inlet Pressure prior to Engine Start. By examining the LPFTP Discharge Pressure sensors, the SSMEC can assess whether the LH2 Inlet Pressure is within the allowable range for SSME Start.

b. Voting Logic - There are two LPFTP Discharge Pressure measurements per engine (one pressure transducer body with two independent electrical outputs). No failures are accepted prior to Engine Start because the measurements are Pad Abort monitors during SSME Start; furthermore, these sensors are used for fuel flow calculation and control after Engine Start.

c. Redline Development - The LPFTP Discharge Pressure Engine Ready limits are based on flight experience. The limits ensure the SSME propellant feed system pressure is adequate for nominal start sequence/performance.

REDLINE DERIVATION: (Continued)

The limits allow for measurement error and the influence of the Orbiter MPS LH2 recirculation pump and are therefore higher and wider than the LH2 Inlet Pressure ICD limits specified for Engine Start.

d. Time Period - The SSMEC begins to monitor for all Engine Ready conditions at PSN4 + 10 seconds. The SSMEC requires that the Engine Ready mode be achieved in order to accept the Start Enable command.
e. Requirements - NA
f. Preplanned Contingency Procedures - NA

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Adverse effect on Engine Start transient.

CAUSES OF EXCEEDING REDLINE:

(8) Vehicle pressurization system or External Tank vent valve malfunction.
(9) Orbiter MPS LH2 recirculation pump malfunction.
(10) Transducer malfunction.
(11) Controller electronics malfunction.
(12) Harness malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
E41Pn092D	0.162	0	300						
E41Pn127D	0.162	0	300						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET 1 ZONE R3
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: SSME LPFP Discharge Temperature Engine Ready Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41T1093D	ME-1 LPFP Disch Temp Ch A DW 93		37	42	Deg R	CI
E41T1128D	ME-1 LPFP Disch Temp Ch B DW 128		37	42	Deg R	CI
E41T2093D	ME-2 LPFP Disch Temp Ch A DW 93		37	42	Deg R	CI
E41T2128D	ME-2 LPFP Disch Temp Ch B DW 128		37	42	Deg R	CI
E41T3093D	ME-3 LPFP Disch Temp Ch A DW 93		37	42	Deg R	CI
E41T3128D	ME-3 LPFP Disch Temp Ch B DW 128		37	42	Deg R	CI

TIME PERIOD:

(1) PSN4 (T-4 minutes) plus 10 seconds to START ENABLE (T-9.5 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) SSMEC monitored.
(3) All ENGINE READY parameters must be within limits for two continuous seconds to obtain ENGINE READY mode. After ENGINE READY is achieved, no ENGINE READY parameter may leave the redline envelope for more than one continuous second.
(4) All qualified sensors must meet ENGINE READY limits.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(5) For qualification requirement see SSME-34.
(6) ENGINE READY requirement.
(7) ENGINE START inhibited by SSMEC. No FID or inhibit until ENGINE READY is obtained and lost or START ENABLE command is given without ENGINE READY.

REDLINE DERIVATION: CRITICALITY: 3

(8) Limits verify proper quality (subcooled) propellant to the engine to ensure that the start sequence/performance will be within specified limits.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Adverse effect on ENGINE START transient.

CAUSES OF EXCEEDING REDLINE:

(10) Fuel bleed valve malfunction (CLOSED) or restriction in recirculation line.
(11) Orbiter MPS LH2 recirculation system obstruction/restriction.
(12) Orbiter MPS LH2 recirculation pump malfunction.
(13) Inadequate propellant conditioning time.

CAUSES OF EXCEEDING REDLINE: (Continued)

(14) Transducer malfunction.
(15) Controller electronics malfunction.
(16) Harness malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.R								
E41Tn093D	0.019	30	55						
E41Tn128D	0.019	30	55						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET 1 ZONE R3
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: SSME LPOT Discharge Pressure Engine Ready Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41P1064D	ME-1 LPOT Disch Press Ch A DW 70	1 of 2	95	NA	psia	CI
E41P1065D	ME-1 LPOT Disch Press Ch B DW 71					
E41P2064D	ME-2 LPOT Disch Press Ch A DW 70	1 of 2	95	NA	psia	CI
E41P2065D	ME-2 LPOT Disch Press Ch B DW 71					
E41P3064D	ME-3 LPOT Disch Press Ch A DW 70	1 of 2	95	NA	psia	CI
E41P3065D	ME-3 LPOT Disch Press Ch B DW 71					

TIME PERIOD:

(1) PSN4 (T-4 minutes) plus 10 seconds to START ENABLE (T-9.5 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) SSMEC monitored.
(3) All ENGINE READY parameters must be within limits for two continuous seconds to obtain ENGINE READY mode. After ENGINE READY is achieved, no ENGINE READY parameter may leave the redline envelope for more than one continuous second.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) ENGINE READY requirement.
(5) MCF posted and ENGINE START inhibited by SSMEC on second redline violation. No FID or inhibit until ENGINE READY is obtained and lost or START ENABLE command is given without ENGINE READY.

REDLINE DERIVATION: CRITICALITY: 3

(6) Verifies proper SSME propellant feed system pressure to ensure that the start sequence/performance will be within specified limits.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Adverse effect on ENGINE START transient.

CAUSES OF EXCEEDING REDLINE:

(8) Vehicle pressurization system or External Tank vent valve malfunction.
(9) Oxidizer system prevalve in CLOSED position or restriction in feed duct.
(10) Transducer malfunction.
(11) Controller electronics malfunction.
(12) Harness malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
E41Pn064D	0.325	0	600						
E41Pn065D	0.325	0	600						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET 1 ZONE H4
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: SSME Preburner Pump Discharge Temperature ENGINE READY Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41T1020D	ME-1 PBP Disch Temp Ch A DW 11	1 of	NA	186.5	Deg R	CI
E41T1125D	ME-1 PBP Disch Temp Ch B DW 55	2	NA	186.5	Deg R	CI
E41T2020D	ME-2 PBP Disch Temp Ch A DW 11	1 of	NA	186.5	Deg R	CI
E41T2125D	ME-2 PBP Disch Temp Ch B DW 55	2	NA	186.5	Deg R	CI
E41T3020D	ME-3 PBP Disch Temp Ch A DW 11	1 of	NA	186.5	Deg R	CI
E41T3125D	ME-3 PBP Disch Temp Ch B DW 55	2	NA	186.5	Deg R	CI

TIME PERIOD:

(1) PSN4 (T-4 minutes) plus 10 seconds to START ENABLE (T-9.5 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) SSMEC monitored.
(3) All ENGINE READY parameters must be within limits for two continuous seconds to obtain ENGINE READY mode. After ENGINE READY is achieved, no ENGINE READY parameter may leave the redline envelope for more than one continuous second.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) ENGINE READY requirement.
(5) MCF posted and ENGINE START inhibited by SSMEC on second redline violation. No FID or inhibit until ENGINE READY is obtained and lost or START ENABLE command is given without ENGINE READY.

REDLINE DERIVATION: CRITICALITY: 3

(6) Limit verifies that proper quality (subcooled) propellant to the engine to ensure that the start sequence/performance will be within specified limits.
(7) Limit derived from maximum acceptable temperature based on anti-geyser line removal simulation test experience.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Adverse effect on ENGINE START transient.

CAUSES OF EXCEEDING REDLINE:

(9) Degradation of Orbiter LOX duct insulation.
(10) Oxidizer bleed valve malfunction (CLOSED) or restriction in bleed system.
(11) Inadequate propellant conditioning time.

CAUSES OF EXCEEDING REDLINE: (Continued)

(12) Transducer malfunction.
(13) Controller electronics malfunction.
(14) Harness malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.R								
E41Tn020D	0.040	160	230						
E41Tn125D	0.040	160	230						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET 1 ZONE J5
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: SSME Preburner Purge Pressure Engine Ready Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41P1059D	ME-1 Oxid Prebnr Pge Press DW 75		NA	50	psia	CI
E41P1106D	ME-1 Fuel Preburn Pge Press DW 74		NA	50	psia	CI
E41P2059D	ME-2 Oxid Prebnr Pge Press DW 75		NA	50	psia	CI
E41P2106D	ME-2 Fuel Preburn Pge Press DW 74		NA	50	psia	CI
E41P3059D	ME-3 Oxid Prebnr Pge Press DW 75		NA	50	psia	CI
E41P3106D	ME-3 Fuel Preburn Pge Press DW 74		NA	50	psia	CI

TIME PERIOD:

(1) PSN4 (T-4 minutes) plus 10 seconds to START ENABLE (T-9.5 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) SSMEC monitored.
(3) All ENGINE READY parameters must be within limits for two continuous seconds to obtain ENGINE READY mode. After ENGINE READY is achieved, no ENGINE READY parameter may leave the redline envelope for more than one continuous second.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) ENGINE READY requirement.
(5) ENGINE START inhibited by SSMEC. No FID or inhibit until ENGINE READY is obtained and lost or START ENABLE command is given without ENGINE READY.

REDLINE DERIVATION: CRITICALITY: 3

(6) Verifies that GSE supplied GN2 purge has been terminated prior to SSME start.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) SSME preburners may fail to ignite, resulting in a launch pad abort.

CAUSES OF EXCEEDING REDLINE:

(8) Malfunction of or failure to close SSME MPS GN2 shutoff valve.
(9) Transducer malfunction.
(10) Controller electronics malfunction.
(11) Harness malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
E41Pn059D	0.812	0	1500						
E41Pn106D	0.812	0	1500						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.9 SHEET 1 ZONE Q4, M5
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: SSME Emergency Shutdown Pressure ENGINE READY Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41P1107D	ME-1 Emerg Sht Dn Press Ch A DW 72		NA	50	psia	CI
E41P1108D	ME-1 Emerg Sht Dn Press Ch B DW 73		NA	50	psia	CI
E41P2107D	ME-2 Emerg Sht Dn Press Ch A DW 72		NA	50	psia	CI
E41P2108D	ME-2 Emerg Sht Dn Press Ch B DW 73		NA	50	psia	CI
E41P3107D	ME-3 Emerg Sht Dn Press Ch A DW 72		NA	50	psia	CI
E41P3108D	ME-3 Emerg Sht Dn Press Ch B DW 73		NA	50	psia	CI

TIME PERIOD:

(1) PSN4 (T-4 minutes) plus 10 seconds to START ENABLE (T-9.5 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) SSMEC monitored.
(3) All ENGINE READY parameters must be within limits for two continuous seconds to obtain ENGINE READY mode. After ENGINE READY is achieved, no ENGINE READY parameter may leave the redline envelope for more than one continuous second.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) ENGINE READY requirement.
(5) ENGINE START inhibited by SSMEC. No FID or inhibit until ENGINE READY is obtained and lost or START ENABLE command is given without ENGINE READY.

REDLINE DERIVATION: CRITICALITY: 3

(6) Limit verifies helium pressure is removed from propellant valve actuators.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Failure to vent pneumatic pressure during PSN4 results in pneumatic shutdown if hydraulic lockup mode is commanded during ascent.

CAUSES OF EXCEEDING REDLINE:

(8) Emergency shutdown solenoid valve malfunction.
(9) Emergency shutdown pressure actuated valve malfunction.
(10) Transducer malfunction.
(11) Controller electronics malfunction.
(12) Harness malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
E41Pn107D	0.812	0	1500						
E41Pn108D	0.812	0	1500						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.9 SHEET 1 ZONE R4
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: SSME MOV/MFV Hydraulic Temperature ENGINE READY Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41T1109D	ME-1 MOV Hyd Temp Ch A DW 59	1 of	490	NA	Deg R	CI
E41T1110D	ME-1 MOV Hyd Temp Ch B DW 60	2	490	NA	Deg R	CI
E41T1111D	ME-1 MFV Hyd Temp Ch A DW 61	1 of	490	NA	Deg R	CI
E41T1112D	ME-1 MFV Hyd Temp Ch B DW 62	2	490	NA	Deg R	CI
E41T2109D	ME-2 MOV Hyd Temp Ch A DW 59	1 of	490	NA	Deg R	CI
E41T2110D	ME-2 MOV Hyd Temp Ch B DW 60	2	490	NA	Deg R	CI
E41T2111D	ME-2 MFV Hyd Temp Ch A DW 61	1 of	490	NA	Deg R	CI
E41T2112D	ME-2 MFV Hyd Temp Ch B DW 62	2	490	NA	Deg R	CI
E41T3109D	ME-3 MOV Hyd Temp Ch A DW 59	1 of	490	NA	Deg R	CI
E41T3110D	ME-3 MOV Hyd Temp Ch B DW 60	2	490	NA	Deg R	CI
E41T3111D	ME-3 MFV Hyd Temp Ch A DW 61	1 of	490	NA	Deg R	CI
E41T3112D	ME-3 MFV Hyd Temp Ch B DW 62	2	490	NA	Deg R	CI

TIME PERIOD:

(1) PSN4 (T-4 minutes) plus 10 seconds to START ENABLE (T-9.5 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) SSMEC monitored.
(3) All ENGINE READY parameters must be within limits for two continuous seconds to obtain ENGINE READY mode. After ENGINE READY is achieved, no ENGINE READY parameter may leave the redline envelope for more than one continuous second.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) ENGINE READY requirement.
(5) MCF posted and ENGINE START inhibited by SSMEC on second redline violation. No FID or inhibit until ENGINE READY is obtained and lost or START ENABLE command is given without ENGINE READY.

REDLINE DERIVATION: CRITICALITY: 3

(6) Minimum temperature required to ensure proper hydraulic actuator slew rate during flight.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Extremely low temperature may result in hydraulic fluid freezeup.

CAUSES OF EXCEEDING REDLINE:

(8) Low hydraulic circulation pump performance.
(9) Excessively high return system pressure.
(10) Restriction across SSME hydraulic supply filter or supply system.
(11) Transducer malfunction.
(12) Controller electronics malfunction.
(13) Harness malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.R								
E41Tn109D	0.258	360	760						
E41Tn110D	0.258	360	760						
E41Tn111D	0.258	360	760						
E41Tn112D	0.258	360	760						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.9 SHEET 1 ZONE P2, L2
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: SSME HPFT Discharge Temperature Qualification Anomaly | EMERG COND: NONE

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41T1173D	ME-1 HPFT Disch Temp Ch A2 DW 45	(2)	310	600	Deg R	CI
E41T1182D	ME-1 HPFT Disch Temp Ch A3 DW 64	(2)	310	600	Deg R	CI
E41T1174D	ME-1 HPFT Disch Temp Ch B2 DW 46	(2)	310	600	Deg R	CI
E41T1189D	ME-1 HPFT Disch Temp Ch B3 DW 69	(2)	310	600	Deg R	CI
E41T2173D	ME-2 HPFT Disch Temp Ch A2 DW 45	(2)	310	600	Deg R	CI
E41T2182D	ME-2 HPFT Disch Temp Ch A3 DW 64	(2)	310	600	Deg R	CI
E41T2174D	ME-2 HPFT Disch Temp Ch B2 DW 46	(2)	310	600	Deg R	CI
E41T2189D	ME-2 HPFT Disch Temp Ch B3 DW 69	(2)	310	600	Deg R	CI
E41T3173D	ME-3 HPFT Disch Temp Ch A2 DW 45	(2)	310	600	Deg R	CI
E41T3182D	ME-3 HPFT Disch Temp Ch A3 DW 64	(2)	310	600	Deg R	CI
E41T3174D	ME-3 HPFT Disch Temp Ch B2 DW 46	(2)	310	600	Deg R	CI
E41T3189D	ME-3 HPFT Disch Temp Ch B3 DW 69	(2)	310	600	Deg R	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Engine Start (T-6.5 seconds).

REQUIREMENTS: FIGURES/TABLES:

(2) 3 of 4 temperature sensors per engine required. (A report only Failure Identifier (FID) is issued for the first sensor violation, no action is required.)

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) SSME Controller (SSMEC) monitored.
(4) Major Component Failure (MCF) posted and Engine Start inhibited by SSMEC for two or more sensor violations on the same engine.
(5) High Pressure Fuel Turbine (HPFT) Discharge Temperatures are a redline measurement in Engine Start and Mainstage.
(6) A smart failure of a sensor's signal conditioning circuit within the controller following a sensor failure on the opposite channel could result in an erroneous engine shutdown. This condition has an extremely low probability of occurrence.

REDLINE DERIVATION: CRITICALITY: 3

(7) a. SSID Intent Summary - The HPFT Discharge Temperature measurements protect the High Pressure Fuel Turbopump (HPFTP) turbine blades from high temperatures leading to structural failure during Engine Start and Mainstage operation. In addition, the measurements monitor for HPFTP Lift-Off Seal leakage prior to Engine Start (Reference SSID SSME-44

REDLINE DERIVATION: (Continued)

'HPFTP Lift-Off Seal Anomaly.') For these reasons, the measurements are verified to indicate reasonable values per the requirements outlined in this SSID.

b. Voting Logic - There are four HPFT Discharge Temperature measurements per engine. The measurements are Pad Abort monitors during SSME Start and Redline monitors during SSME Mainstage. To maintain redundancy during SSME Start and Mainstage, only one sensor qualification failure per engine prior to Engine Start is accepted.
c. Redline Development - The HPFT Discharge Temperature qualification limits during chill are based on experience. The maximum limit adequately accounts for the influence of the SSME GN2 heater. The minimum limit is sufficiently low enough to account for a cold ambient environment and HPFTP Lift-Off Seal leakage, however, large HPFTP Lift-Off Seal leaks could violate the minimum qualification limit.
d. Time Period - The HPFT Discharge Temperatures measurements are monitored for qualification from the beginning of LH2 chilldown (T-6 hours) until Engine Start (T-6.5 seconds) to ensure the integrity of the measurements prior to lift-off. Qualification monitoring continues after Engine Start with different limits, however, Engine Start is specified as the end time because SSME Launch Commit Criteria ends at Engine Start.
e. Requirements - Reference Voting Logic above.
f. Preplanned Contingency Procedures - NA

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Insufficient measurement redundancy during SSME Start and Mainstage. Premature SSME shutdown if additional failures occur after Engine Start.

CAUSES OF EXCEEDING REDLINE:

(9) HPFTP Lift-Off Seal leakage.
(10) Transducer/measurement system failure.
(11) Controller electronics malfunction.
(12) Harness failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.R								
E41Tn173D	1.407	150	2450						
E41Tn182D	1.407	150	2450						
E41Tn174D	1.407	150	2450						
E41Tn189D	1.407	150	2450						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.13	SHEET 1	ZONE Q5,P5
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: SSME SUBSYSTEM: SSME

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LCC VIOLATION CALL: SSME HPOT Discharge Temperature Qualification Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41T1175D	ME-1 HPOT Disch Temp Ch A2 DW 47	(3)	360	600	Deg R	CI
E41T1190D	ME-1 HPOT Disch Temp Ch A3 DW 122	(3)	360	600	Deg R	CI
E41T1176D	ME-1 HPOT Disch Temp Ch B2 DW 48	(3)	360	600	Deg R	CI
E41T1191D	ME-1 HPOT Disch Temp Ch B3 DW 123	(3)	360	600	Deg R	CI
E41T2175D	ME-2 HPOT Disch Temp Ch A2 DW 47	(3)	360	600	Deg R	CI
E41T2190D	ME-2 HPOT Disch Temp Ch A3 DW 122	(3)	360	600	Deg R	CI
E41T2176D	ME-2 HPOT Disch Temp Ch B2 DW 48	(3)	360	600	Deg R	CI
E41T2191D	ME-2 HPOT Disch Temp Ch B3 DW 123	(3)	360	600	Deg R	CI
E41T3175D	ME-3 HPOT Disch Temp Ch A2 DW 47	(3)	360	600	Deg R	CI
E41T3190D	ME-3 HPOT Disch Temp Ch A3 DW 122	(3)	360	600	Deg R	CI
E41T3176D	ME-3 HPOT Disch Temp Ch B2 DW 48	(3)	360	600	Deg R	CI
E41T3191D	ME-3 HPOT Disch Temp Ch B3 DW 123	(3)	360	600	Deg R	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to ENGINE START

REQUIREMENTS: FIGURES/TABLES:

(2) SSMEC monitored.
(3) 3 of 4 temperature sensors per engine required. (A report only FID is issued for the first sensor violation, no action is required.)

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) MCF posted and ENGINE START inhibited by SSMEC for two or more sensor violations on the same engine.
(5) HPOT disch temps are a redline measurement in engine start and mainstage.
(6) A smart failure of a sensor's signal conditioning circuit within the controller following a sensor failure on the opposite channel, could result in an erroneous engine shutdown. This condition has an extremely low probability of occurrence.

REDLINE DERIVATION: CRITICALITY: 3

(7) Redlines are based on flight and test experience and ensure that sensors mandatory after ENGINE START are qualified and functional for flight.
(8) Minimum qualification redline violations on an engine could indicate Oxidizer Preburner Oxidizer Valve (OPOV) leakage. (Reference SSID SSME-01, 'SSME OPOV LOX Supply Line Temperature Anomaly.')

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Reduced redline redundancy.

CAUSES OF EXCEEDING REDLINE:

(10) Transducer/measurement system failure.
(11) Controller electronics malfunction.
(12) Harness malfunction.
(13) OPOV leakage.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.R								
E41Tn175D	1.407	150	2450						
E41Tn190D	1.407	150	2450						
E41Tn176D	1.407	150	2450						
E41Tn191D	1.407	150	2450						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET 1 ZONE J5,H5
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: SSME HPOT Intermediate Seal Purge Pressure Qualification Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41P1014D	ME-1 HPOT I-Seal Pge P Ch A		0	650	psia	CI
E41P1015D	ME-1 HPOT I-Seal Pge P Ch B		0	650	psia	CI
E41P2014D	ME-2 HPOT I-Seal Pge P Ch A		0	650	psia	CI
E41P2015D	ME-2 HPOT I-Seal Pge P Ch B		0	650	psia	CI
E41P3014D	ME-3 HPOT I-Seal Pge P Ch A		0	650	psia	CI
E41P3015D	ME-3 HPOT I-Seal Pge P Ch B		0	650	psia	CI

TIME PERIOD:

(1) Purge Sequence No. 1 to ENGINE START

REQUIREMENTS: FIGURES/TABLES:

(2) MEC monitored.

PREPLANNED CONTINGENCY PROCEDURE:

(3) Resolve anomaly before recycling for launch.

NOTES:

(4) Prestart redline sensor qualification requirement.
(5) ENGINE START inhibited by MEC.

REDLINE DERIVATION: CRITICALITY: 3

(6) Violation indicative of measurement system malfunction.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Loss of redline redundancy.

CAUSES OF EXCEEDING REDLINE:

(8) Transducer malfunction.
(9) Controller electronics malfunction.
(10) Harness malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
E41Pn014D	0.325	0	600						
E41Pn015D	0.325	0	600						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET 1 ZONE L8
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

SSME HPOT Secondary Seal Cavity Pressure Qualification Anomaly

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SSME HPFT Coolant Liner Pressure Qualification Anomaly

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LCC VIOLATION CALL: SSME Fuel Flow Rate Channel Qualification Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41R1034D	ME-1 Fuel Flowrate Sensor A1 DW 34		(3)	(3)	gpm	CI
E41R1102D	ME-1 Fuel Flowrate Sensor A2 DW124		(3)	(3)	gpm	CI
E41R1089D	ME-1 Fuel Flowrate Sensor B1 DW 89		(3)	(3)	gpm	CI
E41R1103D	ME-1 Fuel Flowrate Sensor B2 DW125		(3)	(3)	gpm	CI
E41R2034D	ME-2 Fuel Flowrate Sensor A1 DW 34		(3)	(3)	gpm	CI
E41R2102D	ME-2 Fuel Flowrate Sensor A2 DW124		(3)	(3)	gpm	CI
E41R2089D	ME-2 Fuel Flowrate Sensor B1 DW 89		(3)	(3)	gpm	CI
E41R2103D	ME-2 Fuel Flowrate Sensor B2 DW125		(3)	(3)	gpm	CI
E41R3034D	ME-3 Fuel Flowrate Sensor A1 DW 34		(3)	(3)	gpm	CI
E41R3102D	ME-3 Fuel Flowrate Sensor A2 DW124		(3)	(3)	gpm	CI
E41R3089D	ME-3 Fuel Flowrate Sensor B1 DW 89		(3)	(3)	gpm	CI
E41R3103D	ME-3 Fuel Flowrate Sensor B2 DW125		(3)	(3)	gpm	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to START ENABLE (T-9.5 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) SSMEC monitored.
(3) Monitor the SSMEC failure ID word (DW 5) to verify no annunciation of a qualification violation. A FID listed below will be posted if the flowmeter measurement exceeds limits.
   FID 111 Delimiter 103,104,105,106
   FID 011 Delimiter 103,104,105,106

PREPLANNED CONTINGENCY PROCEDURE:

(4) If FID is a result of fuel flowmeter motion caused by tanking or MPS troubleshooting procedures, then issue a CONTROLLER RESET to clear the FID, MCF and INHIBIT (reference OMI S0007, Vol. 5 for controller reset procedure), LCC violation cleared, continue countdown. A CONTROLLER RESET reinitializes a sensor channel and causes the engine bleed valves to close. Requirements of OMRSD S00E00.122 (safing for loss of LO2 bleed flow), LCC MPS-33 (LH2 recirc interruption), and LCC MPS-24 (thermal conditioning requirements for interruption of bleed flow) must be observed.
(5) A RESUME command should not be used to clear the MCF and INHIBIT to continue the countdown. The failed sensor channel(s) will remain disqualified and represent an unacceptable loss of redundancy in Start and Mainstage. An additional failure during start on the same engine will result in a pad abort.

NOTES:

(6) Prestart performance sensor channel qualification requirement.
(7) First, second and third failure: post resumable MCF, FID, and ENGINE START inhibited by SSMEC.
(8) True qualification limit units are flowmeter blade passes recorded per second (pps). The minimum limit for each sensor is 0 pps. The maximum limit is 25 pps. The pps measurement for each individual sensor is not provided to the vehicle data table (VDT). Instead, Fuel Flowrate (in gpm) is provided. Fuel Flowrate is dependent upon Calculated Kf (MSID E41Qx195D) as well as pps. Qualification limits in gpm can be calculated using the equation: Fuel Flowrate = (pps*60)/(Calc Kf).

REDLINE DERIVATION: CRITICALITY:

(9) Violation indicative of fuel flow rate sensor channel malfunction.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Loss of control parameter redundancy.

CAUSES OF EXCEEDING REDLINE:

(11) Controller electronics malfunction.
(12) Fuel flowmeter motion caused by tanking or MPS troubleshooting procedures.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	gpm								
E41Rn034D	1.0	440	24000						
E41Rn102D	1.0	440	24000						
E41Rn089D	1.0	440	24000						
E41Rn103D	1.0	440	24000						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET 1 ZONE R3
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: SSME MCC Pressure Interchannel Qualification Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41P1036D	ME-1 MCC Pressure A1		(3)	(3)	psia	CI
E41P1035D	ME-1 MCC Pressure A2		(3)	(3)	psia	CI
E41P2036D	ME-2 MCC Pressure A1		(3)	(3)	psia	CI
E41P2035D	ME-2 MCC Pressure A2		(3)	(3)	psia	CI
E41P3036D	ME-3 MCC Pressure A1		(3)	(3)	psia	CI
E41P3035D	ME-3 MCC Pressure A2		(3)	(3)	psia	CI
E41P1052D	ME-1 MCC Pressure B1		(4)	(4)	psia	CI
E41P1124D	ME-1 MCC Pressure B2		(4)	(4)	psia	CI
E41P2052D	ME-2 MCC Pressure B1		(4)	(4)	psia	CI
E41P2124D	ME-2 MCC Pressure B2		(4)	(4)	psia	CI
E41P3052D	ME-3 MCC Pressure B1		(4)	(4)	psia	CI
E41P3124D	ME-3 MCC Pressure B2		(4)	(4)	psia	CI

TIME PERIOD:

(1) Purge Sequence No. 1 to ENGINE START

REQUIREMENTS: FIGURES/TABLES:

(2) SSMEC monitored.
(3) The pressure difference between Channel A1 and Channel A2 can be no greater than 75 psi.
(4) The pressure difference between Channel B1 and Channel B2 can be no greater than 75 psi.

PREPLANNED CONTINGENCY PROCEDURE:

(5) Resolve anomaly before recycling for launch.

NOTES:

(6) Prestart performance sensor qualification requirement.
(7) ENGINE START inhibited by SSMEC.

REDLINE DERIVATION: CRITICALITY: 3

(8) Violation indicative of MCC pressure sensor malfunction.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Loss of performance parameter redundancy.

CAUSES OF EXCEEDING REDLINE:

(10) Transducer malfunction.
(11) Controller electronics malfunction.
(12) Harness malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
E41Pn036D	1.894	0	3500						
E41Pn035D	1.894	0	3500						
E41Pn052D	1.894	0	3500						
E41Pn124D	1.894	0	3500						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET 1 ZONE M4
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: SSME MCC Press Channel Qualification Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41P1016D	ME-1 MCC Pressure Ch A		0	37	psia	CI
E41P1017D	ME-1 MCC Pressure Ch B		0	37	psia	CI
E41P2016D	ME-2 MCC Pressure Ch A		0	37	psia	CI
E41P2017D	ME-2 MCC Pressure Ch B		0	37	psia	CI
E41P3016D	ME-3 MCC Pressure Ch A		0	37	psia	CI
E41P3017D	ME-3 MCC Pressure Ch B		0	37	psia	CI

TIME PERIOD:

(1) Purge Sequence No. 4 to ENGINE START

REQUIREMENTS: FIGURES/TABLES:

(2) MEC monitored.

PREPLANNED CONTINGENCY PROCEDURE:

(3) Resolve anomaly before recycling for launch.

NOTES:

(4) Prestart performance sensor qualification requirement.
(5) ENGINE START inhibited by MEC.

REDLINE DERIVATION: CRITICALITY: 3

(6) Limits set to ensure engine mixture ratio within ICD limits.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Off nominal engine performance.
(8) Loss of performance parameter redundancy.

CAUSES OF EXCEEDING REDLINE:

(9) Abnormal boattail thermal environment.
(10) Transducer malfunction.
(11) Controller electronics malfunction.
(12) Harness malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
E41Pn016D	1.894	0	3500						
E41Pn017D	1.894	0	3500						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO N/A SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: SSME LPFP Discharge Pressure Qualification Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41P1092D	ME-1 LPFP Disch Press Ch A DW 92		0	61	psia	CI
E41P1127D	ME-1 LPFP Disch Press Ch B DW 127		0	61	psia	CI
E41P2092D	ME-2 LPFP Disch Press Ch A DW 92		0	61	psia	CI
E41P2127D	ME-2 LPFP Disch Press Ch B DW 127		0	61	psia	CI
E41P3092D	ME-3 LPFP Disch Press Ch A DW 92		0	61	psia	CI
E41P3127D	ME-3 LPFP Disch Press Ch B DW 127		0	61	psia	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to START ENABLE (T-9.5 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) SSMEC monitored.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) Prestart performance sensor qualification requirement.
(4) MCF posted and ENGINE START inhibited by SSMEC for redline violations.

REDLINE DERIVATION: CRITICALITY: 3

(5) Violation indicates MPS fuel system anomaly or measurement system malfunction.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Loss of performance parameter redundancy or propellant conditions outside ENGINE READY limits (see ENGINE READY requirements).

CAUSES OF EXCEEDING REDLINE:

(7) Transducer malfunction.
(8) Controller electronics malfunction.
(9) Harness malfunction.
(10) MPS fuel system anomaly.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
E41Pn092D	0.162	0	300						
E41Pn127D	0.162	0	300						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET 1 ZONE R3
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: SSME Preburner Purge Pressure Qualification Anomaly	EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41P1059D	ME-1 Oxid Prebnr Pge Press DW 75		0	535	psia	CI
E41P1106D	ME-1 Fuel Preburn Pge Press DW 74		0	160	psia	CI
E41P2059D	ME-2 Oxid Prebnr Pge Press DW 75		0	535	psia	CI
E41P2106D	ME-2 Fuel Preburn Pge Press DW 74		0	160	psia	CI
E41P3059D	ME-3 Oxid Prebnr Pge Press DW 75		0	535	psia	CI
E41P3106D	ME-3 Fuel Preburn Pge Press DW 74		0	160	psia	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to START ENABLE (T-9.5 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) SSMEC monitored.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) Prestart sensor qualification requirement.
(4) ENGINE START inhibited by SSMEC.

REDLINE DERIVATION: CRITICALITY: 3

(5) Violation indicates purge system anomaly or failed measurement system.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Failure to properly inert preburners could result in icing or partial blockage of injectors, which could lead to engine damage.

CAUSES OF EXCEEDING REDLINE:

(7) High GN2 source pressure.
(8) PCA malfunction or orifice blockage.
(9) Check valve fails to open.
(10) Controller electronics malfunction.
(11) Transducer malfunction.
(12) Harness malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
E41Pn059D	0.812	0	1500						
E41Pn106D	0.812	0	1500						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.9 SHEET 1 ZONE Q4, M5
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: SSME LPFP Discharge Temperature Qualification Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41T1093D	ME-1 LPFP Disch Temp Ch A		35	45	Deg R	CI
E41T1128D	ME-1 LPFP Disch Temp Ch B		35	45	Deg R	CI
E41T2093D	ME-2 LPFP Disch Temp Ch A		35	45	Deg R	CI
E41T2128D	ME-2 LPFP Disch Temp Ch B		35	45	Deg R	CI
E41T3093D	ME-3 LPFP Disch Temp Ch A		35	45	Deg R	CI
E41T3128D	ME-3 LPFP Disch Temp Ch B		35	45	Deg R	CI

TIME PERIOD:

(1) Purge Sequence No. 4 to START ENABLE (T-9.5 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) SSMEC monitored.
(3) 1 of 2 measurements per SSME acceptable.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) During Start Prep phase SSMEC posts report only FID for first channel disqualification. See SSME-18 for ENGINE READY requirement.
(5) During start and mainstage phase a report only FID posted for first and second channel disqualification and fixed density mode will be entered after second disqualification.
(6) Prestart performance sensor qualification requirement.
(7) ENGINE START inhibited by SSMEC.

REDLINE DERIVATION: CRITICALITY: 3

(8) Violation indicates MPS fuel system anomaly or measurement system malfunction.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Loss of performance measurement redundancy or propellant conditions outside ENGINE READY limits (see ENGINE READY requirements).

CAUSES OF EXCEEDING REDLINE:

(10) Transducer malfunction.
(11) Controller electronics malfunction.
(12) Harness malfunction.
(13) MPS fuel system anomaly.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.R								
E41Tn093D	0.019	30	55						
E41Tn128D	0.019	30	55						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET 1 ZONE R3
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: SSME Propellant Valve Position Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41Hx024D	ME-x MFV Actuator Position Ch A		(3)(4)	(3)(4)	Pct	CI
E41Hx084D	ME-x MFV Act Pos Ch B		(4)	(4)	Pct	CI
E41Hx025D	ME-x MOV Actuator Position Ch A		(3)(4)	(3)(4)	Pct	CI
E41Hx085D	ME-x MOV Act Pos Ch B		(4)	(4)	Pct	CI
E41Hx028D	ME-x OPOV Actuator Position Ch A		(3)(4)	(3)(4)	Pct	CI
E41Hx088D	ME-x OPOV Act Pos Ch B		(4)	(4)	Pct	CI
E41Hx027D	ME-x FPOV Actuator Position Ch A		(3)(4)	(3)(4)	Pct	CI
E41Hx087D	ME-x FPOV Act Pos Ch B		(4)	(4)	Pct	CI
E41Hx026D	ME-x CCV Actuator Position Ch A		(3)(4)	(3)(4)	Pct	CI
E41Hx086D	ME-x CCV Act Pos Ch B		(4)	(4)	Pct	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to SRB Ignition (T-0)

REQUIREMENTS: FIGURES/TABLES:

(2) SSMEC monitored during all controller power on phases.
(3) Channel A must read within +/- 6% of model output commanded position.
(4) The difference between Channel A and Channel B RVDT position must be less than 3%. (8)

PREPLANNED CONTINGENCY PROCEDURE:

(5) Resolve anomaly before recycling for launch.

NOTES:

(6) Valve actuator requirement.
(7) X = 1, 2, and 3 for Engines 1, 2, and 3, respectively.
(8) If violation occurs, SSMEC issues MCF/inhibit response.
(9) ENGINE START inhibited by SSMEC.

REDLINE DERIVATION: CRITICALITY: 3

(10) Maximum allowable tolerances of valve positioning without loss of engine control.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Loss of valve positioning control.

CAUSES OF EXCEEDING REDLINE:

(12) Position indicator malfunction (RVDT).
(13) Hydraulic actuator malfunction.
(14) Controller electronics malfunction.
(15) Harness malfunction.
(16) Low hydraulic supply pressure.
(17) Hydraulic return system blockage or restriction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	pcnt								
E41Hn024D	0.068	-5	105						
E41Hn084D	0.068	-5	105						
E41Hn025D	0.068	-5	105						
E41Hn085D	0.068	-5	105						
E41Hn028D	0.072	-5	105						
E41Hn088D	0.072	-5	105						
E41Hn027D	0.072	-5	105						
E41Hn087D	0.072	-5	105						
E41Hn026D	0.072	-5	105						
E41Hn086D	0.072	-5	105						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.9	SHEET 1	ZONE R3,P3
	DWG NO 10.9	SHEET 1	ZONE O3,M3
	DWG NO 10.9	SHEET 1	ZONE L3
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: ME Shutdown Switch Contact Disagree | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V90X7551X	SEL ME-1 Shutdown Command	(2)	OFF	N/A	Event	DI
V90X7552X	SEL ME-2 Shutdown Command	(2)	OFF	N/A	Event	DI
V90X7553X	SEL ME-3 Shutdown Command	(2)	OFF	N/A	Event	DI
ME SHDN C	ME Shutdown Switch C (A)	(3)	(4)	N/A	Event	CI
ME SHDN L	ME Shutdown Switch L (A)	(3)	(4)	N/A	Event	CI
ME SHDN R	ME Shutdown Switch R (A)	(3)	(4)	N/A	Event	CI

TIME PERIOD:

(1) From Transition to OPS 1 (T-19 mins) to Go for RSLS start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) One time RM output check between OPS 1 (T-19 mins) and T-31 seconds.
(3) Required for ground and crew insight into state of SSME shutdown switch.
(4) Message not annunciated.
(5) Capability must exist to sustain one failure and still be able to mode guidance for engine out conditions.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(6) Intent of this LCC is to identify the requirement for a hold if the fault message is annunciated.
(7) OFF equals zero.

REDLINE DERIVATION: CRITICALITY: 1R

(8) The main engine shutdown switches are 2-contact switches. Both contacts should be in a "zero" (OFF) state. If one contact experiences a short to power, a switch contact disagree will exist and the GPCs will annunciate a message (ME SHDN SW C(L,R). Shutdown function of switch no longer works; however, the safing feature (which also sets the engine fail flag allowing guidance to mode) will work when the pb is pushed unless the second contact fails low. One failure (second contact fails low) away from not being able to mode guidance for an engine out condition with data path fail.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Vehicle control will be degraded if the guidance software is not moded for loss of a single engine's thrust. Vehicle control may be lost if this is the failure of a second engine.

CAUSES OF EXCEEDING REDLINE:

(10) Switch contact short.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.13	SHEET 1 of 1	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: SSME

LCC VIOLATION CALL: MPS Engine Limit Control Auto Switch Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V72K0071X	MPS Eng Limit Control #1 Auto (A)		ON	N/A	Event	CI
V72K0072X	MPS Eng Limit Control #2 Auto (A)		ON	N/A	Event	CI
V72K0073X	MPS Eng Limit Control #3 Auto (A)		ON	N/A	Event	CI

TIME PERIOD:

(1) To T-20 minutes: Required for ground insight into state of the SSME Limit shutdown switch

REQUIREMENTS: FIGURES/TABLES:

(2) The SSME limit switch should be enabled for the AUTO mode for launch.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) Intent of this SSID is to identify the requirement for the measurement to be present for launch.

REDLINE DERIVATION: CRITICALITY: 1R

(4) The auto function is required for launch for the SSME limit switch.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) SSME limit management will not be possible for multiple contact failures.
(6) The auto function of the switch will be impaired. The auto function includes.
    Automatic inhibit of SSME limits.
    Automatic shutdown due to redline violations.

CAUSES OF EXCEEDING REDLINE:

(7) Switch contact short.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET 1 of 1 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: SSME

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LCC VIOLATION CALL: SSME Preburner Pump Discharge Temperature Sensor Qualification Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41T1020D	ME-1 PBP Disch Temp Ch A DW 11	1 of	NA	237	Deg R	CI
E41T1125D	ME-1 PBP Disch Temp Ch B DW 55	2	NA	237	Deg R	CI
E41T2020D	ME-2 PBP Disch Temp Ch A DW 11	1 of	NA	237	Deg R	CI
E41T2125D	ME-2 PBP Disch Temp Ch B DW 55	2	NA	237	Deg R	CI
E41T3020D	ME-3 PBP Disch Temp Ch A DW 11	1 of	NA	237	Deg R	CI
E41T3125D	ME-3 PBP Disch Temp Ch B DW 55	2	NA	237	Deg R	CI

TIME PERIOD:

(1) Purge Sequence No. 4 to Engine Start

REQUIREMENTS: FIGURES/TABLES:

(2) SSMEC monitored.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) No violation call for single channel failure.
(4) Qualification requirement.
(5) Engine Start inhibited by SSMEC.

REDLINE DERIVATION: CRITICALITY: 3

(6) Both channels above maximum redline is indicative of sensor tip failure.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Potential contamination of the LOX system with sensor debris.

CAUSES OF EXCEEDING REDLINE:

(8) Transducer structural failure.
(9) Two controller electronics failures.
(10) Two harness open circuit failures.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.R								
E41Tn020D	0.040	160	230						
E41Tn125D	0.040	160	230						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET 1 ZONE J5
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: SSME POGO Precharge Pressure Qualification Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41P1055D	ME-1 POGO Prechg Press Ch A		0	1600	psia	CI
E41P1056D	ME-1 POGO Prechg Press Ch B		0	1600	psia	CI
E41P2055D	ME-2 POGO Prechg Press Ch A		0	1600	psia	CI
E41P2056D	ME-2 POGO Prechg Press Ch B		0	1600	psia	CI
E41P3055D	ME-3 POGO Prechg Press Ch A		0	1600	psia	CI
E41P3056D	ME-3 POGO Prechg Press Ch B		0	1600	psia	CI

TIME PERIOD:

(1) Purge Sequence No. 1 to Engine Start

REQUIREMENTS: FIGURES/TABLES:

(2) MEC monitored.

PREPLANNED CONTINGENCY PROCEDURE:

(3) Resolve anomaly before recycling for launch.

NOTES:

(4) Qualification requirement.
(5) Engine Start inhibited by MEC.

REDLINE DERIVATION: CRITICALITY: 3

(6) Value outside of sensor range is indicative of measurement system failure.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Loss of critical measurement during start. Failure to confirm POGO GOX flow during engine start results in MCF and vehicle commanded engine shutdown (pad abort).

CAUSES OF EXCEEDING REDLINE:

(8) Transducer malfunction.
(9) Controller electronics malfunction.
(10) Harness failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
E41Pn055D	0.812	0	1500						
E41Pn056D	0.812	0	1500						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET 1 ZONE F5
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

SSME MCC LOX Dome Purge

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Main Engine TVC Servo Override Command Anomaly

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SSME Reference Junction Temperature Qualification Anomaly

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LCC VIOLATION CALL: SSME MCC Pc Discriminator Qualification Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41P1029D	ME-1 HPFTP Disch Pressure DW 29	(3)	-80	145	psia	CI
E41P1030D	ME-1 HPOTP Disch Pressure DW 30	(3)	-60	200	psia	CI
E41P2029D	ME-2 HPFTP Disch Pressure DW 29	(3)	-80	145	psia	CI
E41P2030D	ME-2 HPOTP Disch Pressure DW 30	(3)	-60	200	psia	CI
E41P3029D	ME-3 HPFTP Disch Pressure DW 29	(3)	-80	145	psia	CI
E41P3030D	ME-3 HPOTP Disch Pressure DW 30	(3)	-60	200	psia	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to START ENABLE (T-9.5 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) SSMEC monitored.
(3) 1 of 2 measurements acceptable.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) A report only FID is issued for the first sensor violation, no action is required.
(5) Prestart MCC Pc Discriminator qualification requirement.
(6) ENGINE START inhibited by SSMEC on the second sensor failure.

REDLINE DERIVATION: CRITICALITY: 3

(7) Violation indicative of measurement system malfunction.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Loss of ability to discriminate between an erroneous MCC Pc Channel and a good MCC Pc Channel in the event of a slow MCC Pc Channel drift.

CAUSES OF EXCEEDING REDLINE:

(9) Transducer malfunction.
(10) Controller electronics malfunction.
(11) Harness malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
E41Pn029D	5.142	0	9500						
E41Pn030D	3.788	0	7000						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET 1 ZONE O4, J4
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

LCC VIOLATION CALL: SSME HPFTP Lift-Off Seal Anomaly | EMERG COND: Yellow (8)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41T1173D	ME-1 HPFT Disch Temp Ch A2 DW 45		360	NA	Deg R	CI
E41T1182D	ME-1 HPFT Disch Temp Ch A3 DW 64		360	NA	Deg R	CI
E41T1174D	ME-1 HPFT Disch Temp Ch B2 DW 46		360	NA	Deg R	CI
E41T1189D	ME-1 HPFT Disch Temp Ch B3 DW 69		360	NA	Deg R	CI
E41T2173D	ME-2 HPFT Disch Temp Ch A2 DW 45		360	NA	Deg R	CI
E41T2182D	ME-2 HPFT Disch Temp Ch A3 DW 64		360	NA	Deg R	CI
E41T2174D	ME-2 HPFT Disch Temp Ch B2 DW 46		360	NA	Deg R	CI
E41T2189D	ME-2 HPFT Disch Temp Ch B3 DW 69		360	NA	Deg R	CI
E41T3173D	ME-3 HPFT Disch Temp Ch A2 DW 45		360	NA	Deg R	CI
E41T3182D	ME-3 HPFT Disch Temp Ch A3 DW 64		360	NA	Deg R	CI
E41T3174D	ME-3 HPFT Disch Temp Ch B2 DW 46		360	NA	Deg R	CI
E41T3189D	ME-3 HPFT Disch Temp Ch B3 DW 69		360	NA	Deg R	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Start Enable (T-9.5 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) All qualified sensors per SSME-24 (SSME HPFT Discharge Temperature Qualification Anomaly) are required to be above the limit. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Immediately perform the emergency safing steps of OMI S1004, "SSME MFV and HPFTP Lift-Off Seal Leakage", to isolate engine from fuel supply. LCC violation confirmed, No Go for launch.

NOTES:

(4) SSME Controller (SSMEC) monitored.
(5) SSMEC will respond to each qualified sensor violation by posting a Failure Identifier (FID), a resumable Major Component Failure (MCF), and inhibiting Engine Start. If a RESUME command is issued, the sensor will be removed from the HPFTP Lift-Off Seal Leak monitor, but will remain qualified for redline monitoring after Engine Start.
(6) If 60 Kbit measurement visibility is lost, low resolution visibility is available in the 128 Kbit datastream.

REDLINE DERIVATION: CRITICALITY: 1R

(7) a. SSID Intent Summary - The High Pressure Fuel Turbopump (HPFTP) Lift-Off Seal prevents LH2 in the pump end of the HPFTP from entering the turbine end of the HPFTP prior to Engine Start. After Engine Start, pump end pressure opens the seal and cools the turbine end hardware. The High Pressure Fuel Turbine (HPFT) Discharge Temperature measurements are used

REDLINE DERIVATION: (Continued)

to monitor for HPFTP Lift-Off Seal leakage during chill.

b. Voting Logic - NA
c. Redline Development - The minimum limit is based on flight experience. The minimum limit is sufficiently low enough to account for a cold ambient environment and the influence of the HPFTP turbine coolant tube helium purge (Reference SSID SSME-09, 'Fuel System Purge Pressure Anomaly.')
d. Time Period - The HPFTP Lift-Off Seal leak monitor is required from the beginning of LH2 chilldown (T-6 hours) until Start Enable (T-9.5 seconds). The monitor ends at Start Enable rather than Engine Start to exclude the possibility of a late HPFTP Lift-Off Seal leak causing an on-pad abort. The time between Start Enable and Engine Start is small and any HPFTP Lift-Off Seal leak during that time would be insignificant compared to the LH2 lead of the SSME start transient.
e. Requirements - There are four HPFT Discharge Temperature measurements per engine. HPFTP Lift-Off Seal leakage cannot be tolerated due to the Yellow Emergency Condition associated with it, therefore, all qualified measurements per SSID SSME-24 are required to be above the HPFTP Lift-Off Seal leakage limit. A single qualified indication below the limit fails the LCC requirement.
f. Preplanned Contingency Procedures - HPFTP Lift-Off Seal leakage is a criticality category 1 failure requiring immediate action. This PCP isolates the fuel supply from the engine in order to reduce the probability of fire or explosion due to hydrogen concentration buildup resulting from HPFTP Lift-Off Seal leakage.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) A Yellow condition exists for confirmed HPFTP Lift-Off Seal leakage. Unburned hydrogen will be expelled from the nozzle; there is a potential for fire/explosion.

CAUSES OF EXCEEDING REDLINE:

(9) HPFTP Lift-Off Seal leakage.
(10) Cold thermocouple environment due to cold ambient conditions.
(11) Transducer/measurement system failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.R								
E41Tn173D	1.407	150	2450						
E41Tn182D	1.407	150	2450						
E41Tn174D	1.407	150	2450						
E41Tn189D	1.407	150	2450						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET 1 ZONE Q5,P5
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSME SUBSYSTEM: SSME

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SECTION 21

MAIN PROPULSION SYSTEM

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SECTION 21: MAIN PROPULSION SYSTEM

SSID No.	Description/Violation Call	Page
MPS-01	MPS Helium Supply Pressure Anomaly	21-01.1
MPS-02	MPS Aft/Mid Fuselage Helium Supply Temperature Anomaly	21-02.1
MPS-03	SSME Helium Regulator Outlet Pressure Anomaly	21-03.1
MPS-04	MPS LH2 Inboard Fill and Drain Valve Position/Power Indication Anomaly	21-04.1
MPS-05	MPS LH2 Outboard Fill/Drain Valve Position Anomaly	21-05.1
MPS-06	LH2 Fill Line Drain Anomaly	21-06.1
MPS-07	MPS LO2 Inboard Fill and Drain Valve Position/ Power Indication Anomaly	21-07.1
MPS-08	MPS LO2 Outboard Fill and Drain Valve Position Indication Anomaly	21-08.1
MPS-09	LO2 Drainback Anomaly	21-09.1
MPS-10	MPS LH2 Topping Valve Position Indication Anomaly	21-10.1
MPS-11	MPS LH2 17 Inch Feed Manifold Disconnect Temperature/High Point Bleed Temperature Anomaly	21-11.1
MPS-12	MPS LH2 High Point Bleed Valve Anomaly	21-12.1
MPS-13	LO2 17 Inch Disconnect Valve/Latch Position Indication Anomaly	21-13.1
MPS-14	LH2 17 Inch Disconnect Valve/Latch Position Indication Anomaly	21-14.1
MPS-15	LO2 17 Inch Disconnect Valve/Latch Position Indication Anomaly	21-15.1
MPS-16	LH2 17 Inch Disconnect Valve/Latch Position Indication Anomaly	21-16.1
MPS-17	MPS LH2 17 Inch Feedline Disconnect Power/RPC Anomaly	21-17.1

SECTION 21: MAIN PROPULSION SYSTEM (CONTINUED)

SSID No.	Description/Violation Call	Page
MPS-18	MPS LO2 17 Inch Feedline Disconnect Power/RPC Anomaly	21-18.1
MPS-19	MPS LO2/LH2 Feedline Relief Isolation Valve Position/Power Indication Anomaly	21-19.1
MPS-20	MPS RTLS Dump Valve Position Indication Anomaly	21-20.1
MPS-21	MPS LO2 ECO Sensor Anomaly	21-21.1
MPS-22	MPS LH2 Low Level Sensor Anomaly	21-22.1
MPS-23	MPS ECO Sensor Power Supply Anomaly	21-23.1
MPS-24	MPS LO2 Engine Inlet Temperature Anomaly - High	21-24.1
MPS-25	MPS LO2 Engine Inlet Temperature Anomaly	21-25.1
MPS-26	MPS Engine 1 LH2 Prevalve Position Indication Anomaly	21-26.1
MPS-27	MPS Engine 1 LH2 Prevalve Power Indication Anomaly	21-27.1
MPS-28	MPS Engine 2 LH2 Prevalve Position Indication Anomaly	21-28.1
MPS-29	MPS Engine 2 LH2 Prevalve Power Indication Anomaly	21-29.1
MPS-30	MPS Engine 3 LH2 Prevalve Position Indication Anomaly	21-30.1
MPS-31	MPS Engine 3 LH2 Prevalve Power Indication Anomaly	21-31.1
MPS-32	LH2 4 Inch Disconnect Valve Power Anomaly	21-32.1
MPS-33	Main Engine LH2 Recirculation Anomaly	21-33.1
MPS-34	MPS Valve Position Qualification Anomaly	21-34.1
MPS-35	Engine 1 LO2 Prevalve Power Anomaly	21-35.1
MPS-36	Engine 2 LO2 Prevalve Power Anomaly	21-36.1

SECTION 21: MAIN PROPULSION SYSTEM (CONTINUED)

SSID No.	Description/Violation Call	Page
MPS-37	Engine 3 LO2 Prevalve Power Anomaly	21-37.1
MPS-38	MPS Helium Isolation Valve Open Indication Anomaly	21-38.1
MPS-39	MPS Pneumatic Helium Crossover Valve Power Anomaly	21-39.1
MPS-40	MPS Helium Interconnect Valve Power Anomaly	21-40.1
MPS-41	MPS Helium Supply Blowdown Valve Power Anomaly	21-41.1
MPS-42	MPS Repressurization Valve Power Anomaly	21-42.1
MPS-43	MPS GO2 Pressure Flow Control Valve Power (REQUIREMENT DELETED)	21-43.1
MPS-44	MPS GH2 Pressure Flow Control Valve Power Anomaly	21-44.1
MPS-45	MPS GH2 Pressure Flow Control Valve Power Anomaly	21-45.1
MPS-46	Pneu Helium Regulator Outlet Pressure Anomaly	21-46.1
MPS-47	MPS LO2 Overboard Bleed Valve (PV19) Position Qualification Anomaly	21-47.1
MPS-48	Orbiter/ET LH2 Disconnect Purge Anomaly	21-48.1
MPS-49	MPS LO2 Outboard Fill and Drain Valve (PV9) Open and Close Power Anomaly	21-49.1
MPS-50	MPS LO2 Inboard Fill and Drain Valve (PV10) Open and Close Power Anomaly	21-50.1
MPS-51	MPS LH2 Outboard Fill and Drain Valve (PV11) Open and Close Power Anomaly	21-51.1
MPS-52	MPS LH2 Inboard Fill and Drain Valve (PV12) Open and Close Power Anomaly	21-52.1
MPS-53	MPS LH2 Low Level Sensor Voltage Anomaly	21-53.1

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LCC VIOLATION CALL: MPS Helium Supply Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41P1150C	MPS E1 He Supply Bottle Press		4100	4500	psia	CI
V41P1250C	MPS E2 He Supply Bottle Press		4100	4500	psia	CI
V41P1350C	MPS E3 He Supply Bottle Press		4100	4500	psia	CI
V41P1600A	MPS Pneu Vlvs He Sup Bottle Press		4100	4500	psia	CI

TIME PERIOD:

(1) From Stable Purge Sequence 4 (approximately T-2 minutes 55 seconds to T-13 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(2) Helium is provided for SSME intermediate seal purging to prevent H2/O2 mixing. If purge is lost when the engine is operating and the limits are enabled the engine will shutdown. This helium supply also provides for engine purges at shutdown, engine pneumatic shutdown capability, propellant dump pressurization, operation of MPS valves, reentry repressurization and purging, and aft compartment purging/inerting.
(3) Maximum redline of 4500 psia is based on maximum system design operating pressure including regulator inlet pressure certification limit and is required to prevent exceeding system structural limits.
(4) Operational helium supply pressure instrumentation is required for all four systems (Caution and Warning) and is required for in-flight BFS dp/dt computation (20 psi/3 seconds for engine systems only) for leak detection/ isolation.
(5) The operational helium supply pressure measurement for the engine sytems required for Caution and Warning activation when supply pressure is less than 1150 psia. The Flight Rules require the pneumatic system interconnect to maintain SSME operation.
(6) Minimum of 4100 psia is required to ensure that there is sufficient helium mass to satisfy the worst case mission (RTLS) requirements.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Loss of leak detection and isolation capability.
(8) Maximum: Tank pressure cycle life reduced as function of delta P over 4500 psig. See Redline Derivation (3). System margin of safety reduced below minimum requirements, possible system damage.

CONSEQUENCES OF EXCEEDING REDLINE: (Continued)

(9) Minimum: Premature engine shutdown and loss of aft compartment purges (critical for TAL/RTLS).

CAUSES OF EXCEEDING REDLINE:

(10) Malfunctioning helium loading GSE - minimum and maximum.
(11) System leak or regulator malfunction (high pressure and flow) - minimum.
(12) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
V41P1n50C	10	0	5000	1150					
V41P1600A	20	0	5000					3800	

METER/DISPLAY RANGE - MSID: V41P1n50C LOW: 0 HIGH: 5000
V41P1600A LOW: 0 HIGH: 5000

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.8 SHEET N/A ZONE E7,U2
DWG NO SHEET ZONE L7,S7
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS72-941099 SHEET 51 ZONE G8,H5

ELEMENT: Orbiter SUBSYSTEM: MPS

LCC VIOLATION CALL: MPS Aft/Mid Fuselage Helium Supply Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41T1151A	MPS E1 Aft Fuselage He Supply Temp	2	-5	65	deg F	DI
V41T1251A	MPS E2 Aft Fuselage He Supply Temp	of	-5	65	deg F	DI
V41T1351A	MPS E3 Aft Fuselage He Supply Temp	3(2)	-5	65	deg F	DI
V41T1152A	MPS E1 Mid Fuselage He Supply Temp	2	45	135	deg F	DI
V41T1252A	MPS E2 Mid Fuselage He Supply Temp	of	45	135	deg F	DI
V41T1352A	MPS E3 Mid Fuselage He Supply Temp	3(2)	45	135	deg F	DI

TIME PERIOD:

(1) Verify between T-6 minutes and Go For APU Start (T-5 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) If instrumentation error can be confirmed, 1 of 3 measurements is acceptable. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Instrumentation failure is confirmed for a measurement indicating off scale high or low, exhibiting a step function change or functioning erratically.

NOTES:

(4) Tank maximum temperature for structural limitations is 200 deg F.

REDLINE DERIVATION: CRITICALITY: 1R

(5) Helium is provided for SSME intermediate seal purging to prevent H2/O2 mixing. If the purge is lost when engine is operating and the limits are enabled, the engine will shutdown. The helium supply also provides for engine purges at shutdown, engine pneumatic shutdown capability, propellant dump pressurization, operation of MPS valves, re-entry repressurization and purging, and aft compartment purging/inerting.

(6) The minimum redline assures that helium is delivered to the SSME inlet at an acceptable temperature to facilitate proper engine seal performance. Engine ICD interface temperature requirement for a nominal mission is -30 deg F and for an RTLS abort is -80 deg F. Aft fuselage temperature of -5 deg F is based on the fact that the mid fuselage should not be below 45 deg F.

(7) The maximum redline in conjunction with helium tank pressure, assures the minimum acceptable GHe mass (approximately 200 pounds) is loaded. Requires pressurization to flight limits (4100-4500 psia) by T-3 hours. Refer to OMRSD File II, Volume 1, Requirement S00FF0.070 for actual pressurization time.

REDLINE DERIVATION: (Continued)

(8) Only one operational transducer is required since the external environment for all three systems is assumed to be essentially identical and the internal inlet/outlet flows are essentially identical.
(9) Continuous verification is not required to protect requirement if hold occurs after check since previous Flight/Loading Data Indicator Supply Temperatures are essentially stable between T-6 minutes and Go For APU Start.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Minimum: Violate engine seal requirements - higher seal leakage at lower temperatures.
(11) Maximum: Improper helium load (mass quantity).

CAUSES OF EXCEEDING REDLINE:

(12) Improper loading of helium tanks.
(13) Launch holds would result in lower helium temperatures.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.F								
V41T1n51A	2.51	-334.0	293.7						
V41T1n52A	2.51	-334.0	293.7						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.8 SHEET N/A ZONE F8,E7,
DWG NO SHEET ZONE L7,L8,
DWG NO SHEET ZONE S8,R7
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS72-941099 SHEET 51 ZONE H8

ELEMENT: Orbiter SUBSYSTEM: MPS

LCC VIOLATION CALL: SSME Helium Regulator Outlet Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41P1154A1	MPS E1 Reg A He Outlet Press		730	788	psia	CI
V41P1153A1	MPS E1 Reg B He Outlet Press		730	788	psia	CI
V41P1254A1	MPS E2 Reg A He Outlet Press		730	788	psia	CI
V41P1253A1	MPS E2 Reg B He Outlet Press		730	788	psia	CI
V41P1354A1	MPS E3 Reg A He Outlet Press		730	788	psia	CI
V41P1353A1	MPS E3 Reg B He Outlet Press		730	788	psia	CI

TIME PERIOD:

(1) From initiation of Purge Sequence 4 + 1 minute (approx. T-2 minutes 55 seconds) to Go for SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) CAUTION - Engine system instrumentation failure may not be confirmed by closing redundant isolation valve and monitoring for decrease in SSME regulator out pressure. Application of this procedure may allow SSME valve drift causing hazardous leakage of propellant overboard.
(3) GSE maintains MPS/SSME helium bottles flight pressures until approximately T-12.5 seconds per SSID: MPS-01.
(4) SSME Controller (SSMEC) monitors High Pressure Oxidizer Turbopump (HPOTP) Intermediate Seal (IMSL) purge pressure (E41P1014B, etc). If IMSL pressure is below 164 psia, Engine Start is inhibited (reference SSID: SSME-10). After Engine Start, the IMSL Redline limit is 159 psia and 140 psia after Engine Cutoff.
(5) Measurements are required during flight for use in isolation of a helium leak.
(6) The MC284-0398-0005 relief valve cracking pressure is 805 psia (790 psig) and relief valve reseat pressure is 800 psia (785 psig).
(7) The MC284-0398-0006 relief valve is an interchangeable part and has a cracking pressure of 815 psia (800 psig) and reseat pressure of 810 psia (795 psig). Currently the fleet utilizes both MC284-0398-0005 and MC284-0398-0006 relief valves.
(8) Reference OMRSD S00FB0.082 for SSME regulator monitoring requirements prior to LCC effectivity.
(9) Loss of MPS Engine Reg A He Outlet Press indication will result in:
    a) Hardware Caution and Warning (MPS light on Panel F7 and indicator light on Panel R13).
    b) Master Alarm.

NOTES: (Continued)

c) Systems Management (SM) Alert and fault message.
d) Loss of MPS Engine Reg A He Outlet Press data to the OMS/MPS Multifunction Electronic Display Subsystem (MEDS) display.
e) Loss of MPS He Reg A data to BFS SYS SUM 1.

(10) Loss of MPS Engine Reg B He Outlet Press indication will result in:
a) Loss of MPS He Reg B data to BFS SYS SUM 1.
b) Systems Management (SM) Alert and fault message

REDLINE DERIVATION: CRITICALITY: 1R

(11) a) SSID Intent Summary - Engine helium is used to charge the Pogo Accumulator and for engine purges prior to Engine Start, during engine operation and following Engine Cutoff. Insufficient helium pressure will result in violation of the SSME HPOTP IMSL Purge Pressure redline and an early engine shutdown. Elevated helium pressure could result in loss of helium through the helium relief valve, prematurely depleting the helium supply, and thereby lead to violation of the HPOTP IMSL redline. Insufficient helium pressure could also lead to violation of the SSME Pogo Purge and Ancillary minimum limit and elevated helium pressure exceeding the ICD max of 800 psia could lead to violation of Pogo Purge and Ancillary max limit.

b) Voting Logic - N/A

c) Maximum Redline Derivation - Engineering upper limit for SSME regulator is 789 psia (ATP max allowable of 788 psia for 387 scfm demand, 4400 psia inlet pressure, low temperature, plus 1 psi test stand instrumentation uncertainty). Also, based on the first three -0006 flights, mean + K sigma calculated as 789 psia, and maximum observed was 768 psia. If pressure is increasing, DPS Analog-Digital conversion will indicate 788 psia when Digital Signal Conditioner output is greater than or equal to 788 and less than 792 psia. LCC upper limit will be invoked when the data value toggles from 788 to 792 psia.
Minimum Redline Derivation - A minimum 730 psia regulator outlet pressure is required by the SSMEs to maintain adequate HPOTP IMSL purge pressure (reference SSID: SSME-10).

d) Time Period - The HPOTP IMSL is purged with helium upon entry into PSN4 (at approximately T-4 minutes) and the Pogo Accumulator is charged with helium at Start Enable (at approximately T-9.5 seconds).

e) Requirements - N/A

f) Preplanned Contingency Procedures - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(12) Low: Violation of ATP allowable indicates regulator setpoint shift, potential impending failure, and unacceptable loss of single-fault tolerance for flight (reference LCC groundrules Paragraph 1.4.A). Inadequate purge flow due to both regulators failed closed will result in SSME shutdown when HPOTP IMSL purge pressure drops below redline value with limits enabled.

CONSEQUENCES OF EXCEEDING REDLINE: (Continued)

(13) High: Violation of ATP allowable indicates regulator setpoint shift, potential impending failure, and unacceptable loss of single-fault tolerance for flight (reference LCC groundrules Paragraph 1.4.A). Regulator failed open will result in actuation of the relief valve and helium loss requiring isolation of the failed regulator. Inability to isolate will result in possible helium depletion and premature SSME shutdown due to either HPOTP IMSL redline violation or inadequate helium to perform zero-g shutdown. Helium depletion can result in uncontained SSME damage if limits inhibited and HPOTP IMSL redline is violated. In addition, high supply pressure can result in diminished margin to Pogo Purge and Ancillary Monitor max limit during Engine Start phase. To protect Pogo max limit, helium pressure should not exceed SSME/Orbiter Interface Control Document (ICD) max of 800 psia.

CAUSES OF EXCEEDING REDLINE:

(14) Minimum: a) Helium regulator malfunction/failure.
b) Relief valve leaks/stuck open.
c) Instrumention failure.
d) Low Supply Pressure.
e) Significant leakage.

(15) Maximum: a) Helium regulator creeps/stuck open.
b) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
Pressures listed in Measurement Information Table below are based on generic transducer measurements and will differ slightly based on individual transducer actcal curves.									
UNITS-->	psia								
V41P1153A	4	0	1000					679	810
V41P1154A	4	0	1000	680	810			679	810
V41P1253A	4	0	1000					679	810
V41P1254A	4	0	1000	680	810			679	810
V41P1353A	4	0	1000					679	810
V41P1354A	4	0	1000	680	810			679	810

METER/DISPLAY RANGE - MSID: LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.8	SHEET N/A	ZONE F4,S4,
	DWG NO	SHEET	ZONE E4,M4,
	DWG NO	SHEET	ZONE L4,R4
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS72-941099	SHEET 51	ZONE D4,D7

ELEMENT: Orbiter SUBSYSTEM: MPS

LCC VIOLATION CALL: MPS LH2 Inboard Fill and Drain Valve Position/Power Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1410X	MPS LH2 Inbd F/D Vlv (PV12) CL Ind	(1)	ON	NA	Event	DI
V41X1405E	MPS LH2 Inbd F/D Vlv CL Pwr (LV35)	(2)	ON	NA	Event	CI
V41X1406E	MPS LH2 Inbd F/D Vlv OP Pwr (LV34)	(2)	OFF	NA	Event	CI

TIME PERIOD:

(1) Verify after valve has been commanded closed following transition to LH2 Reduced Fast Fill (approximately T-4.5 hours) (3)
(2) From valve closure following transition to LH2 Reduced Fast Fill (approximately T-4.5 hours) to Go For RSLS Start (T-31 seconds) (4,5)

REQUIREMENTS: FIGURES/TABLES:

(3) Loss of the PV12 closed indication ON is acceptable following one time verification of the closed indication ON after PV12 is commanded closed as long as both open (LV34) and close (LV35) power indications indicate correctly.
(4) Loss of closed power (LV35) ON and/or open power (LV34) OFF concurrent with PV12 cycling from open to closed is acceptable for confirmed instrumentation failure. (6)
(5) Loss of 1 of 2 power indications (LV34 or LV35) after PV12 valve cycle is acceptable for confirmed instrumentation failure. (7)

PREPLANNED CONTINGENCY PROCEDURE:

(6) Open power indication (LV34) remaining ON and/or closed power indication (LV35) remaining OFF concurrent with successful PV12 valve cycle confirms instrumentation failure. If either power indicator (LV34 and/or LV35) does not transition to the required state, then the PV12 closed position indicator requires continuous monitoring until T-31 seconds. LCC violation cleared, continue countdown.
(7) If prior to LH2 Terminate Replenish at T-1 minute 57 seconds, then attempt to verify instrumentation failure by performing the following (ref S1004):
    A. For closed power failed OFF (LV35):
        - Verify no helium spike occurred concurrent with loss of closed power ON.
        - Apply open power.
        - Verify PV12 open indicator remains OFF.
        - Remove open power.
    B. For open power failed ON (LV34):
        - Remove closed power.
        - Verify helium spike occurs concurrent with loss of closed power.
        - Verify valve open indicator remains OFF.
        - Reapply closed power.
        - Verify helium regulator demand concurrent with the application of closed power.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

If instrumentation failure of the open or close power indicator (LV34 or LV35) is confirmed, then the PV12 closed position indicator requires continuous monitoring until T-31 seconds. To ensure redundancy for flight, repeat preplanned procedure during T-9 minute hold. LCC violation cleared, continue countdown.

NOTES:

(8) The LH2 Inboard Fill and Drain Valve (PV12) timing is verified per S00FF0.190.

(9) The LH2 Outboard Fill and Drain Valve (PV11) is commanded closed at T-48 seconds and verified by the Ground Launch Sequencer (GLS).

(10) Both the LH2 Inboard (PV12) and Outboard (PV11) Fill and Drain Valves are bi-stable, remaining in last commanded position. A differential pressure across actuator piston is required to move valve from one position to another.

REDLINE DERIVATION: CRITICALITY: 1R

(11) a. SSID Intent Summary - The MPS LH2 Inboard Fill and Drain Valve is used to isolate the LH2 Feed System from the ground during LH2 Terminate Replenish. The valve is commanded closed at the beginning of reduced fast fill (approximately T-4.5 hours). The valve must be verified fully closed to provide isolation during fill line drain and to provide redundant (with Outboard Fill and Drain Valve) isolation against overboard loss of propellant during ascent.

b. Voting Logic - N/A.

c. Maximum and Minimum Redline Derivation - When the LH2 Inboard Fill and Drain Valve is closed, the closed indication as well as the close power indication should be ON while the open power indication should be OFF. Lift-off with closed pneumatics failed OFF or open pneumatics failed ON does not provide adequate level of redundancy for isolation of propellant in manifold from gas in Fill and Drain Line and/or prevention of Fill and Drain System water hammer.

d. Time Period - The beginning of the time period coincides with the closing of the LH2 Inboard Fill and Drain Valve at the transition to LH2 Reduced Fast Fill. The end time of T-31 seconds was chosen because this valve must remain closed to prevent loss of propellant overboard through the redundant LH2 Outboard Fill and Drain Valve which is closed at T-48 seconds.

e. Requirements - The close position indicator monitors the valve position while the open and close power indicators are a means of determining if the open and close commands for the valve are ON or OFF. Since the valve pneumatics can be verified to be in their proper state and the valve is bi-stable, a one time verification of the close position indicator after the valve has been closed at transition to LH2 Reduced Fast Fill (approximately T-4.5 hours) is sufficient. However, the open and close

REDLINE DERIVATION: (Continued)

power indicators are monitored continuously from valve closure until they are committed for flight at Go For RSLS Start (T-31 seconds). An open power indication failed ON or closed power indication failed OFF is acceptable once functionality of the control solenoid has been verified via the preplanned contingency procedure.

f. Preplanned Contingency Procedures - If one or both power indicators fail concurrent with PV12 valve cycle, system pressures, flow rates and the closed position indicator can be used to determine the valve state. If the valve is determined to be closed then the valve position indicator will be used to monitor till T-31 seconds.

If a power indicator fails after PV12 has been closed troubleshooting can be performed to determine that closed pneumatics to the valve is applied and open pneumatics is not. The valve can only change state if there is a differential pressure across the actuator piston. If closing pneumatics to the valve was lost, a helium spike would be noticed in the aft, since the valve's pneumatics vents into the aft compartment. Instrumentation failure may be confirmed for open power indication failed ON or close power indication failed OFF by setting the "good" power to its exception state and verifying the valve remains closed by monitoring the valve position indicator. Once the failure has been determined to be instrumentation failure only, set the "good" power back to its nominal state. The valve position indicator will then be used to monitor the valve state till T-31 seconds. This troubleshooting can only be done prior to Terminate LH2 Replenish (T-1 minute 57 seconds). The potential exists for loss of propellant from the ET into the inerted fill and drain line if troubleshooting is performed after this milestone. To ensure system redundancy verification of valve state must be repeated during the T-9 minute hold.

CONSEQUENCES OF EXCEEDING REDLINE:

(12) Propellant loss overboard when Tail Service Mast (TSM) drain is initiated. Outboard Fill and Drain Valve remains open until T-48 seconds to drain Orbiter Fill and Drain System.
(13) Failure of the redundant Outboard Fill and Drain Valve to remain closed in conjunction with a failure of the Inboard Fill and Drain Valve to remain closed will result in a loss of LH2 overboard.
(14) Introduction of gas trapped in the Fill and Drain Line to the Feed Line Manifold may cause loss of engine Net Positive Suction Pressure (NPSP) and possible shutdown of all three SSMEs.
(15) Possible Fill and Drain Line rupture due to 200 psi water hammer.
(16) Failure to perform nominal propellant dump post Main Engine Cut Off (MECO). The Inboard Fill and Drain Valve is opened at the start of dump to allow the system to be vacuum inerted.

CAUSES OF EXCEEDING REDLINE:

(17) Mechanical (valve) failure.
(18) Position indicator (microswitch) failure.

CAUSES OF EXCEEDING REDLINE: (Continued)

(19) Erroneous open command - V41K1401XL and V41K1402XL.
(20) Erroneous close command - V41K1412XL.
(21) Panel R4, MPS Propellant Fill/Drain LH2 Inbd switch in OPEN position (should be in GND position).
(22) Ground open command V41K1403NL ON.
(23) Helium solenoid valve failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.12	SHEET N/A	ZONE D6,D5
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS72-941099	SHEET 115	ZONE E20

ELEMENT: Orbiter SUBSYSTEM: MPS

LCC VIOLATION CALL:	EMERG COND:
MPS LH2 Outboard Fill/Drain Valve Position Anomaly	None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1389X	MPS LH2 Otbd F/D Vlv (PV11) CL Ind		ON	NA	Event	DI

TIME PERIOD:

(1) Verify between T-34 seconds and Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) Closure of the Outboard Fill and Drain Valve (PV11) will be inhibited if LH2 Tail Service Mast (TSM) drain time is not verified (Reference SSID MPS-06).
(3) The Outboard Fill and Drain Valve is commanded closed at T-48 seconds.
(4) The Outboard Fill and Drain Valve is bi-stable, remaining in last commanded position. A differential pressure across actuator piston is required to move valve from one position to another.

REDLINE DERIVATION: CRITICALITY: 1R

(5) a. SSID Intent Summary - The MPS LH2 Outboard Fill and Drain Valve is the interface between the ground and the orbiter LH2 Fill and Drain Line. The valve is open throughout LH2 loading operations. During LH2 Terminate Replenish the orbiter LH2 Fill and Drain Line and the LH2 TSM lines are drained of propellant. The Outboard Fill and Drain Valve must remain open during this time to ensure LH2 is not trapped between the Inboard and Outboard Fill and Drain Valves. The Outboard Fill and Drain Valve is commanded close at the completion of the fill line drain at T-48 seconds and provides redundant isolation with the LH2 Inboard Fill and Drain Valve and the LH2 Topping Valve against overboard loss of propellant during ascent.

b. Voting Logic - N/A.

c. Maximum and Minimum Redline Derivation - The Outboard Fill and Drain Valve closed indication must transition to ON to verify that the valve has been properly closed and the power pneumatics are in the proper state (closed power ON and open power OFF). A one time verification is sufficient since a subsequent loss of power pneumatics is an accepted risk. Since the valve is bi-stable, lift-off with close pneumatics failed OFF or open pneumatics failed ON will not allow the Outboard Fill and Drain Valve to close after it is opened for post-Main Engine Cut Off (MECO) propellant dump. Absence of the Outboard Fill and Drain Valve

REDLINE DERIVATION: (Continued)

closed indicator ON after vacuum inert is complete will prompt dump software to command the Inboard Fill and Drain Valve closed. This will prevent excessive loss of entry helium which is required for aft compartment, Orbital Maneuvering System (OMS) pods, and ET/Orbiter umbilical inerting. The Inboard Fill and Drain Valve remains open after a nominal vacuum inert.

d. Time Period - For close position indicator, SSID requires single verify (DI) between T-34 seconds and Go For RSLS Start at T-31 seconds. Valve is commanded closed at T-48 seconds. Ten seconds is allowed for valve response; one second is allowed for data processing.

e. Requirements - N/A

f. Preplanned Contingency Procedures - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Failure of Inboard Fill and Drain Valve (redundant) or Topping Valve (redundant) to remain closed in conjunction with a failure of the Outboard Fill and Drain Valve to remain closed will result in loss of LH2 overboard.
(7) An Outboard Fill and Drain Valve remaining open during descent will require LH2 Fill and Drain Line cleaning.
(8) Closure of Outboard Fill and Drain Valve and trapped LH2 in line exposes vehicle to risk that relief function of the Inboard Fill and Drain Valve will fail and cause a rupture of the Fill and Drain System.

CAUSES OF EXCEEDING REDLINE:

(9) Mechanical (valve) failure.
(10) Position indicator (microswitch) failure.
(11) Erroneous open command V41K1391XL.
(12) Erroneous close command V41K1393XL.
(13) Panel R4, MPS Propellant Fill/Drain LH2 Outbd switch in OPEN position (should be in GND position).
(14) Ground open command V41K1391NL ON.
(15) Helium solenoid valve failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.12	SHEET N/A	ZONE B6, B5
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS72-941099	SHEET 115	ZONE E24

ELEMENT: Orbiter SUBSYSTEM: MPS

LCC VIOLATION CALL: LH2 Fill Line Drain Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GLHX4323E	A100680 TSM Drain Vlv Open #1 Ind	1 of	ON	NA	Event	CI
GLHX4333E	A100680 TSM Drain Vlv Open #2 Ind	2	ON	NA	Event	CI
	and					
GLHX4412E	A100681 TSM Drain SOV Open Ind	1 of	ON	NA	Event	CI
GLHX4413E	A100681 TSM Drain SOV Close Ind	2	OFF	NA	Event	CI
	or					
GLHX4322E	A100680 TSM Drain Vlv Close #1 Ind	1 of	OFF	NA	Event	CI
GLHX4332E	A100680 TSM Drain Vlv Close #2 Ind	2	OFF	NA	Event	CI
	and					
GLHX4412E	A100681 TSM Drain SOV Open Ind	1 of	ON	NA	Event	CI
GLHX4413E	A100681 TSM Drain SOV Close Ind	2	OFF	NA	Event	CI
	and					
GLHT4118A	A100710 Orbiter Inlet Temp		-416	NA	deg F	CI

TIME PERIOD:

(1) After initiation of LH2 Terminate Replenish (T-1 minute 57 seconds) and after LH2 Topping Valve (PV13) verified closed and from LH2 TSM Drain Valve Opening to LH2 Outboard Fill/Drain Valve (PV11) Close Command (T-48 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Drain must be for minimum of 50 seconds. Due to propellant loading sequencer/GLS interlock timing requirements, verification after 45 seconds of drain satisfies the 50 seconds drain requirement (nominal).
(3) An automatic hold will be called to allow time to verify TSM drain using secondary pneumatics in the event of a primary pneumatics failure.

PREPLANNED CONTINGENCY PROCEDURE:

(4) Reference OMIs S0007 Vol. 5 and S1004 for a Preplanned Contingency Procedure for TSM drain valve primary pneumatic failure.
(5) The associated "Bypass" will be set for any valve position indicator detected in the MINIMUM state prior to LH2 terminate replenish (T-1 minute 57 seconds). This indicates that an instrumentation failure has occurred.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(6) The fill/drain line between PV12 and PV11 must be drained of LH2 to prevent being zero-fault tolerant to PV12 relief function failure.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Possible fill/drain system rupture during ascent.

CAUSES OF EXCEEDING REDLINE:

(8) Mechanical valve failure.
(9) Instrumentation or electrical circuitry failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	deg.F								
GLHT4118A	0.072	-427	-409						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter/ET SUBSYSTEM: MPS

LCC VIOLATION CALL: MPS LO2 Inboard Fill and Drain Valve Position/ Power Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1509X	MPS LO2 Inbd F/D Vlv (PV10) CL Ind	(1)	ON	NA	Event	DI
V41X1505E	MPS LO2 Inbd F/D Vlv CL Pwr (LV31)	(2)	ON	NA	Event	CI
V41X1506E	MPS LO2 Inbd F/D Vlv OP Pwr (LV30)	(2)	OFF	NA	Event	CI

TIME PERIOD:

(1) Verify after valve has been commanded closed (approximately T-4 minutes 48 seconds) following Terminate Replenish (3)
(2) From T-4 minutes 30 seconds to Go For RSLS Start (T-31 seconds) (4)

REQUIREMENTS: FIGURES/TABLES:

(3) Loss of the PV10 closed position indication is acceptable following one time verification of the closed position indication ON state after PV10 is commanded closed as long as both open (LV30) and close (LV31) power indications indicate correctly.
(4) Loss of closed power (LV31) ON and/or open power (LV30) OFF concurrent with PV10 cycling from open to closed is acceptable for confirmed instrumentation failure. (5)

PREPLANNED CONTINGENCY PROCEDURE:

(5) Open power indication (LV30) remaining ON and/or closed power indication (LV31) remaining OFF concurrent with successful PV10 valve cycle confirms instrumentation failure. If either power indicator (LV30 or LV31) does not transition to the required state, then the PV10 closed position indicator requires continuous monitoring until T-31 seconds. LCC violation cleared, continue countdown.

NOTES:

(6) The LO2 Outboard Fill and Drain Valve (PV9) is commanded closed at T-48 seconds and verified by the Ground Launch Sequencer (GLS).
(7) Both the LO2 Inboard (PV10) and Outboard (PV9) Fill and Drain Valves are bi-stable, remaining in last commanded position. A differential pressure across actuator piston is required to move valve from one position to another.

REDLINE DERIVATION: CRITICALITY: 1R

(8) a. SSID Intent Summary - The MPS LO2 Inboard Fill and Drain Valve separates the LO2 Feed System from the LO2 Fill and Drain Line. The valve is open throughout LO2 loading operations and is commanded closed during Terminate Replenish at approximately T-4 minutes 48 seconds. Once closed the LO2 Fill and Drain Line and the LO2 TSM lines are drained of propellant. The LO2 Inboard Fill and Drain Valve must be verified closed

REDLINE DERIVATION: (Continued)

to provide isolation during fill line drain and to provide redundant (with Outboard Fill and Drain Valve) isolation against overboard loss of propellant during ascent.

b. Voting Logic - N/A.

c. Maximum and Minimum Redline Derivation - When the LO2 Inboard Fill and Drain Valve is closed, the closed indication as well as the close power indication should be ON while the open power indication should be OFF. Lift-off with closed pneumatics failed OFF or open pneumatics failed ON does not provide adequate level of redundancy for isolation of propellant in manifold from gas in Fill and Drain Line and/or prevention of Fill and Drain System water hammer.

d. Time Period - The beginning of the time period coincides with the closing of the Inboard Fill and Drain Valve during LO2 Terminate Replenish. The end time of T-31 seconds was chosen because this valve must remain closed to prevent loss of propellant overboard through the redundant LO2 Outboard Fill and Drain Valve which is closed at T-48 seconds.

e. Requirements - The close position indicator monitors the valve position while the open and close power indicators are a means of determining if the open and close commands for the valve are ON or OFF. Since the valve pneumatics can be verified to be in their proper state and the valve is bi-stable a one time verification of the close position indicator after the valve has been closed at Terminate Replenish (approximately T-4 minutes 48 seconds) is sufficient. However, the open and close power indicators are monitored continuously from valve closure until they are committed for flight at Go For RSLS Start (T-31 seconds).

f. Preplanned Contingency Procedures - If one or both power indicators fail concurrent with PV10 valve cycle, system pressures, flow rates and the closed position indicator can be used to determine the valve state. If the valve is determined to be closed then the valve position indicator will be used to monitor till T-31 seconds.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Propellant loss overboard when TSM drain is initiated. The Outboard Fill and Drain Valve remains open until T-48 seconds to drain the Orbiter Fill and Drain System.
(10) Failure of the Outboard Fill and Drain Valve to remain closed in conjunction with the redundant Inboard Fill and Drain Valve to remain closed will result in loss of LO2 overboard.
(11) Introduction of gas trapped in Fill and Drain Line to the Feed Line Manifold may cause loss of engine Net Positive Suction Pressure (NPSP) and possible shutdown of all three SSMEs.
(12) Possible Fill and Drain Line rupture due to 700 psi water hammer.
(13) Failure to perform nominal vacuum inert post Main Engine Cut Off (MECO). Inboard Fill and Drain Valve is opened at the start of vacuum inert to allow the system to be inerted.

CAUSES OF EXCEEDING REDLINE:

(14) Mechanical (valve) failure.
(15) Position indicator (microswitch) failure.
(16) Erroneous open (V41K1501XL and V41K1502XL) or close (V41K1512XL) command.
(17) Panel R4, MPS Propellant Fill/Drain LO2 Inbd switch in OPEN position (should be in GND position).
(18) Ground open command V41K1503NL ON.
(19) Helium solenoid valve failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.11	SHEET N/A	ZONE C6,C5,
	DWG NO	SHEET	ZONE D5
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS72-941099	SHEET 116	ZONE E21

ELEMENT: Orbiter SUBSYSTEM: MPS

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LCC VIOLATION CALL: MPS LO2 Outboard Fill and Drain Valve Position Indication Anomaly	EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1514X	MPS LO2 Otbd F/D Vlv (PV9) CL Ind		ON	NA	Event	DI

TIME PERIOD:

(1) Verify between T-34 seconds and Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) Closure of PV9 will be inhibited if LO2 Tail Service Mast (TSM) drain time is not verified (Reference SSID: MPS-09).
(3) Outboard Fill and Drain Valve is commanded closed at T-48 seconds.
(4) The Outboard Fill and Drain Valve is bi-stable, remaining in last commanded position. A differential pressure across actuator piston is required to move valve from one position to another.

REDLINE DERIVATION: CRITICALITY: 1R

(5) a. SSID Intent Summary - The MPS LO2 Outboard Fill and Drain Valve is the interface between the ground and the orbiter LO2 Fill and Drain Line. The valve is open throughout loading operations. During LO2 Terminate Replenish the orbiter LO2 Fill and Drain Line and the LO2 TSM lines are drained of propellant. The Outboard Fill and Drain Valve must remain open during this time to ensure LO2 is not trapped between the Inboard and Outboard Fill and Drain Valves. The Outboard Fill and Drain Valve is commanded close at the completion of the fill line drain at T-48 seconds and provides redundant isolation with the LO2 Inboard Fill and Drain Valve against overboard loss of propellant during ascent.

b. Voting Logic - N/A.

c. Maximum and Minimum Redline Derivation - The Outboard Fill and Drain Valve close indication must transition to ON to verify that the valve has been properly closed and the power pneumatics are in the proper state (closed power ON and open power OFF). A one time verification is sufficient since a subsequent loss of power pneumatics is an accepted risk. Since the valve is bi-stable, lift-off with close pneumatics failed OFF or open pneumatics failed ON will not allow the valve to close after it is opened for vacuum inert. Absence of the outboard valve closed indicator ON after vacuum inert is complete will prompt dump software to command the Inboard Fill and Drain Valve closed. This will prevent excessive loss of entry helium which is required for aft

REDLINE DERIVATION: (Continued)

compartment, Orbital Maneuvering System (OMS) pods, and ET/Orbiter umbilical inerting. The Inboard Fill and Drain valve remains open after nominal vacuum inert.

d. Time Period - For close position indicator, SSID requires single verify (DI) between T-34 seconds and Go For RSLS Start at T-31 seconds. Valve is commanded closed at T-48 seconds. Ten seconds is allowed for valve response; one second is allowed for data processing.

e. Requirements - N/A

f. Preplanned Contingency Procedures - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Failure of Inboard Fill and Drain Valve to remain closed in conjunction with the redundant Outboard Fill and Drain Valve to remain closed will result in loss of LO2 overboard.
(7) An Outboard Fill and Drain Valve remaining open during descent will require LO2 Fill and Drain Line cleaning.
(8) Closure of Outboard Fill and Drain Valve and trapped LO2 in line exposes vehicle to risk that relief function of the Inboard Fill and Drain Valve will fail and cause rupture of Fill and Drain System.

CAUSES OF EXCEEDING REDLINE:

(9) Mechanical (valve) failure.
(10) Position indicator (microswitch) failure.
(11) Erroneous open command V41K1518XL.
(12) Erroneous close command V41K1515XL.
(13) Panel R4, MPS Propellant Fill/Drain LO2 Outbd switch in OPEN position (should be in GND position).
(14) Ground open command V41K1518NL ON.
(15) Helium solenoid valve failure.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.11 SHEET N/A ZONE B6, C4
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS72-941099 SHEET 116 ZONE E24

ELEMENT: Orbiter SUBSYSTEM: MPS

LCC VIOLATION CALL: LO2 Drainback Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GLOX2113E	A86462 TSM Drain Vlv Open #1	1 of	ON	NA	Event	CI
GLOX3113E	A86462 TSM Drain Vlv Open #2	2	ON	NA	Event	CI
	or					
GLOX2112E	A86462 TSM Drain Vlv Close #1	1 of	OFF	NA	Event	CI
GLOX3112E	A86462 TSM Drain Vlv Close #2	2	OFF	NA	Event	CI
	and					
GLOP2016A	A86467 Skid Outlet Pressure		NA	12.0	psig	CI

TIME PERIOD:

(1) After initiation of LO2 Terminate Replenishment, from TSM Drain Valve Opening to LO2 Outboard Fill/Drain Valve (PV9) Close Command (T-48 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) TSM Drain Valve A86462 shall be verified to be open for a duration of 3 minutes minimum during the period from LO2 Inboard Fill/Drain Valve (PV10) verified closed to initiation of closed command to LO2 Outboard Fill/Drain Valve (PV9) at T-48 seconds.

PREPLANNED CONTINGENCY PROCEDURE:

(3) The associated "Bypass" will be set for any valve position indicator detected in the MINIMUM state prior to T-5 minutes. This indicates that an instrumentation failure has occurred.
(4) Reference OMIs S0007 Vol. 5 and S1003 for the TSM drain verification procedure.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(5) To accommodate draining of the MPS LO2 fill/drain line between the Orbiter Inboard and Outboard Fill/Drain Valves PV10/PV9. The fill/drain system (line, valves, and disconnect) was not designed for launch loads with liquid trapped between PV10/PV9. For the undrained condition, the fill/drain flight-half disconnect and fill/drain line were analyzed and found to be satisfactory for at least 100 missions. The fill/drain valves were analyzed and found to be acceptable for only 2.25 missions (Letter to JSC from RI dated 09/19/88). Also, section of line between the inboard and outboard valves must be drained to prevent being zero-fault tolerant on the inboard valve relief function.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Trapped LO2 would not be drained, subjecting the Orbiter fill/drain line to damage because of the presence of up to 300 pounds of LO2.
(7) Possible fill/drain system rupture during ascent if relief function fails to work.

CAUSES OF EXCEEDING REDLINE:

(8) TSM drain valve A86462 failure to open.
(9) Instrumentation or electrical failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	psig								
GLOP2016A	2	0	500						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter/ET SUBSYSTEM: MPS/LO2

LCC VIOLATION CALL: MPS LH2 Topping Valve Position Indication Anomaly	EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1456X	MPS LH2 Topping Vlv (PV13) CL Ind		ON	NA	Event	CI

TIME PERIOD:

(1) Prior to initiation of TSM drain to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Must be verified after valve commanded closed (Approximately T-1 minute 52 seconds) at LH2 Replenish Termination.
(3) Do not initiate TSM Drain if LH2 Topping valve is OPEN.

PREPLANNED CONTINGENCY PROCEDURE:

(4) If closed indication does not indicate ON when valve initially commanded closed, HOLD at T-31 seconds, recycle to T-20 minutes, cycle valve. Open power OFF and open position OFF are acceptable after initial closed indication ON verification.
(5) If the closed position indicator fails ON prior to the valve being commanded closed for flight and the failure can be isolated to an instrumentation failure (ref. SSID: MPS-34) verification of the open power OFF (V41X1458E1) and open position OFF (V41X1453E1) is an acceptable substitute for the closed position indicator.

NOTES:

(6) PV13 open command: V41K1411XL
(7) Use of backup verification for confirmed instrumentation loss is an acceptable risk that the valve function is not imparied and will fully cycle to the closed position.

REDLINE DERIVATION: CRITICALITY: 1R

(8) PV13 must be verified fully closed to provide isolation during fill line drain and to provide redundant (with outboard fill/drain valve) isolation against overboard loss of propellant during ascent.
(9) PV13 is normally closed, pneumatically actuated to the open position.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Propellant loss overboard when TSM drain is initiated. Outboard fill/drain valve remains open until T-48 seconds to drain Orbiter fill/drain system.
(11) Failure of outboard fill valve (redundant) to remain closed will result in loss of LH2 overboard.

CAUSES OF EXCEEDING REDLINE:

(12) Mechanical (valve) failure.
(13) Position indicator (microswitch failure).
(14) Panel R4, MPS Propellant Fill/Drain LH2 Inbd switch in OPEN position (should be in GND position).
(15) Erroneous open command V41K1411XL.
(16) Helium solenoid valve failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.12	SHEET N/A	ZONE C6
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS72-941099	SHEET 115	ZONE E21

ELEMENT: Orbiter SUBSYSTEM: MPS

LCC VIOLATION CALL: MPS LH2 17 Inch Feed Manifold Disconnect Temperature/High Point Bleed Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41T1428A	MPS LH2 17in Feed Manf Disc Temp Backup Measurement	(3)	NA	-419(1)	deg F	CI
GLHT4119A	A131135 Hi Point Bleed Temp		NA	-415(2)	deg F	BU

TIME PERIOD:

(1) From L-30 minutes to Go For RSLS Start (T-31 seconds)
(2) From T-75 seconds to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(3) For confirmed instrumentation failure of primary measurement, use backup measurement. (4)

PREPLANNED CONTINGENCY PROCEDURE:

(4) Backup measurement GLHT4119A, A131135 Hi Point Bleed Temperature, may be used when the primary measurement V41T1428A has failed off-scale or is indicating warmer than -419 deg. F during loading when the backup measurement is within its normal operating data base. (6)

NOTES:

(5) The nominal value for the LH2 17 inch Feed Manf Disc Temp, V41T1428A, is -422 deg. F with the ET pressurized (fast fill and prepress) and -423 deg. F with the ET vented. The -419 deg. F maximum limit provides 1.4 deg. headroom from the data base maximum -420.4 deg. F.
(6) The nominal value for the Hi point Bleed Temp, GLHT4119A, is less than -417.5 deg. F with the ET pressurized (fast fill and prepress) and less than -412 deg. F with the ET vented. The -415 deg F maximum limit provides 2.5 degrees headroom from the data base maximum of -417.5 deg. F based on 6 operations using the short element probe with the narrow range calibration.

REDLINE DERIVATION: CRITICALITY: 1R

(7) Primary redline development:

	Max
Basic redline (8)	-415.5 deg F
Instr. tol. (4%)	-1.0
Subcooling to prevent bubble formation (1.6 deg subcooling indicated at bubble inception condition during special test on STS-26R WCDDT plus 0.4 deg margin to compensate for limited data base).	-2.0
Compensate for bulk heating (T-31 sec. to T-6.4 sec.).	-0.5
Redline	-419.0 deg. F

REDLINE DERIVATION: (Continued)

(8) Basic redline is saturation temperature at 41 psia minimum ullage pressure plus 2.5 psi head.
(9) This redline ensures the absence of gas bubble in the LH2 feedline which could possibly be ingested by the engine(s).
(10) Backup redline - A reading of -415 deg. F or colder assures good quality propellant in the LH2 disconnect area for SSME start with allowances for facility variations.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Gas bubble ingestion into engine(s) with possible pump cavitation resulting in possible engine damage.

CAUSES OF EXCEEDING REDLINE:

(12) Formation of gas bubble in LH2 feedline manifold:
A. High point bleed valve and/or T-0 disconnect not open or obstruction in bleed line.
B. Excessive heat leak in feed system.
C. Inadequate recirculation flow.
D. Excessive back pressure in facility vent system.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
UNITS-->	deg.F								
V41T1428A	NL	-431.4	-405						
GLHT4119A	0.072	-427	-409						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.12 SHEET N/A ZONE V5
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS72-941099 SHEET 115 ZONE D6

ELEMENT: Orbiter SUBSYSTEM: MPS

LCC VIOLATION CALL: MPS LH2 High Point Bleed Valve Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1469E	MPS LH2 Hi Pt Bl Vlv (PV22) CL Ind	1 of 2	ON	NA	Event	DI
GLHT4119A	A131135 Hi Point Bleed Temp	2	-409.5	NA	Deg F	DI

TIME PERIOD:

(1) Verify between T-14 seconds and Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) PV22 shall be closed at a point in the countdown that will allow sufficient time to achieve closure and the High Point Bleed temperature to be equal to or greater than the minimum value specified. The closure of PV22 will occur no earlier than T-26 seconds.

PREPLANNED CONTINGENCY PROCEDURE:

(3) Prior to T-31 seconds, an anomaly detected with either the closed indicator for PV22 or the High Point Bleed temperature measurement could result in a False Pass of this LCC. Countdown hold time permitting, the High Point Bleed temperature measurement should be logically "Failed" so the remaining valid measurement will verify this LCC.

NOTES:

(4) PV22 open commands: V41K1465NL (CMD A) and V41K1466NL (CMD B).

REDLINE DERIVATION: CRITICALITY: 1R

(5) PV22 must be verified closed or the High Point Bleed temperature indicating off-scale high to provide redundancy to the TSM T-0 disconnect (PD17) for isolation against overboard loss of propellant during ascent.
(6) PV22 is normally closed and is pneumatically operated to the open position. Normal closing response of the valve is less than 2 seconds (signal to switch).
(7) PV22 closure no earlier than T-26 seconds protects the SSMEs against the ingestion of a GH2 bubble from the Orbiter manifold. Verification that the High Point Bleed temperature is off-scale high be made approximately 12 seconds later to provide sufficient time for the temperature to respond.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) PD17 should close at TSM separation and provide redundancy against overboard propellant loss during ascent. Propellant loss overboard will be 0.7 lbm/sec if PD17 also fails to close. Considering aspiration, 0.1 lbm of H2 could accumulate during period between TSM separation and SSME rise to level of T-0 umbilical. Potential explosion (equivalent to 3.3 lb. TNT) produces base heat shield overpressure in excess of structural capability (1.32 psi). Total propellant loss during ascent is 285 lbm.

CAUSES OF EXCEEDING REDLINE:

(9) Mechanical (valve) failure.
(10) Position indicator (microswitch) failure.
(11) Erroneous open commands V41K1465NL and V41K1466NL.
(12) Panel R4, MPS Propellant Fill/Drain LH2 Inbd switch in OPEN position (should be in GND position).
(13) Helium solenoid valve (LV79) failure to deactivate.
(14) GSE High Point Bleed temperature transducer or transmission system failure.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
UNITS-->	deg.F								
GLHT4119A	0.072	-427	-409						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.12 SHEET N/A ZONE H7
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

LCC VIOLATION CALL: LO2 17 Inch Disconnect Valve/Latch Position Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1529X	MPS LO2 17in Disc Vlv(PD1)OP Ind A	1 of	ON	NA	Event	CI
V41X1545X	MPS LO2 17in Disc Vlv(PD1)OP Ind B	2	ON	NA	Event	CI
V41X1891X	MPS LO2 17in(PD1)Latch Lcked Ind A	1 of	ON	NA	Event	CI
V41X1892X	MPS LO2 17in(PD1)Latch Lcked Ind B	2	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(2) Valve - verify the valve is open prior to SSME start.
(3) Latch - locked indication required to maintain hardware single-fault tolerance. Latch prevents inadvertent closure of valve flapper.

CONSEQUENCES OF EXCEEDING REDLINE:

(4) Inability to initiate chilldown/propellant loading.
(5) Inability to obtain ENGINE READY and sustain engine operation.
(6) Loss of intelligence for ET separation.
(7) Inability to drain vehicle during ground abort.
(8) Possible LO2 geyser.

CAUSES OF EXCEEDING REDLINE:

(9) Mechanical (valve) failure.
(10) Position indicator (microswitch) failure.
(11) Erroneous commands/failed avionics.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.15	SHEET N/A	ZONE K7,J7
	DWG NO 10.11	SHEET N/A	ZONE V6,V8
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS72-941099	SHEET 115,116	ZONE C3

ELEMENT: Orbiter SUBSYSTEM: MPS

LCC VIOLATION CALL: LH2 17 Inch Disconnect Valve/Latch Position Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1429X	MPS LH2 17in Disc Vlv(PD2)OP Ind A	1 of	ON	NA	Event	CI
V41X1445X	MPS LH2 17in Disc Vlv(PD2)OP Ind B	2	ON	NA	Event	CI
V41X1991X	MPS LH2 17in(PD2)Latch Lcked Ind A	1 of	ON	NA	Event	CI
V41X1992X	MPS LH2 17in(PD2)Latch Lcked Ind B	2	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY:

(2) Valve - verify the valve is open prior to SSME start.
(3) Latch - locked indication required to maintain hardware single-fault tolerance. Latch prevents inadvertent closure of valve flapper.

CONSEQUENCES OF EXCEEDING REDLINE:

(4) Inability to initiate chilldown/propellant loading.
(5) Inability to obtain ENGINE READY and sustain engine operation.
(6) Loss of intelligence for ET separation.
(7) Inability to drain vehicle during ground abort.

CAUSES OF EXCEEDING REDLINE:

(8) Mechanical (valve) failure.
(9) Position indicator (microswitch) failure.
(10) Erroneous commands/failed avionics.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.15 SHEET N/A ZONE K4
DWG NO 10.12 SHEET N/A ZONE U6
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS72-941099 SHEET 115,116 ZONE C3

ELEMENT: Orbiter SUBSYSTEM: MPS

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LCC VIOLATION CALL: LO2 17 Inch Disconnect Valve/Latch Position Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1530X	MPS LO2 17in Disc Vlv(PD1)CL Ind A	1 of	OFF	NA	Event	CI
V41X1534X	MPS LO2 17in Disc Vlv(PD1)CL Ind B	2	OFF	NA	Event	CI
V41X1893X	MPS LO2 17in(PD1)Ltch Unlckd Ind A		OFF	NA	Event	CI
V41X1894X	MPS LO2 17in(PD1)Ltch Unlckd Ind B		OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(2) Both valve closed position switches failed ON will result in ET separation inhibit and prevent helium repressurization of the LO2 manifold during a nominal dump. Orbiter software will proceed with ET separation and pressurized LO2 dump if 1 of 2 qualified close position switches is ON. 1 of 2 closed indications are required for single-fault tolerance.

(3) Any latch unlocked position switch failed ON will allow Orbiter software to actuate flapper into latch during the ET separation sequence if the latch fails to travel to the fully unlocked position. Orbiter software will command pneumatics to close flapper if one unlocked switch indicates ON and two locked switches indicate OFF. If latch does not indicate unlocked, flapper will not be commanded to close pneumatically, but will be closed in backup (mechanical) mode during umbilical retract. All are required single-fault tolerance. Umbilical retract with flapper commanded closed into a locked or partially locked latch is not certified.

CONSEQUENCES OF EXCEEDING REDLINE:

(4) ET separation inhibit will delay automatic separation 6 seconds for RTLS and 15 seconds for TAL, and require manual separation after 6 minutes for nominal mission. Loss of pressurized nominal LO2 dump is not a concern since subsequent vacuum inerting operations will expel excess residuals.

(5) Disconnect flapper will be actuated into latch if latch fails to travel to the fully unlocked position. Possible flapper damage during umbilical retract causing flapper(s) to remain open, which results in propulsive venting during ET separation.

CAUSES OF EXCEEDING REDLINE:

(6) Position indicator (microswitch) failure.
(7) Failed data system.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.15	SHEET N/A	ZONE K7,J7
	DWG NO 10.11	SHEET N/A	ZONE V6,V7
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS72-941099	SHEET 115,116	ZONE C3

ELEMENT: Orbiter SUBSYSTEM: MPS

LCC VIOLATION CALL: LH2 17 Inch Disconnect Valve/Latch Position Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1430X	MPS LH2 17in Disc Vlv(PD2)CL Ind A	1 of	OFF	NA	Event	CI
V41X1434X	MPS LH2 17in Disc Vlv(PD2)CL Ind B	2	OFF	NA	Event	CI
V41X1993X	MPS LH2 17in(PD2)Ltch Unlckd Ind A		OFF	NA	Event	CI
V41X1994X	MPS LH2 17in(PD2)Ltch Unlckd Ind B		OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(2) Both valve closed position switches failed ON will result in ET separation inhibit (Orbiter software will proceed with ET separation if 1 of 2 qualified close position switches is ON). 1 of 2 closed indications are required for single-fault tolerance.
(3) Any latch unlocked position switch failed ON will allow Orbiter software to actuate flapper into latch during the ET separation sequence if the latch fails to travel to the fully unlocked position. Orbiter software will command pneumatics to close flapper if one unlocked switch indicates ON and two locked switches indicate OFF. If latch does not indicate unlocked, flapper will not be commanded to close pneumatically, but will be closed in backup (mechanical) mode during umbilical retract. All are required for single-fault tolerance. Umbilical retract with flapper commanded closed into a locked or partially locked latch is not certified.

CONSEQUENCES OF EXCEEDING REDLINE:

(4) ET separation inhibit will delay automatic separation 6 seconds for RTLS and 15 seconds for TAL, and require manual separation after 6 minutes for nominal mission.
(5) Disconnect flapper will be actuated into latch if latch fails to travel to the fully unlocked position. Possible flapper damage during umbilical retract causing flapper(s) to remain open, which results in propulsive venting during ET separation.

CAUSES OF EXCEEDING REDLINE:

(6) Position indicator (microswitch) failure.
(7) Failed data system.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.15	SHEET N/A	ZONE K3,L3
	DWG NO 10.12	SHEET N/A	ZONE U7,U6
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS72-941099	SHEET 115,116	ZONE C3

ELEMENT: Orbiter SUBSYSTEM: MPS

LCC VIOLATION CALL: MPS LH2 17 Inch Feedline Disconnect Power/RPC Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1382E	MPS LH2 17in Disc Vlv OP Pwr(LV48)	2	ON	NA	Event	CI
V76X4186E	PCA-MPS LH2 Feed D/V OP RPC B ON	of	ON	NA	Event	CI
V76X4187E	PCA-MPS LH2 Feed D/V OP RPC C ON	3	ON	NA	Event	CI
V41X1381E	MPS LH2 17in Disc Vlv CL Pwr(LV49)	2	OFF	NA	Event	CI
V76X4189E	PCA-MPS LH2 Feed D/V CL RPC B ON	of	OFF	NA	Event	CI
V76X4190E	PCA-MPS LH2 Feed D/V CL RPC C ON	3	OFF	NA	Event	CI
V41X1383E	MPS LH2 17in Disc Lock Pwr (LV67)	2	ON	NA	Event	CI
V76X4430E	MPS-LH2 Fd Disc Lock Vlv RPC B ON	of	ON	NA	Event	CI
V76X4431E	MPS-LH2 Fd Disc Lock Vlv RPC C ON	3	ON	NA	Event	CI
V41X1384E	MPS LH2 17in Disc Unlock Pwr(LV68)	2	OFF	NA	Event	CI
V76X4432E	MPS-LH2 Fd Disc Unlock V RPC B ON	of	OFF	NA	Event	CI
V76X4433E	MPS-LH2 Fd Disc Unlock V RPC C ON	3	OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) PD2 open commands:
V41K1413XL (Cmd A)
V41K1414XL (Cmd B)
V41K1415XL (Cmd C)
PD2 latch lock commands:
V41K1981XL (Cmd A)
V41K1982XL (Cmd B)
V41K1983XL (Cmd C)
PD2 closed commands:
V41K1416XL (Cmd A)
V41K1417XL (Cmd B)
V41K1418XL (Cmd C)
PD2 latch unlock commands:
V41K1984XL (Cmd A)
V41K1985XL (Cmd B)
V41K1986XL (Cmd C)

REDLINE DERIVATION: CRITICALITY: 1R

(3) Loss of open or lock power is assumed to be an instrumentation failure instead of loss of the function. Rationale is that if power is actually off, dual failures are still required to close the valve. Requires inadvertent application of close or unlock power combined with failure (structural) of flapper or latch to remain in the open or locked position.
(4) Valve and latch are bi-stable, remaining in last commanded position. A differential pressure across actuator piston is required to move valve or latch from one position to the other.

REDLINE DERIVATION: (Continued)

(5) The 2 of 3 criteria retains single-fault tolerance against pressure differential across actuator piston which would move latch to the unlocked position or flapper into the locked latch.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Partial violation - loss of redundancy against pressure differential across actuator piston resulting in movement of latch to the unlocked position or flapper movement into the locked latch.
(7) Complete violation - inability to initiate chilldown/propellant loading; inability to obtain ENGINE READY and sustain engine operation; inability to drain vehicle during ground abort.

CAUSES OF EXCEEDING REDLINE:

(8) EPDC failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO		SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO		SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

LCC VIOLATION CALL: MPS LO2 17 Inch Feedline Disconnect Power/RPC Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1807E	MPS-LO2 17in Disc Vlv OP Pwr(LV46)	2	ON	NA	Event	CI
V76X4196E	PCA-MPS Lox Feed D/V OP RPC B On	of	ON	NA	Event	CI
V76X4197E	PCA-MPS Lox Feed D/V OP RPC C On	3	ON	NA	Event	CI
V41X1806E	MPS-LO2 17in Disc Vlv CL Pwr(LV47)	2	OFF	NA	Event	CI
V76X4199E	PCA-MPS Lox Feed D/V CL RPC B On	of	OFF	NA	Event	CI
V76X4200E	PCA-MPS Lox Feed D/V CL RPC C On	3	OFF	NA	Event	CI
V41X1808E	MPS-LO2 17in Disc Lock Pwr (LV65)	2	ON	NA	Event	CI
V76X4420E	MPS-LO2 Fd Disc Lock Vlv RPC B On	of	ON	NA	Event	CI
V76X4421E	MPS-LO2 Fd Disc Lock Vlv RPC C On	3	ON	NA	Event	CI
V41X1809E	MPS-LO2 17in Disc Unlock Pwr(LV66)	2	OFF	NA	Event	CI
V76X4422E	MPS-LO2 Fd Disc Unlock V RPC B On	of	OFF	NA	Event	CI
V76X4423E	MPS-LO2 Fd Disc Unlock V RPC C On	3	OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) PD1 open commands:
V41K1521XL (Cmd A)
V41K1522XL (Cmd B)
V41K1523XL (Cmd C)

PD1 closed commands:
V41K1524XL (Cmd A)
V41K1525XL (Cmd B)
V41K1526XL (Cmd C)

PD1 latch lock commands:
V41K1881XL (Cmd A)
V41K1882XL (Cmd B)
V41K1883XL (Cmd C)

PD1 latch unlock commands:
V41K1884XL (Cmd A)
V41K1885XL (Cmd B)
V41K1886XL (Cmd C)

REDLINE DERIVATION: CRITICALITY: 1R

(3) Loss of open or lock power is assumed to be an instrumentation failure instead of loss of the function. Rationale is that if power is actually OFF, dual failures are still required to close the valve. Requires inadvertent application of close or unlock power combined with failure (structural) of flapper or latch to remain in the open or locked position.

(4) Valve and latch are bi-stable, remaining in last commanded position. A differential pressure across actuator piston is required to move valve or latch from one position to the other.

REDLINE DERIVATION: (Continued)

(5) The 2 of 3 criteria retains single-fault tolerance against pressure differential across actuator piston which would move latch to the unlocked position or flapper into the locked latch.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Partial violation - loss of redundancy against pressure differential across actuator piston resulting in movement of latch to the unlocked position or flapper movement into the locked latch.
(7) Complete violation - inability to initiate chilldown/propellant loading; inability to obtain ENGINE READY and sustain engine operation; inability to drain vehicle during ground abort; possible LO2 geyser.

CAUSES OF EXCEEDING REDLINE:

(8) EPDC failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

LCC VIOLATION CALL: MPS LO2/LH2 Feedline Relief Isolation Valve Position/Power Indication Anomaly | EMERG COND: Yellow (5)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1541E1	MPS LO2 Fdln Rlf SOV (PV7) OP Ind	2	OFF	NA	Event	CI
V41X1542E1	MPS LO2 Fdln Rlf SOV (PV7) CL Ind	of	ON	NA	Event	CI
V41X1549E1	MPS LO2 Fdln Rlf SOV (PV7) CL Pwr	3	ON	NA	Event	CI
V41X1441E1	MPS LH2 Fdln Rlf SOV (PV8) OP Ind	2	OFF	NA	Event	CI
V41X1442E1	MPS LH2 Fdln Rlf SOV (PV8) CL Ind	of	ON	NA	Event	CI
V41X1449E1	MPS LH2 Fdln Rlf SOV (PV8) CL Pwr	3	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) CAUTION - Feedline relief isolation valve failure to remain closed results in the potential to vent propellants overboard.

Perform the following Emergency Safing (Ref. S1003 and S1004):

- Command valve OPEN
- Inhibit CLOSE command issuance
- Reduce affected cryogenic system pressure to lowest applicable Orbiter Maintenance Requirements and Specification (OMRS) limits
- Initiate drain

NOTES:

(3) Valve transfer from the open position to the closed position is verified by Orbiter Maintenance Requirements and Specifications Document (OMRSD) requirement prior to start of Cryo Loading. The relief valves become operative following engine shutdown by opening these shutoff valves. The valves are mounted on the inboard fill and drain valve bodies.

REDLINE DERIVATION: CRITICALITY: 1R

(4) a. SSID Intent Summary - Isolation valve failure to remain closed results in cryogenic propellant being applied to the (LO2 or LH2) manifold relief valve resulting in a critical loss of redundancy and increased potential to vent propellants overboard.

b. Voting logic - A change in state in 2 of 3 of the specified function designators confirms valve is no longer in the closed position.

REDLINE DERIVATION: (Continued)

c. Minimum and Maximum Redline Development - Function is to isolate main propellant feed systems from the feedline relief systems. Violation confirms isolation of the relief system from the feed system has been compromised.

d. Time period - Valve is closed prior to start of tanking and must remain in that state through the remainder of cryogenic ground operations.

e. Requirements - N/A

f. Preplanned Contingency Procedure - A change of state in 2 of 3 of the specified function designators confirms the valve is no longer in the closed position. Safing will be performed to prevent the isolation valve from cycling back to the closed position. This will prevent trapping propellants, and potential uncontrolled rise in pressure, between the closed isolation valve and the closed relief valve . Cryogenic manifold pressure in the affected system will be lowered to the minimum allowed per the OMRS. This will maximize the margin against the relief valve unseating which would result in venting of propellant overboard. These valves are required to remain closed during ascent to provide critical redundancy against loss of propellants overboard. With the isolation valve failed open a failure of a relief valve to remain closed during ascent will result in an unacceptable overboard loss of LO2 or LH2 (LO2 - 6200 lbs; LH2 - 640 lbs). A No Go for launch will be recommended.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Emergency condition Yellow is based on the potential to vent propellants overboard which presents an ignition and fire hazard.
(6) Isolation valves are normally open and pneumatically operated to the closed position. If the isolation valves fail to remain closed, cryogenic propellant will flow to the (LO2 or LH2) manifold relief valve. A subsequent cycle of the isolation valve back to closed will trap propellants between the closed isolation valve and the closed relief valve. The relief valve senses manifold pressure and will not react properly to a pressure rise resulting from propellant trapped between the two valves. This will result in an increase in pressure that cannot be monitored, so potential for damage to the system is not assessable. Damage to the relief valve could cause venting of propellant overboard resulting in a potential ignition and fire hazard. Failure of relief valve to remain closed during ascent will result in overboard loss of LO2 or LH2 (LO2 - 6200 lbs; LH2 - 640 lbs).

CAUSES OF EXCEEDING REDLINE:

(7) Mechanical failure of pneumatically operated valve.
(8) Failure of the helium solenoid valve to the vent position.
(9) Loss of redundant close commands.
(10) Loss of Main Propulsion System (MPS) 750 pneumatics.
(11) Panel R4, MPS Feedline Rlf Isol LO2 or LH2 switch in OPEN position (should be in General Purpose Computer (GPC) position).

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.12	SHEET N/A	ZONE E6,F6
	DWG NO 10.11	SHEET N/A	ZONE D6,E8
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS72-941099	SHEET 41R/41P	ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

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LCC VIOLATION CALL: MPS RTLS Dump Valve Position Indication Anomaly | EMERG COND: Yellow (5)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1911E1	MPS LH2 RTLS Otbd DV (PV18) OP Pwr	2	OFF	NA	Event	CI
V41X1917E1	MPS LH2 RTLS Otbd DV (PV18) OP Ind	of	OFF	NA	Event	CI
V41X1919X1	MPS LH2 RTLS Otbd DV (PV18) CL Ind	3	ON	NA	Event	CI
V41X1921E1	MPS LH2 RTLS Inbd DV (PV17) OP Pwr	2	OFF	NA	Event	CI
V41X1927E1	MPS LH2 RTLS Inbd DV (PV17) OP Ind	of	OFF	NA	Event	CI
V41X1929X1	MPS LH2 RTLS Inbd DV (PV17) CL Ind	3	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) CAUTION - Failure of either the inboard or the outboard Return To Launch Site (RTLS) dump valves to remain closed results in a loss of critical redundancy for preventing an LH2 dump overboard.

Perform the following Emergency Safing (Ref. S1004)

- Inhibit OPEN command issuance on the other RTLS dump valve
- Reduce LH2 cryogenic system pressure to lowest applicable Orbiter Maintenance Requirements and Specifications (OMRS) limits
- Initiate drain

NOTES:

(3) Valve transfer from open position to closed position verified by Orbiter Maintenance Requirements and Specifications Document (OMRSD) requirements prior to Start of Cryo Tanking. The RTLS dump valves are normally closed and pneumatically operated to the open position.

REDLINE DERIVATION: CRITICALITY: 1R

(4) a. SSID Intent Summary - There are two series dump valves in the 1.5" RTLS dump system. These valves isolate the LH2 manifold from the ambient atmosphere at the RTLS dump port near the 50-1 door. Failure of one valve to remain closed results in a critical loss of redundancy for preventing an LH2 dump. Failure of a second (redundant) valve on ascent results in an unacceptable overboard loss (1800 lbs) of LH2.

b. Voting Logic - A change in state of 2 of 3 of the specified function designators confirms valve is no longer in the closed position.

REDLINE DERIVATION: (Continued)

c. Minimum and Maximum Redline Development - Function is to isolate main propellant feed manifold from atmosphere. Violation confirms isolation of the LH2 feed manifold is single fault tolerant.

d. Time Period - Valve is closed prior to start of tanking and must remain in that state through the remainder of cryogenic ground operations.

e. Requirements - N/A

f. Preplanned Contingency Procedure - A change of state in 2 of 3 of the specified function designators confirms that an RTLS dump valve is no longer in the closed position. Safing will be performed to prevent the redundant valve from cycling open. LH2 system pressure will be reduced to the minimum allowed per the OMRS and drain will be initiated. A No Go for launch will be recommended.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Emergency condition Yellow is based on the potential to dump propellants which presents an ignition and fire hazard.
(6) Hydrogen is present in the LH2 manifold from Main Propulsion System (MPS) chill down through LH2 drain and inert. LH2 is present from MPS chill down complete through drain complete. An RTLS dump valve confirmed no longer in the closed position is a loss of critical redundancy for the prevention of an LH2 dump overboard, resulting in a potential ignition and fire hazard. Should the second valve fail open, hydrogen would be free to flow unimpeded through the 1.5" dump line and would exit through the port near the 50-1 door.
(7) Failure of second (redundant) valve on ascent results in an unacceptable overboard loss (1800 lbs) of LH2.

CAUSES OF EXCEEDING REDLINE:

(8) Mechanical failure (a leak in the opening helium solenoid valve can leak helium into the actuator).
(9) Erroneous open commands.
(10) Instrumentation error.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.12	SHEET N/A	ZONE T6
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS72-941099	SHEET 71	ZONE A4,B4

ELEMENT: Orbiter SUBSYSTEM: MPS

LCC VIOLATION CALL: MPS LO2 ECO Sensor Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1555X	MPS LO2 Left ECO Sensor 1		Wet	NA	Event	CI
V41X1556X	MPS LO2 Left ECO Sensor 2		Wet	NA	Event	CI
V41X1557X	MPS LO2 Right ECO Sensor 2		Wet	NA	Event	CI
V41X1558X	MPS LO2 Right ECO Sensor 1		Wet	NA	Event	CI

TIME PERIOD:

(1) From removal of ECO Simulated DRY and WET Commands (during T-9 minute hold) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) Potential Transatlantic Abort Landing if three or more sensors indicate dry in flight. Arming is based on mass calculations made in flight to determine the remaining Liquid Oxygen (LO2). At ARM COMMAND, first sensor indicating DRY is bypassed by flight software.
(3) Most probable sensor failure is failed WET.

REDLINE DERIVATION: CRITICALITY: 1R

(4) a. SSID Intent Summary - Sensors provide engine cutoff for low liquid oxygen level. Once sensors are armed in flight, two unbypassed dry indications will initiate an all engine shutdown. A functioning SSME Low Level Cutoff capability is required as a backup to the SSME programmed velocity cutoff cue to protect against SSME propellant depletion. An improper indication of any circuit is sufficient justification to suspect integrity of other circuits.

b. Voting Logic - N/A

c. Maximum and Minimum Redline Derivation - Minimum redline is based on the expected sensor indication of WET between T-9 minutes (approximately) and T-31 seconds. A true DRY condition cannot exist within that time frame since the ET is loaded. A DRY indication is indicative of a failed sensor.

d. Time Effectivity - The Start time begins with the removal of ECO Simulated DRY and WET Commands during the T-9 minute hold and ends at T-31 seconds due to the dynamic cryogenic environments associated with these sensors and their critical functions for flight.

REDLINE DERIVATION: (Continued)

e. Requirements - N/A

f. Preplanned Contingency Procedures - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Possible mission impact because of early SSME shutdown, which could result in a severe vehicle underspeed.

CAUSES OF EXCEEDING REDLINE:

(6) Sensor or electrical malfunction.
(7) Connector loss of continuity or any other circuit anomaly resulting in high circuit resistance.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.11	SHEET N/A	ZONE V6,U6,
	DWG NO	SHEET	ZONE T6
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS72-941099	SHEET 118	ZONE G5

ELEMENT: Orbiter SUBSYSTEM: MPS

LCC VIOLATION CALL: MPS LH2 Low Level Sensor Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
T41X1730X	ET-LH2 Low Level Liq Sensor No 1		WET	NA	Event	CI
T41X1731X	ET-LH2 Low Level Liq Sensor No 2		WET	NA	Event	CI
T41X1732X	ET-LH2 Low Level Liq Sensor No 3		WET	NA	Event	CI
T41X1733X	ET-LH2 Low Level Liq Sensor No 4		WET	NA	Event	CI

TIME PERIOD:

(1) From removal of ECO Simulated DRY and WET Commands (during T-9 minute hold) to Go For RSLS Start (T-31 seconds).

REQUIREMENTS: FIGURES/TABLES:

(2) 4 of 4 indicating WET with 3 of 4 verified functional up to the start of the LCC time period (per all associated OMRS) is acceptable.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) Potential Transatlantic Abort Landing if three or more sensors indicate dry in flight. Arming is based on mass calculations made in flight to determine the remaining propellant. At ARM Command, one sensor indicating DRY at the first software cycle is bypassed by flight software.
(4) Most probable sensor failure is failed WET.
(5) The measurements monitored by this SSID utilize Flight Critical MDMs.
(6) An acceptable failure identified by LCC MPS-22 coupled with an acceptable failure identified in LCC MPS-23 may result in an overall reduction in Low Level Cut-Off System reliability.

REDLINE DERIVATION: CRITICALITY: 1R

(7) a. SSID Intent Summary - Sensors provide engine cutoff for low liquid hydrogen level. Once sensors are armed in flight, two unbypassed dry indications will initiate an all engine shutdown. A functioning SSME Low Level Cutoff capability is required as a backup to the SSME programmed velocity cutoff cue to protect against SSME propellant depletion. The LH2 LLCO System is triple fault tolerant, allowing for two LLCO sensors to fail as well as a propellant system depletion failure to drive the need for a LH2 low level cutoff.

b. Voting Logic - N/A

c. Maximum and Minimum Redline Derivation - Minimum redline of 4 of 4 sensors indicating WET is based on the required sensor indication of WET between T-9 minutes (approximately) and T-31 seconds. A true DRY condition cannot exist within that time frame since the LH2 LLCO sensors

REDLINE DERIVATION: (Continued)

are covered in liquid hydrogen. A DRY indication is indicative of a failed sensor. A sensor failed to the WET (pass) state prior to T-9 minutes would be detected during OMRS checkout requirement (ref 7(e)).

d. Time Effectivity - Due to OMRSD checkout requirements and the dynamic environment associated with these sensors the LCC monitoring start time begins with the removal of the ECO Simulated Dry and Wet Commands during the T-9 minute hold. Due to the critical nature of these sensors and the need to ensure that all sensors remain in a WET state after removal of the ECO Simulated Commands, the LCC ending effectivity is T-31 seconds when the system is committed for flight.

e. Requirements - The requirement to maintain 4 of 4 sensors indicating WET ensures that there cannot be a sensor failed to the DRY state as that state is the one required to move the onboard software closer to an engine shutdown. The requirement to have 3 of 4 LLCO sensors verified functional allows accepting a sensor failure to the WET state if it occurs during OMRSD checkout timeframe. That failure is also acceptable for ascent.

For a failed WET sensor: As only two operational sensors are required to provide a functioning SSME Low Level Cutoff capability, one sensor failed to the WET state prior to liftoff will maintain adequate redundancy. Two additional failures to the WET state plus an unrelated failure causing a LH2 depletion would be required to potentially cause an uncontained SSME failure. The likelihood of two additional LLCO sensors failed WET coupled with a need for the LLCO system during flight is considered remote (Less than 1 in 1000).

Sensors are driven to the DRY state at the beginning of Fast Fill per OMRS S00FD0.121-C by activating the ECO Simulated WET and DRY Commands. This command state of the sensors verifies circuit integrity and functionality during cryogenic load. The sensors remain in this configuration, with the exception of momentary checkouts during Replenish per OMRS S00FF0.200-1R and S00FF0.204-1R, until the commands are removed at T-9 minutes. Any sensor indicating WET with the ECO Simulated WET and DRY Commands ON is failed to the pass state and considered non-functional. Any sensor failure would invoke system troubleshooting per OMRS S00E00.227, which will validate the functionality of the remaining 3 sensors as well as provide insight into a possible cause of the sensor failure. A sensor failed to the WET state after the Simulated Commands are removed during the T-9 minutes hold is a remote possibility and considered an acceptable risk.

For a failed DRY sensor: At ARM, the flight software performs a status check of the LH2 LLCO Sensors. If a sensor is indicating DRY at that time, it will be bypassed. Only one sensor indicating DRY at ARM will be bypassed, any other sensors indicating DRY will not be bypassed. Once two unbypassed sensors indicate DRY, an all engine shutdown will be initiated. For a failed DRY sensor, two additional sensors failed to the DRY state would be required to cause a premature all engine

REDLINE DERIVATION: (Continued)

shutdown.

Due to the designed failure mode of the sensors being to the WET state, the low likelihood of an LH2 depletion (while the possibility of a LH2 depletion does exist, the system is designed to favor a LO2 depletion prior to LH2 depletion) and the criticality of a premature all engine shutdown, a failure of any LH2 LLCO sensor to the DRY state is considered an unacceptable risk.

f. Preplanned Contingency Procedures - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Possible mission impact because of early SSME shutdown, which could result in a severe vehicle underspeed.
(9) Possible Safety of Flight impact if LH2 LLCO sensors are unable to initiate SSME shut down and SSMEs run to fuel depletion (requires multiple LH2 LLCO sensor system failures).
(10) Reference Integrated Hazard Reports IMPS-03 and IMPS-17.

CAUSES OF EXCEEDING REDLINE:

(11) Sensor or electrical malfunction.
(12) Connector loss of continuity or any other circuit anomaly resulting in off nominal circuit resistance.
(13) Failure within the FA MDM.
(14) Failure within the MPS Point Sensor Box.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.10	SHEET N/A	ZONE C2,C1
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS72-941099	SHEET 117	ZONE E5

ELEMENT: Orbiter SUBSYSTEM: MPS

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LCC VIOLATION CALL: MPS ECO Sensor Power Supply Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76X3050E1	MPS Pt Sensor Elec RPC B On	1 of 2	ON	NA	Event	CI
V76X3055E1	MPS Pt Sensor Elec RPC C On		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES: MPS 23.01

(2) 0 of 2 measurements acceptable if the integrity of the sensors are confirmed per the Preplanned Contingency Procedure. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) If both Remote Power Controllers (RPCs) indicate OFF, then perform Point Sensor Box Contingency Troubleshooting per OMI S1004 during Replenish to verify integrity of associated sensors. If no unexpected errors are reported then LCC violation cleared, continue countdown.

NOTES:

(4) With the loss of both RPC measurements indirect health of the power supply can be determined by careful examination of the output from the associated ET Liquid Level sensors that would normally be DRY or toggling (DRY/WET). The SSME Low Level Cutoff system requires these functioning redundant power busses to provide an adequate level of redundancy (Ref SSIDs MPS-21/22).

REDLINE DERIVATION: CRITICALITY: 1R

(5) a. SSID Intent Summary - This SSID provides verification of power supply redundancy to LH2 Liquid Level (LL) sensor circuit No. 1 and LO2 ECO sensor circuit left No. 1. Direct detection of a power supply failure is accomplished via the RPC monitor capability.

b. Voting Logic - 1 of 2 measurements are required to verify power supply to LH2 LL sensor circuit No. 1 and LO2 ECO sensor circuit left No. 1.

c. Maximum and Minimum Redline Derivation - Minimum redline of ON indicates power supply to LH2 LL sensor circuit No. 1 and LO2 ECO sensor circuit left No. 1 is functioning properly.

d. Time Effectivity - Ending effectivity of T-31 seconds was chosen due to the critical function of the sensors powered by the power supply monitored by the above RPCs.

e. Requirements - With the loss of both RPC measurements indirect health of

REDLINE DERIVATION: (Continued)

the power supply can be determined by careful examination of the output from the associated ET Liquid Level sensors that would normally be DRY or toggling (DRY/WET). The SSME Low Level Cutoff system requires these functioning redundant power busses to provide an adequate level of redundancy (Ref SSIDs MPS-21/22).

f. Preplanned Contingency Procedures - The Preplanned Contingency Procedures (PCP) contained in this SSID serve to verify the functionality of all ET point sensors. The Point Sensor Box Contingency Troubleshooting procedure issues simulation commands which supply a supplemental voltage to the point sensor circuit which causes a DRY indication if the circuit is complete and comparator voltage is present.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Flight with LH2 No. 1 and LO2 left No. 1 ECO sensor circuits failed to WET condition and not bypassed in flight software (ref LCC's MPS-21/22) will result in reduction in redundancy for Low Level Cutoff capability.

CAUSES OF EXCEEDING REDLINE:

(7) EPDC failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

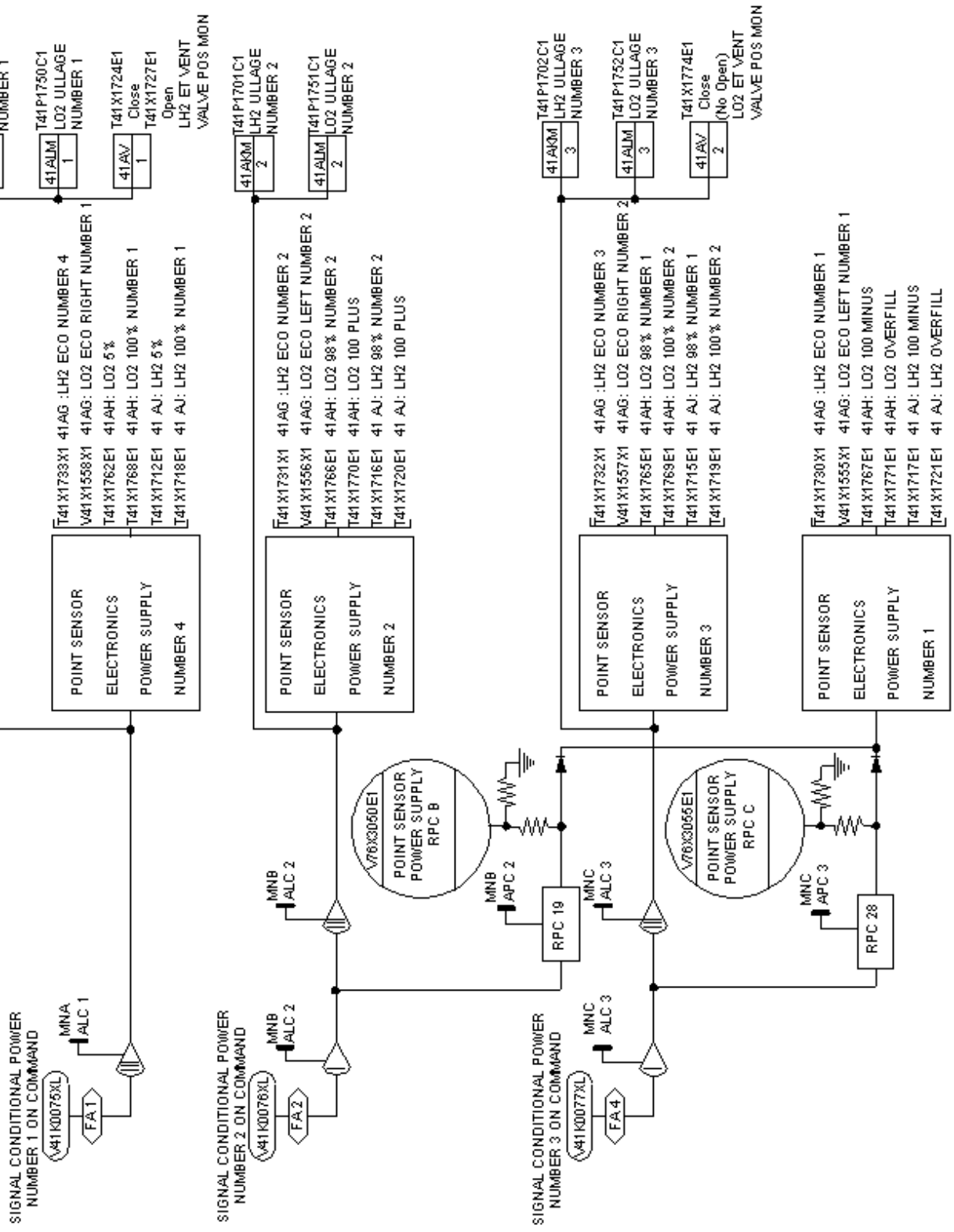

Figure MPS 23.01 - Point Sensor Electronic Power Control

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LCC VIOLATION CALL: MPS LO2 Engine Inlet Temperature Anomaly - High | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41T1131C	MPS E1 LO2 Inlet Temp	2 of 3	NA	-287.7	Deg F	CI
V41T1231C	MPS E2 LO2 Inlet Temp	2 of 3	NA	-287.7	Deg F	CI
V41T1331C	MPS E3 LO2 Inlet Temp	2 of 3	NA	-287.7	Deg F	CI

TIME PERIOD:

(1) Continuous verify for 30 minutes prior to LO2 Terminate Replenish (T-4 minutes 55 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) A minimum of 90 minutes of continuous LO2 bleed flow through the SSMEs is required for initial thermal conditioning (5). If LO2 bleed is interrupted after initial thermal conditioning, a minimum of 60 minutes of continuous bleed flow through the SSMEs is required prior to SSME start (6).

PREPLANNED CONTINGENCY PROCEDURE:

(3) For a violation resulting from an interruption of replenish flow, the replenish time will be set considering the hold time capability as defined in OMRSD S00E00.125. If a revert has resulted in LO2 vent valve cycling or if prepressurization has been initiated, see LCC SEQ-01 for requirements.
(4) All recovery operations must maintain the temperature and time requirements specified above.

NOTES:

(5) 90 minute initial period required by Orbiter/SSME ICD.
(6) 60 minute period for bleed interruptions is based on SSME test stand experience.

REDLINE DERIVATION: CRITICALITY: 1R

(7) Improper thermal conditioning of SSME.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Adverse effect on engine start transient.
(9) Possible launch pad abort.
(10) Possible SSME hardware damage.

CAUSES OF EXCEEDING REDLINE:

(11) Improper bleed flow, damaged insulation.
(12) Stop flow or revert of more than 55 seconds (predicted).
(13) Excessive facility LO2 replenish temperature (Ref S00FF0.145).

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.F								
OV-102									
V41T1n31C	.0997	-305.6	-255.6						
OV-103									
V41T1n31C	.0100	-305.3	-255.3						
OV-104									
V41T1n31C	.0100	-305.3	-255.3						
OV-105									
V41T1n31C	.0997	-305.4	-255.3						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.11	SHEET N/A	ZONE J1,F1,
	DWG NO	SHEET	ZONE 01
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

LCC VIOLATION CALL: MPS LO2 Engine Inlet Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41T1131C	MPS E1 LO2 Inlet Temp	2	-289.2	-281.7	deg F	CI
V41T1231C	MPS E2 LO2 Inlet Temp	of	-289.2	-281.7	deg F	CI
V41T1331C	MPS E3 LO2 Inlet Temp	3	-289.2	-281.7	deg F	CI

TIME PERIOD:

(1) From T-75 seconds to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) For violation of the maximum limit, hold at T-31 seconds until 2 of 3 temperatures return within limits, LCC violation cleared, continue countdown.

NOTES:

(3) -289.2 deg F = 170.5 deg R (Absolute zero = -459.7 deg F).
-281.7 deg F = 178.0 deg R.

(4) See LCC Section 8, SEQ-01 for available hold time requirements and OMRSD Table S00E00.125 for estimating the HOLD time capability as a function of replenish time.

REDLINE DERIVATION: CRITICALITY: 1R

(5) a. SSID Intent Summary - LO2 engine inlet temperature limits ensure that the LO2 being delivered to the engines meets ICD-13M15000, Section 4.0 requirements for thermal conditioning/engine start and avoids low LO2 temperature resulting from a launch HOLD so that the start sequence/performance will be within specified limits.

b. Voting Logic - 2 of 3 inlet temperatures confirms that the bulk temperature of the LO2 in the MPS system meets the specified requirements.

c. Maximum and Minimum Redline Derivation - LO2 engine inlet temperature limits are based on the SSME ICD requirements for proper temperatures at engine start. Engine ICD specifies engine inlet temperatures at engine start to be between 170 deg R and 178 deg R. Proper LO2 inlet temperatures at engine start ensure that a proper start transient is obtained. LO2 inlet temperatures decrease during this time period (from T-75 seconds) of LO2 drainback since colder propellant from the 17 inch feedline is flowing through the SSMEs, Orbiter bleed systems and overboard. During LO2 Replenish operations (prior to LO2 Drainback) engine inlet temperatures are higher since LO2 supplied from the ground

REDLINE DERIVATION: (Continued)

supply is warmer than propellant that has been conditioned in the External Tank. The low limit of 170.5 deg R (0.5 deg R above ICD limit) allows for 0.5 deg R of temperature decrease between T-31 seconds and engine start.

d. Time Period - From T-75 seconds to T-31 seconds ensures that temperatures will be within limits at engine start.

e. Requirements - N/A

f. Preplanned Contingency Procedures - For a violation of the maximum limit, a hold at T-31 seconds will occur. Temperatures will be decreasing at this time, hold until 2 of 3 temperatures return to within limits, LCC violation cleared, continue countdown.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Adverse effect on engine start transient.
(7) Possible launch pad abort.
(8) Possible SSME hardware damage.

CAUSES OF EXCEEDING REDLINE:

(9) Low limit violation will occur under the following conditions when warmer ET feedline fluid is drained and colder ET fluid reaches the engine inlets:
A. Launch HOLD after initiation of drainback. (4)
B. LO2 stop flow, revert, or recycle preceding LO2 drainback initiated after insufficient replenish duration. (4)
C. Excessive/inadvertent fluid draining during drainback.
(10) High limit violation will occur under the following conditions when warmer ET feedline fluid is drained:
A. Environmental conditions with LO2 quality stackup.
B. LO2 system insulation failure.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX

Temperatures listed in Measurement Information Table below are based on generic transducer measurements and will differ slightly based on individual transducer actcal curves.
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY

UNITS-->	deg.F							
V41T1n31C	0.1	-305	-255					

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.11	SHEET N/A	ZONE J1,F1,
	DWG NO	SHEET	ZONE 01
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

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LCC VIOLATION CALL: MPS Engine 1 LH2 Prevalve Position Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1104X	MPS E1 LH2 Prevlv (PV4) OP Ind A		OFF	NA	Event	CI
V41X1106X	MPS E1 LH2 Prevlv (PV4) OP Ind B		OFF	NA	Event	CI

TIME PERIOD:

(1) From Initiation of LH2 Recirculation to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(2) RSLS looks for 1 of 2 open position indicators ON at T-7 seconds.

CONSEQUENCES OF EXCEEDING REDLINE:

(3) One indicator failed ON will allow SSME start attempt if prevalve fails to open at T-9.5 seconds.

CAUSES OF EXCEEDING REDLINE:

(4) Valve position indicator failure.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.12 SHEET N/A ZONE K5
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

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LCC VIOLATION CALL: MPS Engine 1 LH2 Prevalve Power Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1103E	MPS E1 LH2 Prevlv OP Pwr (LV18)	2 of 3	OFF	NA	Event	CI
V76X4110E	PCA-MPS LH2 Prevalve 1 OP RPC A On		OFF	NA	Event	CI
V76X4111E	PCA-MPS LH2 Prevalve 1 OP RPC B On		OFF	NA	Event	CI
V41X1102E	MPS E1 LH2 Prevlv CL Pwr (LV19)	2 of 3	ON	NA	Event	CI
V76X4113E	PCA-MPS LH2 Prevalve 1 CL RPC A On		ON	NA	Event	CI
V76X4114E	PCA-MPS LH2 Prevalve 1 CL RPC B On		ON	NA	Event	CI

TIME PERIOD:

(1) From Initiation of LH2 Recirculation to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) PV4 open commands:
V41K1119XL (Cmd A)
V41K1120XL (Cmd B)
V41K1121XL (Cmd C)

PV4 close commands:
V41K1122XL (Cmd A)
V41K1123XL (Cmd B)
V41K1124XL (Cmd C)

REDLINE DERIVATION: CRITICALITY: 1R

(3) Valve is bi-stable, remaining in the last commanded position. A differential pressure across actuator piston is required to move the valve from one position to the other.
(4) OPEN power failed ON or CLOSE power failed OFF would not allow LH2 prevalve to close at MECO, for an on-pad abort, or after engine failure.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Valve would not close at MECO, for an on-pad abort, or after engine failure with OPEN power failed ON, or CLOSE power failed OFF.

CAUSES OF EXCEEDING REDLINE:

(6) Improper command applied or removed.
(7) Panel R4, MPS LH2 Prevalve Ctr switch in OPEN position (should be in GPC position).

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.12	SHEET N/A	ZONE K5,K3,
	DWG NO	SHEET	ZONE L5,L3
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

LCC VIOLATION CALL: MPS Engine 2 LH2 Prevalve Position Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1204X	MPS E2 LH2 Prevlv (PV5) OP Ind A		OFF	NA	Event	CI
V41X1206X	MPS E2 LH2 Prevlv (PV5) OP Ind B		OFF	NA	Event	CI

TIME PERIOD:

(1) From Initiation of LH2 Recirculation to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(2) RSLS looks for 1 of 2 OPEN position indicators ON at T-7 seconds.

CONSEQUENCES OF EXCEEDING REDLINE:

(3) One indicator failed ON will allow SSME start attempt if prevalve fails to open at T-9.5 seconds.

CAUSES OF EXCEEDING REDLINE:

(4) Valve position indicator failure.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.12 SHEET N/A ZONE 05
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

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LCC VIOLATION CALL: MPS Engine 2 LH2 Prevalve Power Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1203E	MPS E2 LH2 Prevlv OP Pwr (LV20)	2	OFF	NA	Event	CI
V76X4116E	PCA-MPS LH2 Prevalve 2 OP RPC B On	of	OFF	NA	Event	CI
V76X4117E	PCA-MPS LH2 Prevalve 2 OP RPC C On	3	OFF	NA	Event	CI
V41X1202E	MPS E2 LH2 Prevlv CL Pwr (LV21)	2	ON	NA	Event	CI
V76X4119E	PCA-MPS LH2 Prevalve 2 CL RPC B On	of	ON	NA	Event	CI
V76X4120E	PCA-MPS LH2 Prevalve 2 CL RPC C On	3	ON	NA	Event	CI

TIME PERIOD:

(1) From Initiation of LH2 Recirculation to go for RSLS start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) PV5 open commands:
V41K1219XL (Cmd A)
V41K1220XL (Cmd B)
V41K1221XL (Cmd C)

PV5 close commands:
V41K1222XL (Cmd A)
V41K1223XL (Cmd B)
V41K1224XL (Cmd C)

REDLINE DERIVATION: CRITICALITY: 1R

(3) Valve is bi-stable, remaining in the last commanded position. A diferential pressure across actuator piston is required to move the valve form one position to the other.
(4) OPEN power failed ON or CLOSE power failed OFF would not allow LH2 prevalve to close at MECO, for an on-pad abort, or after engine failure.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Valve will not close at MECO, for an on-pad abort, or after engine failure with OPEN power failed ON, or CLOSE power failed OFF.

CAUSES OF EXCEEDING REDLINE:

(6) Improper command applied or removed.
(7) Panel R4, MPS LH2 Prevalve Left switch in OPEN position (should be in GPC position).

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.12	SHEET N/A	ZONE P3,P5,
	DWG NO	SHEET	ZONE Q5,Q3
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

LCC VIOLATION CALL: MPS Engine 3 LH2 Prevalve Position Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1304X	MPS E3 LH2 Prevlv (PV6) OP Ind A		OFF	NA	Event	CI
V41X1306X	MPS E3 LH2 Prevlv (PV6) OP Ind B		OFF	NA	Event	CI

TIME PERIOD:

(1) From Initiation of LH2 Recirculation to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(2) RSLS looks for 1 of 2 OPEN position indicators ON at T-7 seconds.

CONSEQUENCES OF EXCEEDING REDLINE:

(3) One indicator failed ON will allow SSME start attempt if prevalve fails to open at T-9.5 seconds.

CAUSES OF EXCEEDING REDLINE:

(4) Valve position indicator failure.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.12 SHEET N/A ZONE F5
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

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LCC VIOLATION CALL: MPS Engine 3 LH2 Prevalve Power Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1303E	MPS E3 LH2 Prevlv OP Pwr (LV22)	2 of 3	OFF	NA	Event	CI
V76X4122E	PCA-MPS LH2 Prevlv 3 OP RPC C On		OFF	NA	Event	CI
V76X4123E	PCA-MPS LH2 Prevlv 3 OP RPC A On		OFF	NA	Event	CI
V41X1302E	MPS E3 LH2 Prevlv CL Pwr (LV23)	2 of 3	ON	NA	Event	CI
V76X4125E	PCA-MPS LH2 Prevlv 3 CL RPC C On		ON	NA	Event	CI
V76X4126E	PCA-MPS LH2 Prevlv 3 CL RPC A On		ON	NA	Event	CI

TIME PERIOD:

(1) From Initiation of LH2 Recirculation to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) PV6 open commands:
- V41K1319XL (Cmd A)
- V41K1320XL (Cmd B)
- V41K1321XL (Cmd C)

PV6 close commands:
- V41K1322XL (Cmd A)
- V41K1323XL (Cmd B)
- V41K1324XL (Cmd C)

REDLINE DERIVATION: CRITICALITY: 1R

(3) Valve is bi-stable, remaining in the last commanded position. A diferential pressure across actuator piston is required to move the valve from one position to the other.
(4) OPEN power failed ON or CLOSE power failed OFF would not allow LH2 prevalve to close at MECO, for an on-pad abort, or after engine failure.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Valve will not close at MECO, for an on-pad abort, or after engine failure with OPEN power failed ON, or CLOSE power failed OFF.

CAUSES OF EXCEEDING REDLINE:

(6) Improper command applied or removed.
(7) Panel R4, MPS LH2 Prevalve Right switch in OPEN position (should be in GPC position).

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.12	SHEET N/A	ZONE G5,G3,
	DWG NO	SHEET	ZONE H5,H3
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

LCC VIOLATION CALL: LH2 4 Inch Disconnect Valve Power Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1439E	MPS LH2 4in Disc Vlv Cl Pwr (LV51)	1 of	OFF	NA	Event	CI
V41X1440E	MPS LH2 4in Disc Vlv Op Pwr (LV50)	2	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) PD3 open command: V41K1421XL PD3 close command: V41K1422XL

REDLINE DERIVATION: CRITICALITY: 1R

(3) Valve is required OPEN for launch to protect against failure of recirculation/topping system relief valve (RV7) to open.
(4) Valve is bi-stable, remaining in the last commanded position. A diferential pressure across actuator piston is required to move the valve from one position to the other.
(5) Verification of OPEN switch ON is not required. Valve is verified open per OMRSD File II, Volume 1, Requirement S00FB0.090.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Valve closes - if relief valve (RV7) fails to open, recirculation/topping system rupture will occur.

CAUSES OF EXCEEDING REDLINE:

(7) EPDC failure.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.12 SHEET N/A ZONE B7
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

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LCC VIOLATION CALL: Main Engine LH2 Recirculation Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
E41P1018B	ME-1 LPFT Disch Press (Avg) DW9		22.6	NA	psia	CI
E41P2018B	ME-2 LPFT Disch Press (Avg) DW9		22.6	NA	psia	CI
E41P3018B	ME-3 LPFT Disch Press (Avg) DW9		22.6	NA	psia	CI

TIME PERIOD:

(1) From L-30 minutes to Terminate LH2 Replenish (T-1 minute, 57 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) If interruptions are due to a Ground Support Equipment (GSE) power supply failure, then perform the following (ref. S1004):
- Verify no current spikes greater than 20 amps with 100 samples/second data.
- Perform automatic switchover to alternate power supply.
- Verify LPFT Disch Press (Avg) return to limits within one minute.
- If LPFT Disch Press (Avg) does not return to limits within one minute prior to T-5 minutes, hold at T-1 minute 57 seconds for sufficient time to allow 3.5 minutes of continuous recirculation prior to Terminate LH2 Replenish at T-1 minute 57 seconds.

If all applicable substeps above are completed satisfactorily, then LCC violation cleared, continue countdown.

NOTES:

(3) SSME LPFT Disch Press (Avg) is the average of two Low Pressure Fuel Pump (LPFP) Discharge Pressure instruments, Channel A and Channel B. Loss of either channel after achieving Engine Ready causes SSME controller to issue "Major Component Failure Flag" resulting in a countdown Hold.

(4) LH2 recirculation interruptions after T-1 minute 57 seconds are unacceptable and are monitored by SSME-07 and SSME-17.

REDLINE DERIVATION: CRITICALITY: 1

(5) a. SSID Intent Summary - This SSID ensures adequate thermal engine conditioning for a nominal engine start sequence and nominal engine performance. Thermal conditioning of the propellant feed system components and main engines is required to satisfy prestart thermal requirements. This is accomplished by recirculating LH2 from the ET through the LH2 feed lines and the engines. Recirculation of LH2 is accomplished by operating the LH2 Recirculation Pump for each engine. Verification of pump operation is accomplished by monitoring the delta pressure output via the LPFP Discharge Pressure for each engine.

REDLINE DERIVATION: (Continued)

b. Voting Logic - N/A.

c. Maximum and Minimum Redline Derivation - The minimum redline is based on LH2 recirculation pump cavitation with system pressure dispersions at Root Sum Square (RSS) maximum values. A cavitating recirculation pump will generate less than 4 psid.

Parameters	Values	Dispersions
Atmospheric pressure	14.7 psia	+/- 0.2
ET ullage pressure above atmospheric pressure	0.2 psi	+/- 0.1
Instrumentation tolerance (3 Sigma)		+/- 1.2*
Liquid head pressure	2.8 psi	
Recirculation pump delta pressure	4.0 psi	
RSS maximum of dispersions	0.9 psi	

Redline	22.6 psia	

* Tolerance for single transducer

There is not a maximum redline since any pressure above 22.6 psia indicates that the recirculation pumps are operating.

d. Time Period - Monitoring starts at L-30 minutes to ensure proper LH2 system conditioning. All engine starts during ground testing were preceded by at least one hour of continuous LH2 conditioning at less than nominal recirculation pump flow rate. Thirty minutes of recirculation pump operation is considered equivalent to this ground test experience.

LH2 system conditioning continues until LH2 recirculation pumps are secured at T-9.4 seconds. However, monitoring is terminated at T-1 minute 57 seconds (Terminate LH2 Replenish) to allow for an automated hold at T-1 minute 57 seconds to support the preplanned contingency procedure. After T-1 minute 57 seconds, a loss of LH2 system conditioning will be detected by SSID SSME-07 (SSME Phase/Mode Anomaly) and SSME-17 (SSME LPFP Discharge Pressure Engine Ready Anomaly (LPFP Discharge Pressure E41P1092D, 2092D, 3092D and E41P1127D, 2127D, 3127D) out of limits (53 psia minimum)). SSID SSME-07 monitors from T-240 seconds to RSLS Start (T-31 seconds) and SSID SSME-17 monitors from Purge Sequence 4 (T-4 minutes) plus 10 seconds to START ENABLE (T-9.5 seconds).

e. Requirements - N/A

f. Preplanned Contingency Procedures - Ground testing indicates engine temperatures will recover within five minutes after a one minute interruption. Therefore, LH2 recirculation interruptions of less than one minute duration from L-30 minutes to T-5 minutes are acceptable.

Between T-5 minutes and T-1 minute 57 seconds, the five minute recovery time can be maintained for recirculation interruptions of less than one minute provided launch is delayed by up to 3.5 minutes. This will

REDLINE DERIVATION: (Continued)

allow for a five minute recirculation period prior to securing the recirculation pumps at T-9.4 seconds.

After T-1 minute 57 seconds, interruptions of any duration are not acceptable because there is not adequate time to ensure proper thermal conditioning prior to engine start.

If LH2 recirculation is lost due to a power failure and can be reinitiated within one minute, thermal conditioning of the main engines will recover within 5 minutes. Periods in excess of one minute will require an additional 30 minutes of thermal conditioning.

However, current draw on the offending pump must be evaluated prior to restarting the pump. Spikes above 20 amps are indicative of a short and will require evaluation of recirculation pump connector integrity prior to restarting the pump. Software evaluates the data and performs an automatic restart of the pump if the current draw is within limits.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) SSME damage (possibly uncontained) during engine start transient.

CAUSES OF EXCEEDING REDLINE:

(7) Loss of electrical power to recirculation pump.
(8) Recirculation pump binding/seizing.
(9) Recirculation pump contamination.
(10) Recirculation pump cavitation.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
n = 1, 2, AND 3 FOR ENGINES 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
E41Pn018B	0.0156	0	300						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.13 SHEET N/A ZONE R4
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

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LCC VIOLATION CALL: MPS Valve Position Qualification Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1456X	MPS LH2 Topping Vlv (PV13) CL Ind	(1)	OFF	NA	Event	CI
V41X1389X	MPS LH2 Otbd F/D Vlv (PV11) CL Ind	(2)	OFF	NA	Event	CI
V41X1514X	MPS LO2 Otbd F/D Vlv (PV9) CL Ind	(2)	OFF	NA	Event	CI
V41X1469E	MPS LH2 Hi Pt Bl Vlv (PV22) CL Ind	(3)	OFF	NA	Event	CI
V41X1811X	MPS LO2 POGO Recrc 1 (PV20) OP Ind	(4)	OFF	NA	Event	CI
V41X1821X	MPS LO2 POGO Recrc 2 (PV21) OP Ind	(4)	OFF	NA	Event	CI

TIME PERIOD:

(1) From OMRS Satisfaction of PV13 Valve Position (approximately T-6 hours) to PV13 Valve Closure (T-1 minute 57 seconds) (5)
(2) From OMRS Satisfaction of PV9 and PV11 Valve Position (approximately T-6 hours) to PV9 and PV11 Valve Closure (T-48 seconds)
(3) From OMRS Satisfaction of PV22 Valve Position (approximately T-5 hours 30 minutes) to Go for RSLS Start (T-31 seconds) (6)
(4) From OMRS Satisfaction of PV20 and PV21 Valve Position (approximately T-6 hours) to Go for RSLS Start (T-31 seconds) (7)

REQUIREMENTS: FIGURES/TABLES:

(5) Failure of PV13 close position indicator to ON is acceptable for confirmed instrumentation failure. (8)
(6) Failure of PV22 close position indicator to ON is acceptable for confirmed instrumentation failure. (9)
(7) Failure of PV20 or PV21 open position indicator to ON is acceptable for confirmed instrumentation failure. (10)

PREPLANNED CONTINGENCY PROCEDURE:

(8) If the MPS LH2 Topping Vlv (PV13) CL Ind (V41X1456X1) fails ON, then perform the following (Ref. OMI S1004):
- Verify MPS LH2 Topping Vlv (PV13) OP Ind (V41X1453E1) is ON
- Verify MPS LH2 Topping Vlv OP Pwr (LV39) (V41X1458E1) is ON
- Verify system pressures and temperatures indicate normal flow to the Orbiter/ET
- Set bypass for close position indicator (V41X1456X1) ON

Instrumentation failure confirmed. LCC violation cleared, continue countdown.

(9) If the MPS LH2 Hi Pt Bl Vlv (PV22) CL Ind (V41X1469E1) fails ON, then perform the following (Ref. OMI S1004):
- Verify MPS LH2 Hi Pt Bl Vlv (PV22) OP Ind (V41X1468E1) is ON
- Verify MPS LH2 Hi Pt Bl Vlv OP Pwr (LV79) (V41X1467E1) is ON
- Verify A131135 Hi Point Bleed Temp (GLHT4119A) indicates flow
- Set bypass for close position indicator (V41X1469E1) ON

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

Instrumentation failure confirmed. LCC violation cleared, continue countdown.

(10) If the MPS LO2 POGO Recirc 1 (PV20) or MPS LO2 POGO Recirc 2 (PV21) open position indicator fails to ON, then perform the following (Ref. OMI S1003):
- For PV20 verify
  - V41X1818E1 MPS LO2 Pogo Recrc 1 (PV20) Cl Ind - ON
  - V41X1813E1 MPS LO2 Pogo Recrc 1 Cl Pwr (LV77) - ON
- For PV21 verify
  - V41X1828E1 MPS LO2 Pogo Recrc 2 (PV21) Cl Ind - ON
  - V41X1823E1 MPS LO2 Pogo Recrc 2 Cl Pwr (LV78) - ON
- Verify no pressure increase on the A86490 TSM Eng Bleed Press (GLOP285A)

Instrumentation failure confirmed. LCC violation cleard, continue countdown.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(11) a. SSID Intent Summary - This SSID verifies that position indicators have not failed prior to usage by a subsequent launch commit criteria. A switch failed in the position required for launch prior to commanding the valve to that position will "Deceive" the verifying implementer (i.e., Launch Processing System or Redundant Set Launch Sequencer) by indicating that the valve did physically transfer to the required position.

b. Voting Logic - N/A

c. Maximum and Minimum Redline Derivation - The off nominal state position indicators of the listed valves are required to indicate OFF during the time effectivities listed to preclude a false pass when the valves transition to their proper flight configuration position.

d. Time Period - The Time Period Effectivity for PV9, PV11 and PV13 coincides with verification of the valve(s) being open to when the valve(s) are closed. The Time Period Effectivity for PV20, PV21 and PV22 starts with the verification of the valves being in their proper position until T-31 seconds. PV20, PV21 and PV22 are transitioned after T-31 seconds. Failure of these position indicators after T-31 seconds is unlikely and is considered an acceptable risk.
   - LH2 Otbd F/D Vlv (PV11) is cycled closed at T-48 seconds.
   - LO2 Otbd F/D Vlv (PV9) is cycled closed at T-48 seconds.
   - LH2 Topping Vlv (PV13) is cycled closed at T-1 minute, 57 seconds.
   - LO2 POGO Recrc 1 (PV20) and 2 (PV21) are cycled open at T-12.5 seconds.
   - LH2 Hi Pt Bl Vlv (PV22) is cycled closed at T-26 seconds.

e. Requirements - Failure of the LH2 Topping Vlv (PV13) close position indicator to ON, LH2 Hi Pt Bl Vlv (PV22) close position indicator to ON,

REDLINE DERIVATION: (Continued)

or either of the LO2 POGO Recrc Vlv (PV20/PV21) open position indicators to ON is acceptable as long as the valve in question can be verified in its correct state by upstream/downstream pressures and temperatures, and that the power and position indicators of the valve's current state are operating correctly.

f. Preplanned Contingency Procedures - Instrumentation failure is confirmed by verifying the current state power and position indicators are ON and that all upstream and downstream flow, temperature and pressure indications are operating correctly. For LH2 Topping Vlv (PV13) and Hi Pt Bl Vlv (PV22), set indicator bypass for close position indicator (V41X1456X1 for PV13, V41X1469E1 for PV22) ON. Indicator bypasses allow the Ground Launch Sequencer and auto load software to function correctly.

CONSEQUENCES OF EXCEEDING REDLINE:

(12) Violation of this SSID will allow the automated software checks for the closure of PV9 (SSID: MPS-08), PV11 (SSID: MPS-05), PV13 (SSID: MPS-10), PV22 (SSID MPS-12) and the opening of PV20 and PV21 (SSID: RSLS-01), to indicate correct valve transfer regardless of actual valve position.

CAUSES OF EXCEEDING REDLINE:

(13) Valve position indicator (switch) failure.
(14) Data Processing System or Launch Processing System failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.11	SHEET	ZONE B7,S4
	DWG NO 10.11	SHEET	ZONE T4
	DWG NO 10.12	SHEET	ZONE B6,H8
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

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LCC VIOLATION CALL: Engine 1 LO2 Prevalve Power Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1133E	MPS E1 LO2 Prevlv OP Pwr 1 (LV12)	(2)	ON	NA	Event	CI
V41X1145E	MPS E1 LO2 Prevlv OP Pwr 2 (LV83)	(2)	ON	NA	Event	CI
V41X1132E	MPS E1 LO2 Prevlv CL Pwr 1 (LV13)	(3)	OFF	NA	Event	CI
V41X1144E	MPS E1 LO2 Prevlv CL Pwr 2 (LV80)	(3)	OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 Engine # 1 LO2 Prevalve Open Power ON indications acceptable for confirmed instrumentation failure. (5)
(3) 1 of 2 Engine # 1 LO2 Prevalve Closed Power OFF indications acceptable for confirmed instrumentation failure. (6)
(4) If preplanned contingency procedure is performed prior to the T-9 minute hold, then reperform the preplanned contingency procedure during the T-9 minute hold. (5),(6)

PREPLANNED CONTINGENCY PROCEDURE:

(5) If 1 of 2 Engine # 1 LO2 Prevalve Open Power ON indications indicate OFF, then perform the following (ref. S1003):
- Issue Engine # 1 LO2 Prevalve (PV1) Close commands.
  PV1 close command A: V41K1139XL
  PV1 close command B: V41K1140XL
  PV1 close command C: V41K1141XL
  PV1 close command D: V41K1142XL

a. If the Engine # 1 LO2 Prevalve remains open, then remove Engine # 1 LO2 Prevalve Close commands. Instrumentation failure is confirmed. LCC violation cleared, continue countdown.
b. If the Engine # 1 LO2 Prevalve closes, then remove Engine # 1 LO2 Prevalve Open commands (Ref. Preplanned Contingency Procedure (6) below for open commands). Engine # 1 LO2 Prevalve Open Power has failed OFF and LO2 bleed flow through the SSME has been terminated. The Engine # 1 LO2 Prevalve cannot be reopened (ref. S00GEN.385) and an alternate bleed path must be established per S1003 (ref. S00E00.122). LCC violation confirmed, No Go for launch.

(6) If 1 of 2 Engine # 1 LO2 Prevalve Closed Power OFF indications indicate ON, then perform the following (ref. S1003):
- Remove Engine # 1 LO2 Prevalve (PV1) Open commands.
  PV1 open command A: V41K1136XL
  PV1 open command B: V41K1137XL
  PV1 open command C: V41K1138XL
  PV1 open command D: V41K1143XL

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

a. If the Engine #1 LO2 Prevalve remains open, then issue Engine # 1 LO2 Prevalve Open commands. Instrumentation failure is confirmed. LCC violation cleared, continue countdown.
b. If the Engine # 1 LO2 Prevalve closes, then issue Engine # 1 LO2 Prevalve Close commands (Ref. Preplanned Contingency Procedure (5) above for close commands). Engine # 1 LO2 Prevalve Closed Power has failed ON and LO2 bleed flow through the SSME has been terminated. The Engine # 1 LO2 Prevalve cannot be reopened (ref S00GEN.385) and an alternate bleed path must be established per S1003 (ref. S00E00.122). LCC violation confirmed, No Go for launch.

NOTES:

(7) The Engine LO2 Prevalve is bi-stable, remaining in the last commanded position. A differential pressure across the actuator piston is required to move the Engine LO2 Prevalve from one position to another.

REDLINE DERIVATION: CRITICALITY: 1

(8) a. SSID Intent Summary - The SSME is isolated from the LO2 feedline by the Engine LO2 Prevalve. The Engine LO2 Prevalve is commanded open prior to transfer of propellant to the orbiter and must remain open throughout engine operation. Its purpose is to provide a bleed flow during loading operations and to provide propellant during engine operation. The Open and Closed Power indicators are a means of determining what state the Engine LO2 Prevalve commands are in. If the Engine LO2 Prevalve closes during cryogenic flow conditions it must not be reopened due to possible rupture of the LO2 feedline from water hammer. Controlling pneumatics for the Engine # 1 LO2 Prevalve is single fault tolerant as the valve is bi-stable, requiring open pneumatics to be removed and closing pneumatics to be applied for the valve to cycle closed.

b. Voting Logic - N/A.

c. Maximum and Minimum Redline Derivation - When the Engine LO2 Prevalve is open, the Open Power indications should be ON and the Closed Power indications should be OFF. Lift-off with closed pneumatics failed ON or open pneumatics failed OFF does not provide adequate level of redundancy for maintaining the Engine LO2 Prevalve in the open position during engine operation.

d. Time Period - Monitoring of the Open and Closed Power indicators begins after the Engine LO2 Prevalve is opened at the start of the cryogenic load. Due to the criticality of the Engine LO2 Prevalve, monitoring will continue until T-31 seconds. Failure of the power indicators after T-31 seconds is unlikely and is considered an acceptable risk.

e. Requirements - Instrumentation failure is acceptable since actual valve power application can be determined by turning ON Closed Power for Open Power failed OFF or turning OFF Open Power for Closed Power failed ON and monitoring Engine LO2 Prevalve position. Due to the criticality of

REDLINE DERIVATION: (Continued)

the Engine LO2 Prevalve, reverification of functionality must be repeated during the T-9 minute hold if the original running of the preplanned contingency procedure occurred prior to the T-9 minute hold.

f. Preplanned Contingency Procedures - Since the Engine LO2 Prevalve is bi-stable, instrumentation failure may be confirmed by setting the "good" powers to their exception states and verifying that the valve remains open. If the Engine LO2 Prevalve is determined to be closed it must not be reopened due to possible damage from water hammer. An alternate bleed flow path must be established or drain initiated per requirements of OMRS S00E00.122.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) The Engine LO2 Prevalve may not remain open during Main Engine operation. This will result in an uncontained shutdown of a Main Engine.

CAUSES OF EXCEEDING REDLINE:

(10) Improper command applied or removed.
(11) Panel R4, MPS LO2 Prevalve Ctr switch in CLOSED position (should be in GPC position).
(12) Valve power indicator failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.11	SHEET N/A	ZONE J5,K3,
	DWG NO	SHEET	ZONE K6
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

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LCC VIOLATION CALL: Engine 2 LO2 Prevalve Power Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1233E	MPS E2 LO2 Prevlv OP Pwr 1 (LV14)	(2)	ON	NA	Event	CI
V41X1245E	MPS E2 LO2 Prevlv OP Pwr 2 (LV84)	(2)	ON	NA	Event	CI
V41X1232E	MPS E2 LO2 Prevlv CL Pwr 1 (LV15)	(3)	OFF	NA	Event	CI
V41X1244E	MPS E2 LO2 Prevlv CL Pwr 2 (LV81)	(3)	OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 Engine # 2 LO2 Prevalve Open Power ON indications acceptable for confirmed instrumentation failure. (5)
(3) 1 of 2 Engine # 2 LO2 Prevalve Closed Power OFF indications acceptable for confirmed instrumentation failure. (6)
(4) If preplanned contingency procedure is performed prior to the T-9 minute hold, then reperform the preplanned contingency procedure during the T-9 minute hold. (5),(6)

PREPLANNED CONTINGENCY PROCEDURE:

(5) If 1 of 2 Engine # 2 LO2 Prevalve Open Power ON indications indicate OFF, then perform the following (ref. S1003):
- Issue Engine # 2 LO2 Prevalve (PV2) Close commands.
  PV2 close command A: V41K1239XL
  PV2 close command B: V41K1240XL
  PV2 close command C: V41K1241XL
  PV2 close command C: V41K1242XL

a. If the Engine # 2 LO2 Prevalve remains open, then remove Engine # 2 LO2 Prevalve Close commands. Instrumentation failure is confirmed. LCC violation cleared, continue countdown.
b. If the Engine # 2 LO2 Prevalve closes, then remove Engine # 2 LO2 Prevalve Open commands (ref. Preplanned Contingency Procedure (6) below for open commands). Engine # 2 LO2 Prevalve Open Power has failed OFF and LO2 bleed flow through the SSME has been terminated. The Engine # 2 LO2 Prevalve cannot be reopened (ref. S00GEN.385) and an alternate bleed path must be established per S1003 (ref. S00E00.122). LCC violation confirmed, No Go for launch.

(6) If 1 of 2 Engine # 2 LO2 Prevalve Closed Power OFF indications indicate ON then perform the following (ref. S1003):
- Remove Engine # 2 LO2 Prevalve (PV2) Open commands.
  PV2 open command A: V41K1236XL
  PV2 open command B: V41K1237XL
  PV2 open command C: V41K1238XL
  PV2 open command D: V41K1243XL

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

a. If the Engine # 2 LO2 Prevalve remains open, then issue Engine # 2 LO2 Prevalve Open commands. Instrumentation failure is confirmed. LCC violation cleared, continue countdown.
b. If the Engine # 2 LO2 Engine Prevalve closes, then issue Engine # 2 LO2 Prevalve Close commands (Ref. Preplanned Contingency Procedure (5) above for close commands). Engine # 2 LO2 Prevalve Closed Power has failed ON and LO2 bleed flow through the SSME has been terminated. The Engine # 2 LO2 Prevalve cannot be reopened (ref. S00GEN.385) and an alternate bleed path must be established per S1003 (ref. S00E00.122). LCC violation confirmed, No Go for launch.

NOTES:

(7) The Engine LO2 Prevalve is bi-stable, remaining in the last commanded position. A differential pressure across the actuator piston is required to move the Engine LO2 Prevalve from one position to another.

REDLINE DERIVATION: CRITICALITY: 1

(8) a. SSID Intent Summary - The SSME is isolated from the LO2 feedline by the Engine LO2 Prevalve. The Engine LO2 Prevalve is commanded open prior to transfer of propellant to the orbiter and must remain open throughout engine operation. Its purpose is to provide a bleed flow during loading operations and to provide propellant during engine operation. The Open and Closed Power indicators are a means of determining what state the Engine LO2 Prevalve commands are in. If the Engine LO2 Prevalve closes during cryogenic flow conditions it must not be reopened due to possible rupture of the LO2 feedline from water hammer. Controlling pneumatics for the Engine # 2 LO2 Prevalve is single fault tolerant as the valve is bi-stable, requiring open pneumatics to be removed and closing pneumatics to be applied for the valve to cycle closed.

b. Voting Logic - N/A.

c. Maximum and Minimum Redline Derivation - When the Engine LO2 Prevalve is open, the Open Power indications should be ON and the Closed Power indications should be OFF. Lift-off with closed pneumatics failed ON or open pneumatics failed OFF does not provide adequate level of redundancy for maintaining the Engine LO2 Prevalve in the open position during engine operation.

d. Time Period - Monitoring of the Open and Closed Power indicators begins after the Engine LO2 Prevalve is opened at the start of the cryogenic load. Due to the criticality of the Engine LO2 Prevalve, monitoring will continue until T-31 seconds. Failure of the power indicators after T-31 seconds is unlikely and is considered an acceptable risk.

e. Requirements - Instrumentation failure is acceptable since actual valve power application can be determined by turning ON Closed Power for Open Power failed OFF or turning OFF Open Power for Close Power failed ON and monitoring Engine LO2 Prevalve position. Due to the criticality of the

REDLINE DERIVATION: (Continued)

Engine LO2 Prevalve, reverification of functionality must be repeated during the T-9 minute hold if the original running of the preplanned contingency procedure occurred prior to the T-9 minute hold.

f. Preplanned Contingency Procedures - Since the Engine LO2 Prevalve is bi-stable, instrumentation failure may be confirmed by setting the "good" powers to their exception states and verifying that the valve remains open. If the Engine LO2 Prevalve is determined to be closed it must not be reopened due to possible damage from water hammer. An alternate bleed flow path must be established or drain initiated per requirements of OMRS S00E00.122.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) The Engine LO2 Prevalve may not remain open during Main Engine operation. This will result in an uncontained shutdown of a Main Engine.

CAUSES OF EXCEEDING REDLINE:

(10) Improper command applied or removed.
(11) Panel R4, MPS LO2 Prevalve Left switch in CLOSED position (should be in GPC position).
(12) Valve power indicator failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.11	SHEET N/A	ZONE P4,O5,
	DWG NO	SHEET	ZONE P2
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

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LCC VIOLATION CALL: Engine 3 LO2 Prevalve Power Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1333E	MPS E3 LO2 Prevlv OP Pwr 1 (LV16)	(2)	ON	NA	Event	CI
V41X1345E	MPS E3 LO2 Prevlv OP Pwr 2 (LV85)	(2)	ON	NA	Event	CI
V41X1332E	MPS E3 LO2 Prevlv CL Pwr 1 (LV17)	(3)	OFF	NA	Event	CI
V41X1344E	MPS E3 LO2 Prevlv CL Pwr 2 (LV82)	(3)	OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 Engine # 3 LO2 Prevalve Open Power ON indications acceptable for confirmed instrumentation failure. (5)
(3) 1 of 2 Engine # 3 LO2 Prevalve Closed Power OFF indications acceptable for confirmed instrumentation failure. (6)
(4) If preplanned contingency procedure is performed prior to the T-9 minute hold, then reperform the preplanned contingency procedure during the T-9 minute hold. (5),(6)

PREPLANNED CONTINGENCY PROCEDURE:

(5) If 1 of 2 Engine # 3 LO2 Prevalve Open Power ON indications indicate OFF then perform the following (ref. S1003):
- Issue Engine # 3 LO2 Prevalve (PV3) Close commands.
  PV3 close command A: V41K1339XL
  PV3 close command B: V41K1340XL
  PV3 close command C: V41K1341XL
  PV3 close command D: V41K1342XL

a. If the Engine # 3 LO2 Prevalve remains open, then remove Engine # 3 LO2 Prevalve Close commands. Instrumentation failure is confirmed. LCC violation cleared, continue countdown.
b. If the Engine # 3 Prevalve closes, then remove Engine # 3 LO2 Prevalve Open commands (Ref. Preplanned Contingency procedure (6) below for open commands). Engine # 3 LO2 Prevalve Open power has failed OFF and LO2 bleed flow through the SSME has been terminated. The Engine # 3 LO2 Prevalve cannot be reopened (ref. S00GEN.385) and an alternate bleed path must be established per S1003 (ref. S00E00.122). LCC violation confirmed, No Go for launch.

(6) If 1 of 2 Engine # 3 LO2 Prevalve Closed power OFF indications indicate ON, then perform the following (ref. S1003):
- Remove Engine # 3 LO2 Prevalve (PV3) Open commands.
  PV3 open command A: V41K1336XL
  PV3 open command B: V41K1337XL
  PV3 open command C: V41K1338XL
  PV3 open command D: V41K1343XL

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

a. If the Engine # 3 Prevalve remains open, then issue Engine # 3 LO2 Prevalve Open commands. Instrumentation failure is confirmed. LCC violation cleared, continue countdown.
b. If the Engine # 3 LO2 Prevalve closes, then issue Engine # 3 LO2 Prevalve Close commands (Ref. Preplanned Contingency Procedure (5) above for close commands). Engine # 3 LO2 Prevalve Closed Power has failed ON and LO2 bleed flow through the SSME has been terminated. The Engine # 3 LO2 Prevalve cannot be reopened (ref. S00GEN.385) and an alternate bleed path must be established per S1003 (ref. S00E00.122). LCC violation confirmed, No Go for launch.

NOTES:

(7) The Engine LO2 Prevalve is bi-stable, remaining in the last commanded position. A differential pressure across the actuator piston is required to move the Engine LO2 Prevalve from one position to another.

REDLINE DERIVATION: CRITICALITY: 1

(8) a. SSID Intent Summary - The SSME is isolated from the LO2 feedline by the Engine LO2 Prevalve. The Engine LO2 Prevalve is commanded open prior to transfer of propellant to the orbiter and must remain open throughout engine operation. Its purpose is to provide a bleed flow during loading operations and to provide propellant during engine operation. The Open and Closed Power indicators are a means of determining what state the Engine LO2 Prevalve commands are in. If the Engine LO2 Prevalve closes during cryogenic flow conditions it must not be reopened due to possible rupture of the LO2 feedline from water hammer. Controlling pneumatics for the Engine # 3 LO2 Prevalve is single fault tolerant as the valve is bi-stable, requiring open pneumatics to be removed and closing pneumatics to be applied for the valve to cycle closed.

b. Voting Logic - N/A.

c. Maximum and Minimum Redline Derivation - When the Engine LO2 Prevalve is open, the Open Power indications should be ON and the close power indications should be OFF. Lift-off with closed pneumatics failed ON or open pneumatics failed OFF does not provide adequate level of redundancy for maintaining the Engine LO2 Prevalve in the open position during engine operation.

d. Time Period - Monitoring of the Open and Closed Power indicators begins after the Engine LO2 Prevalve is opened at the start of the cryogenic load. Due to the criticality of the Engine LO2 Prevalve, monitoring will continue until T-31 seconds. Failure of the power indicators after T-31 seconds is unlikely and is considered an acceptable risk.

e. Requirements - Instrumentation failure is acceptable since actual valve power application can be determined by turning ON Closed Power for Open Power failed OFF or turning OFF Open Power for Closed Power failed ON and monitoring Engine LO2 Prevalve position. Due to the criticality of

REDLINE DERIVATION: (Continued)

the Engine LO2 Prevalve, reverification of functionality must be repeated during the T-9 minute hold if the original running of the preplanned contingency procedure occurred prior to the T-9 minute hold.

f. Preplanned Contingency Procedures - Since the Engine LO2 Prevalve is bi-stable, instrumentation failure may be confirmed by setting the "good" powers to their exception states and verifying that the valve remains open. If the Engine LO2 Prevalve is determined to be closed it must not be reopened due to possible damage from water hammer. An alternate bleed flow path must be established or drain initiated per requirements of OMRS S00E00.122.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) The Engine LO2 Prevalve may not remain open during Main Engine operation. This will result in an uncontained shutdown of a Main Engine.

CAUSES OF EXCEEDING REDLINE:

(10) Improper command applied or removed.
(11) Panel R4, MPS LO2 Prevalve Right switch in CLOSED position (should be in GPC position).
(12) Valve power indicator failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.11	SHEET N/A	ZONE F4,F2,
	DWG NO	SHEET	ZONE F3
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

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LCC VIOLATION CALL: MPS Helium Isolation Valve Open Indication Anomaly | EMERG COND: Yellow (6)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1645E1	MPS Pneu He Iso Vlv 1 (LV7) OP Pwr	1 of	ON (3)	NA	Event	CI
V41X1646E1	MPS Pneu He Iso Vlv 2 (LV8) OP Pwr	2	ON (3)	NA	Event	CI
V41X1158E1	MPS E1 He Iso Vlv A (LV1) OP Pwr	(2)	ON	NA	Event	CI
V41X1159E1	MPS E1 He Iso Vlv B (LV2) OP Pwr	(2)	ON	NA	Event	CI
V41X1258E1	MPS E2 He Iso Vlv A (LV3) OP Pwr	(2)	ON	NA	Event	CI
V41X1259E1	MPS E2 He Iso Vlv B (LV4) OP Pwr	(2)	ON	NA	Event	CI
V41X1358E1	MPS E3 He Iso Vlv A (LV5) OP Pwr	(2)	ON	NA	Event	CI
V41X1359E1	MPS E3 He Iso Vlv B (LV6) OP Pwr	(2)	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) CAUTION - Do Not attempt to confirm instrumentation failure by closing redundant isolation valve and monitoring for decrease in Space Shuttle Main Engine (SSME) regulator out pressure. Application of this procedure may allow SSME valve drift causing hazardous leakage of propellant overboard.

(3) For loss of both MPS Pneumatic Helium Isolation valves perform the following Emergency Safing (Ref S1004).

- Open the Left Engine Helium Crossover Valve
- Initiate drain

NOTES:

(4) A Launch Commit Criteria (LCC) for leg B utilizing 2 of 3 power on indications between the two Remote Power Controllers (RPCs) and the Isolation Valve power ON indication was not considered adequate since knowledge of circuit integrity up to the open power indication is required. Launch with one valve closed and failure of the valve in the parallel leg to remain open will cause an uncontained engine shutdown.

REDLINE DERIVATION: CRITICALITY: 1R

(5) a. SSID Intent Summary -
SSME - all regulator isolation valves must be open prior to lift-off to ensure Main Propulsion System (MPS)/SSME pneumatic supply redundancy

REDLINE DERIVATION: (Continued)

exists in-flight. Helium isolation valve OPEN power measurements verify single-fault tolerance against engine shutdown.

MPS pneumatic supply - operational pneumatic leg required to provide redundant helium supply for MPS valve actuation, manifold repressurization during MPS dump and abort aft compartment purges. At Main Engine Cut Off (MECO) the SSME #2 low pressure crossover valve (LV10) is opened to support MPS prevalve closure. For pad aborts, LV10 is opened to support valve operations required for system safing.

b. Voting Logic - 1 of 2 Pneu Iso Vlv OP Pwr ON is adequate with confirmation of downstream pressure (ref SSID MPS-46).

c. Maximum and Minimum Redline Derivation -
SSME - all regulator isolation valves must be open prior to lift-off to ensure MPS/SSME pneumatic supply redundancy exists in-flight. Helium isolation valve OPEN power measurements verify single-fault tolerance against engine shutdown.

MPS pneumatic supply - operational pneumatic leg required to provide redundant helium supply for MPS valve actuation, manifold repressurization during MPS dump and abort aft compartment purges. At MECO the SSME #2 low pressure crossover valve (LV10) is opened to support MPS prevalve closure. For pad aborts, LV10 is opened to support valve operations required for system safing.

d. Time Period - From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds). Redundancy for both MPS and SSME helium pneumatic systems is required to insure safe operation during cryogenic load and ascent.

e. Requirements - Loss of both MPS Pneu He Iso Valves can cause a total loss of MPS pneumatic control pressure resulting in the following consequences:
(a) Transition of the LO2 and LH2 Manifold Relief Isolation Valves to OPEN, resulting in loss of redundancy for propellant loss overboard.
(b) Transition of the LO2 Pogo Valves to OPEN, resulting in a loss of LO2 bleed.
(c) Loss of capability to cycle bistable propellant valves, preventing SSME isolation, LO2 anti-geyser configuration, drain (if Tail Service Mast (TSM) is reverted), or ET isolation.

f. Preplanned Contingency Procedures - For loss of both MPS Pneu He Iso Valves, open the Left Engine Helium Crossover Valve and Initiate Drain.

CAUTION - Do not attempt to confirm instrumentation failure by closing redundant isolation valve and monitoring for decrease in SSME regulator out pressure. Application of this procedure may allow SSME valve drift causing hazardous leakage of propellant overboard.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Emergency Condition Yellow is based on a loss of both MPS Pneu He Iso Valves which can cause a total loss of MPS pneumatic control pressure resulting in the following consequences:
   (a) Transition of the LO2 and LH2 Manifold Relief Isolation Valves to OPEN, resulting in loss of redundancy for propellant loss overboard.
   (b) Transition of the LO2 Pogo Valves to OPEN, resulting in a loss of LO2 bleed.
   (c) Loss of capability to cycle bistable propellant valves, preventing SSME isolation, LO2 anti-geyser configuration, drain (if TSM is reverted), or ET isolation.
(7) Loss of MPS pneumatic supply would result in off-nominal pneumatic valve operation at MECO.
(8) Loss of SSME helium supply isolation valve eliminates redundancy of helium supply to SSME.

CAUSES OF EXCEEDING REDLINE:

(9) Circuit failure.
(10) Panel R2, MPS Pneumatics He Isol switch and/or one or more of the MPS He Isolation A or B Left/Ctr/Right switches in CLOSED position (should be in General Purpose Computer (GPC) position/OPEN position from T-16 minutes through launch).
(11) Pneumatic regulator failure, leak in accumulator leg, or dual pneumatic isolation solenoid valve failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.8		SHEET 24,25,	ZONE V1,V3,
	DWG NO		SHEET	ZONE R7,R4,
	DWG NO		SHEET	ZONE K7,K5,
	DWG NO		SHEET	ZONE D7,D5
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	VS72-941099	SHEET	ZONE 41AD
	DWG NO		SHEET	ZONE 41W
	DWG NO		SHEET	ZONE 41X
	DWG NO		SHEET	ZONE 41Y

ELEMENT: Orbiter SUBSYSTEM: MPS

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LCC VIOLATION CALL: MPS Pneumatic Helium Crossover Valve Power Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1614E	MPS Reg He Xover Vlv (LV10) OP Pwr	(2)	OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Not required for instrumentation failure (3).

PREPLANNED CONTINGENCY PROCEDURE:

(3) Perform procedure after LH2 and LO2 systems in stable replenish. Perform stop flow and revert. Close LV7 and LV8. Cycle LH2 prevalve close power until pneumatic out pressure indicates 650 psia to verify LV10 closed. Open LV10 and verify pneumatic accumulator (V41P1650A) repressurizes (4). Close LV10 and repeat LH2 prevalve close power cycling verification to verify LV10 returned to the closed position, then open LV7 and LV8.

NOTES:

(4) Full function of valve must be verified since open power ON causes control circuit to be suspect. Valve must open at MECO to support LO2 prevalve closure (a critical function).
(5) LV10 open command: V41K1613XL.

REDLINE DERIVATION: CRITICALITY: 1R

(6) MPS Reg Helium SSME-2 crossover valve OPEN power OFF is required to maintain single-fault tolerance against SSME-2 shutdown caused by engine helium loss through a pneumatic system leak.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Premature SSME-2 shutdown. Possible abort depending on when failure occurs.

CAUSES OF EXCEEDING REDLINE:

(8) Panel R2, MPS Pneumatics L Eng He Xovr switch in OPEN position (should be in GPC position).
(9) Improper command applied.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.8	SHEET N/A	ZONE U5
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

LCC VIOLATION CALL: MPS Helium Interconnect Valve Power Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1170E	MPS E1 He Intcn Out (LV60) OP Pwr		OFF (2)	NA	Event	CI
V41X1270E	MPS E2 He Intcn Out (LV62) OP Pwr		OFF (2)	NA	Event	CI
V41X1370E	MPS E3 He Intcn Out (LV64) OP Pwr		OFF (2)	NA	Event	CI
V41X1164E	MPS E1 He Intcn In (LV59) OP Pwr		OFF (3)	NA	Event	CI
V41X1264E	MPS E2 He Intcn In (LV61) OP Pwr		OFF (3)	NA	Event	CI
V41X1364E	MPS E3 He Intcn In (LV63) OP Pwr		OFF (3)	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) For suspect Interconnect Out valves, perform the following per OMI S1004: Terminate Helium replenish and open Interconnect In valve on a good SSME. Establish delta P across suspect Interconnect Out valve. If necessary, energize IMSL purge solenoid or FSP solenoid to increase Helium demand on good SSME (4). Pneumatic system will decay. Verify suspect Interconnect Out valve function by cycling the valve and monitor for an increase and then subsequent decrease in pneumatic system pressure. For confirmed valve position and function, LCC violation cleared, continue countdown. Return Helium supply and demand to nominal configuration.

(3) Terminate Helium replenish and monitor for no decrease in MPS pneumatic system pressure. To verify full valve function (6) open Interconnect In valve of suspect system and monitor for a decrease in MPS pneumatic system pressure. Close Interconnect In valve of suspect system and verify MPS pneumatic system pressure decay ceases. For confirmed valve position and function, LCC violation cleared, continue countdown. Activate Helium replenish.

NOTES:

(4) CAUTION: File II OMRS S00FB0.320 prohibits fuel system purge termination to facilitate troubleshooting on Block II SSMEs with LH2 in SSME fuel lines.

(5) If the IMSL Purge Solenoid is energized, the solenoid will remain energized for a period of 120 seconds. Redline monitoring per SSME-10 (SSME HPOTP Intermediate Seal Purge Pressure Anomaly) will be suspended for 120 seconds each time the solenoid changes state.

(6) Full function of valve must be verified since open power "ON" causes control circuit to be suspect.

(7) LV59 open commands: V41K1162XL, V41K1163XL
LV60 open command: V41K1168XL

NOTES: (Continued)

LV61 open commands: V41K1262XL, V41K1263XL
LV62 open command: V41K1268XL
LV63 open commands: V41K1362XL, V41K1363XL
LV64 open command: V41K1368XL

REDLINE DERIVATION: CRITICALITY: 1R

(8) Helium Interconnect Out OPEN power OFF verifies single-fault tolerance against engine shutdown caused by helium loss from engine supply to pneumatic leak.
(9) Helium Interconnect In OPEN power OFF verifies single-fault tolerance against aft overpressurization for a ruptured interconnect line.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) For Interconnect Out OPEN Power OFF failure, premature engine shutdown occurs if pneumatic leak also occurs. Possible abort depending on when failure occurs.
(11) For Interconnect In OPEN Power OFF failure, Aft overpressurization if the interconnect line also ruptures.

CAUSES OF EXCEEDING REDLINE:

(12) Panel R2, MPS He Interconnect Left/Ctr/Right switch not in GPC position.
(13) Improper command applied.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.8	SHEET N/A	ZONE M4,M5,
	DWG NO	SHEET	ZONE F5,F4,
	DWG NO	SHEET	ZONE T5,T4
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

LCC VIOLATION CALL: MPS Helium Supply Blowdown Valve Power Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1632E	MPS He Sply Blwdwn 1 (LV26) OP Pwr	(2)	OFF	NA	Event	CI
V41X1634E	MPS He Sply Blwdwn 2 (LV27) OP Pwr	(2)	OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 acceptable for confirmed instrumentation failure only. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Function may be confirmed by terminating helium fill, issuing series blowdown valve MDM command, and verifying that pneumatic bottle temperature/pressure does not decay. After purge sequence 4 initiation, recycle is required since Helium fill termination during purge sequence 4 will cause engine helium system redline violation.

NOTES:

(4) LV26 open command: V41K1631NL
LV27 open command: V41K1633NL

REDLINE DERIVATION: CRITICALITY: 1R

(5) Provides single-failure tolerance against overboard loss of pneumatic system helium supply. Blowdown valves and LO2 prevalves are downstream of the pneumatic accumulator leg isolation check valve (CV9) which results in loss of helium supply to prevalve actuators. Prevalves will not close at MECO - a critical function. SSME-2 low pressure crossover valve (LV10) opening at MECO will not provide sufficiant pressure to close prevalves.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Overboard loss of pneumatic system helium supply if second blowdown valve fails to remain closed during ascent. LO2 prevalves will not close at MECO, resulting in uncontained engine damage.

CAUSES OF EXCEEDING REDLINE:

(7) EPDC failure.
(8) Improper command applied.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.8	SHEET N/A	ZONE Q3,Q4
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

LCC VIOLATION CALL: MPS Repressurization Valve Power Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1538E	MPS LO2 Manf Reprss 1(LV40) OP Pwr	1 of	OFF	NA	Event	CI
V41X1539E	MPS LO2 Manf Reprss 2(LV41) OP Pwr	2	OFF	NA	Event	CI
V41X1901E	MPS LH2 RTLS Reprss 1(LV74) OP Pwr		OFF(4)	NA	Event	CI
V41X1902E	MPS LH2 RTLS Reprss 2(LV75) OP Pwr		OFF(4)	NA	Event	CI
V41X1436E	MPS LH2 Manf Reprss 1(LV42) OP Pwr	(2)	OFF	NA	Event	CI
V41X1438E	MPS LH2 Manf Reprss 2(LV43) OP Pwr	(2)	OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 measurements acceptable for confirmed instrumentation failure only. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) LH2 manifold repress open power instrumentation failure may be confirmed by terminating helium fill, issuing series repressurization valve MDM commands, and verifying that pneumatic bottle temperature/pressure does not decay. After purge sequence 4 initiation, recycle is required since helium fill termination during purge sequence 4 will cause engine helium system redline violation.

NOTES:

(4) A trouble-shooting procedure for the RTLS repress valve (LV74/LV75) OPEN power failure is not recommended. Opening of the RTLS repress valves will introduce 750 psia helium to the relief valve (RV6) and the relief shutoff valve (PV8) at conditions the system was not designed for. It is expected that the shutoff valve will open and allow helium to enter the manifold and LH2 to leak into the volume between PV8 and RV6 (and eventually relieve overboard); and damage will occur to both valves due to overpressure conditions. Normally the RTLS repress valves are opened to force LH2 out of the manifold through opened RTLS dump valves; helium pressure level is controlled by flow through the RTLS repress orifice RP9.

(5) LV40 open command: V41K1535XL
LV41 open command: V41K1537XL
LV42 open command: V41K1435XL
LV43 open command: V41K1437XL

LV74 open commands:	LV75 open commands:
V41K1905XL (Cmd A)	V41K1906XL (Cmd A)
V41K1907XL (Cmd B)	V41K1908XL (Cmd B)
V41K1909XL (Cmd C)	V41K1910XL (Cmd C)

REDLINE DERIVATION: CRITICALITY: 1R

(6) LO2 manifold repress - provides single-failure tolerance against helium ingestion into the LO2 feed system. Only 1 of 2 required - repress regulator (PR5) provides redundant helium isolation since regulator controls to a manifold pressure of 17-30 psig and manifold pressure during ascent is much greater.
(7) LH2 manifold repress - provides single-failure tolerance against helium ingestion into the LH2 feed system. 2 of 2 functionally required - repress regulator (PR6) does not provide redundant helium isolation since regulator controls to a manifold pressure of 17-30 psig and manifold pressure during ascent is in this pressure range.
(8) LH2 RTLS repress - provides single-failure tolerance against helium ingestion into the LH2 feed system. 2 of 2 required - relief isolation valve (PV8) does not provide redundant helium isolation since helium pressure will back flow isolation valve at a pressure level lower than required to open the LH2 relief valve (RV6).

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Failure of remaining valve (redundant) to remain closed during ascent will allow helium flow into the feed system resulting in unquantified risk to engine operation.

CAUSES OF EXCEEDING REDLINE:

(10) Panel R4, MPS Manf Press LO2/LH2 switch in OPEN position (should be in GPC position).
(11) EPD&C failure.
(12) Improper command applied.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.11	SHEET N/A	ZONE G6,H6
	DWG NO 10.12	SHEET N/A	ZONE E7,C7,
	DWG NO	SHEET	ZONE F6
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

MPS GO2 Pressure Flow Control Valve Power

(THIS REQUIREMENT HAS BEEN DELETED)

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LCC VIOLATION CALL: MPS GH2 Pressure Flow Control Valve Power Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1661E	MPS GH2 Press FCV 1 (LV56) CL Pwr		OFF	NA	Event	CI
V41X1662E	MPS GH2 Press FCV 2 (LV57) CL Pwr		OFF	NA	Event	CI
V41X1663E	MPS GH2 Press FCV 3 (LV58) CL Pwr		OFF	NA	Event	CI

TIME PERIOD:

(1) From stable LH2 replenish (approximately T-3 hours) to replenish termination (T-1 minute 57 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(2) Required to verify ullage pressure signal conditioner function. CLOSE power ON when pressure is greater than 33.2 psia, CLOSE power OFF when pressure is less than 32.8 psia. Ullage pressure during LH2 replenish is less than 32.8 psia. 3 of 3 required to maintain single-failure tolerance. Valve is normally open.

CONSEQUENCES OF EXCEEDING REDLINE:

(3) Flow control valve powered to the closed position. If a second valve remains closed, the ET minimum structural capability requirement (reduced margin of safety) may be violated; and SSME NPSP may be violated in second stage.

CAUSES OF EXCEEDING REDLINE:

(4) Ullage pressure signal conditioner failure.
(5) Ullage pressure transducer failure.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.12 SHEET N/A ZONE N7,S7,
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE I7

ELEMENT: Orbiter SUBSYSTEM: MPS

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LCC VIOLATION CALL: MPS GH2 Pressure Flow Control Valve Power Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1661E	MPS GH2 Press FCV 1 (LV56) CL Pwr		ON	NA	Event	CI
V41X1662E	MPS GH2 Press FCV 2 (LV57) CL Pwr		ON	NA	Event	CI
V41X1663E	MPS GH2 Press FCV 3 (LV58) CL Pwr		ON	NA	Event	CI

TIME PERIOD:

(1) Verify after LH2 prepressurization (approximately T-1 minute 17 seconds) until Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(2) Required to verify ullage pressure signal conditioner function. CLOSE power ON when pressure is greater than 33.2 psia. CLOSE power OFF when pressure less than 32.8 psia. Ullage pressure during repressurization is greater than 33.2 psia. 3 of 3 required to maintain single-failure tolerance. Valve is normally open.

CONSEQUENCES OF EXCEEDING REDLINE:

(3) Flow control valve will remain open. If a second valve remains open, hazardous H2 venting will occur and ET maximum structural capability requirement (reduced margin of safety) will be violated.

CAUSES OF EXCEEDING REDLINE:

(4) Ullage pressure signal conditioner failure.
(5) Ullage pressure transducer failure.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.12 SHEET N/A ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

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LCC VIOLATION CALL: Pneu Helium Regulator Outlet Pressure Anomaly | EMERG COND: Yellow (13)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41P1605A1	MPS Pneu Vlvs Reg He Outlet Press		716	796	psia	CI
V41P1650A1	MPS Pneu Accumulator Pressure		716	796	psia	CI

TIME PERIOD:

(1) From Go for APU Start (T-5 minutes) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 measurements acceptable for confirmed instrumentation failure. (4)
(3) A momentary violation during MPS valve actuation is acceptable.

PREPLANNED CONTINGENCY PROCEDURE:

(4) MPS Pneumatic Valve Regulator Helium Outlet Pressure (V41P1605A1) or MPS Pneumatic Accumulator Pressure (V41P1650A1) instrumentation failure can be verified by examining the function designators (MSIDs) for off-scale high or off-scale low readings. Additionally, there should be no decrease in MPS Helium Tank Pressure (V41P1600A1), or MPS Helium Tank Temperature (V41T1601A1). Also, helium mass decay rate calculation may be used to assess regulator performance. If instrumentation failure confirmed, LCC violation cleared, continue countdown.
(5) For loss of both MPS Pneu He Outlet Press and Accumulator Press, perform the following Emergency Safing (ref. S1004):

- Open the Left Engine Helium Crossover Valve
- Initiate Drain

NOTES:

(6) Relief valve cracking pressure is 805 psia (790 psig).
(7) Relief valve reseat pressure is 800 psia (785 psig).
(8) Relief valve crack and reseat pressures in (6) and (7) are based on MC284-0398-0005 relief valve. The MC284-0398-0006 relief valve is an interchangeable part and has a cracking pressure of 815 psia (800 psig) and reseat pressure of 810 psia (795 psig).
(9) Accumulator measurement isolated from regulator output measurement by a check valve.
(10) Loss of MPS Pneu Vlvs Reg He Outlet Press indication will result in loss of MPS Pneu Vlvs Reg He Outlet Press data to the Multifunction Electronic Display Subsystem (MEDS).
(11) Reference OMRSD S00FB0.083 for pneumatic regulator monitoring requirements prior to LCC effectivity.

REDLINE DERIVATION: CRITICALITY: 1R

(12) a. SSID Intent Summary - Ensures adequate pneumatic control pressure for final MPS valve cycle prior to SSME start, during ascent and scrub/abort operations. Prior to T-5 minutes, pneumatic control pressure is verified by OMRSD S00FB0.083. Pneumatic regulator upper limit is based on maintaining one bit margin from relief valve cracking pressure. Pneumatic regulator lower limit is based on protecting minimum LO2 prevalve actuation pressure for zero-G closure timing.

b. Voting Logic - N/A

c. Maximum and Minimum Redline Derivation - Pneumatic regulator upper limit is based on maintaining one bit margin from relief valve cracking pressure. For example, if pressure is increasing, the Data Processing System (DPS) Analog to Digital (A-D) conversion will indicate 796 psia when Dedicated Signal Conditioner (DSC) output is greater than or equal to 796 and less than 800 psia. The LCC upper limit would be invoked when the data value toggles from 796 to 800 psia.

Pneumatic regulator lower limit is based on protecting minimum LO2 prevalve actuation pressure for zero-G closure timing (700 psig) plus 14.7 psi for regulator outlet pressure slump at altitude (gauge referenced). For example, if pressure is decreasing, DPS A-D conversion would indicate 716 psia when DSC output is greater than 712 and less than or equal to 716 psia. The LCC lower limit would be invoked when the data value toggles from 716 to 712 psia.

d. Time Period - From Go for APU Start (T-5 minutes) to Go for RSLS Start (T-31 seconds). Insures adequate pneumatic control pressure for final MPS valve cycle prior to SSME start, during ascent and scrub/abort operations. Prior to T-5 minutes, pneumatic control pressure is verified by OMRSD S00FB0.083.

e. Requirements - 1 of 2 measurements provide adequate visibility of pneumatic control pressure. During valve cycling, momentary violations may occur due to changes in flow rate through the pneumatic regulator. These pressure fluctuations are a function of the pneumatic regulator and a nominal condition.

Loss of visibility for both MPS Pneu He Outlet Press and Accumulator Press transducers is an unsafe configuration. An undetected loss of MPS pneumatic control pressure could result in the following consequences:
(a) Transition of the LO2 and LH2 Manifold Relief Isolation Valves to OPEN, resulting in loss of redundancy for propellant loss overboard.
(b) Transition of the LO2 Pogo Valves to OPEN, resulting in a loss of LO2 bleed.
(c) Loss of capability to cycle bistable propellant valves, preventing SSME isolation, LO2 anti-geyser configuration, drain (if Tail Service Mast (TSM) is reverted), or ET isolation.

f. Preplanned Contingency Procedures - MPS Pneumatic Valve Regulator Helium Outlet Pressure (V41P1605A1) or MPS Pneumatic Accumulator Pressure

REDLINE DERIVATION: (Continued)

(V41P1650A1) instrumentation failure can be verified by examining the function designators (MSIDs) for off-scale high, off-scale low, or erratic readings. Additionally, there should be no decrease in MPS Helium Tank Pressure (V41P1600A1), or MPS Helium Tank Temperature (V41T1601A1). Also, helium mass decay rate calculation may be used to assess regulator performance.

For loss of both MPS Pneu He Outlet Press and Accumulator Press, open the Left Engine Helium Crossover valve and initiate drain.

CONSEQUENCES OF EXCEEDING REDLINE:

(13) Emergency Condition Yellow is based on a loss of visibility for both MPS Pneu He Outlet Press and Accumulator Press transducers potentially masking an undetected loss of MPS pneumatic control pressure, which would result in the following consequences:
   (a) Transition of the LO2 and LH2 Manifold Relief Isolation Valves to OPEN, resulting in loss of redundancy for propellant loss overboard.
   (b) Transition of the LO2 Pogo Valves to OPEN, resulting in a loss of LO2 bleed.
   (c) Loss of capability to cycle bistable propellant valves, preventing SSME isolation, LO2 anti-geyser configuration, drain (if TSM is reverted), or ET isolation.

(14) Low: Violation of Acceptance Test Procedure (ATP) allowable indicates regulator setpoint shift, potential impending failure, and unacceptable loss of single-fault tolerance for flight (reference LCC groundrules Paragraph 1.4.B). Opening of LH2 prevalves at T-9.5 seconds will reduce accumulator pressure. If pneumatic crossover valve fails to open at Main Engine Cut Off (MECO) and replenish accumulator pressure, LO2 prevalves will not close within the time required by the engine and uncontained damage may result.

(15) High: Violation of ATP allowable indicates regulator setpoint shift, potential impending failure, and unacceptable loss of single-fault tolerance for flight (reference LCC groundrules Paragraph 1.4.B). Regulator failed open will result in actuation of the relief valve and helium loss requiring isolation of the failed regulator. Opening of the LH2 prevalves at T-9.5 seconds will reduce accumulator pressure. Suspect regulator cannot be relied upon to flow when crew opens isolation valve at MECO-30 seconds. If pneumatic crossover valve fails to open at MECO and replenish accumulator pressure, LO2 prevalves will not close within the time required by the engine and uncontained damage may result.

CAUSES OF EXCEEDING REDLINE:

(16) Minimum: A. Helium regulator malfunction/failure.
B. Relief valve leaks/stuck open.

(17) Maximum: Helium regulator creeps/stuck open.

(18) Instrumentation error.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	psia								
V41P1605A1	4	0	1000					700	810
V41P1650A1	4	0	1000					700	

Pressures listed in the Measurement Information Table are based on generic transducer measurements and will differ slightly based on individual transducer actual curves.

METER/DISPLAY RANGE - MSID: V41P1605A LOW: 0 HIGH: 1000

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.8	SHEET N/A	ZONE F4,S4,
	DWG NO	SHEET	ZONE E4,M4,
	DWG NO	SHEET	ZONE L4,R4
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS72-941099	SHEET 41AN	ZONE
	DWG NO	SHEET 41AT	ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

LCC VIOLATION CALL: MPS LO2 Overboard Bleed Valve (PV19) Position Qualification Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1580X	MPS LO2 Ovbd B/V (PV19) CL Ind A		OFF	NA	Event	CI
V41X1581X	MPS LO2 Ovbd B/V (PV19) CL Ind B		OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 measurements acceptable for confirmed instrumentation loss. (4)
(3) 0 of 2 measurements acceptable for confirmed instrumentation losses. This criteria may be satisfied upon successful completion of a confidence cycle test. (5)

PREPLANNED CONTINGENCY PROCEDURE:

(4) Confirm instrumentation failure of one closed indicator ON by verifying that the redundant closed indicator is OFF, the closing solenoid power (V41X1582E1) and RPC indicators (V76X4178E1 and V76X4179E1) are OFF, and the open indicator (V41X1587E1) is ON. If instrumentation failure is confirmed, that indicator check in the RSLS will be bypassed by issuing the related LPS Bypass Flag (V99X8835X for Ind A or V99X8837X for Ind B) after G1 transition (T-19 minutes). This will change the RSLS closed verification voting logic from 1 of 2 to 1 of 1.
(5) A second instrumentation failure (both closed indicators ON), will be considered acceptable by performing a confidence cycle test during or after LO2 Topping to verify valve function. OMRS requirement S00E00.122 (Safing for loss of LO2 bleed flow) and LCC MPS-24 (Thermal conditioning for interruption of bleed flow) must be observed. After commanding the Overboard Bleed Valve closed, verify that the TSM Eng Bleed Press (GLOP2585A) decreases and the Bleed Valve open indicator (V41X1587E1) goes OFF. After removing the close commands, verify that the TSM Eng Bleed press increases and the Bleed Valve open position indication goes ON. If successful, issue BOTH LPS Bypass Flags after G1 transition (T-19 minutes).

NOTES:

(6) The LO2 Overboard Bleed Valve (PV19) is closed (close commands are activated, valve is normally open) by the RSLS at T-9.4 seconds. The RSLS verifies 1 of 2 closed position indications are ON at T-7 seconds. Since loss of the close position indicator does not meet the criticality requirements of Paragraph 2.2.E, a manual hold will not be called below T-31 seconds.

REDLINE DERIVATION: CRITICALITY: 1R

(7) This SSID verifies that position indicator has not failed prior to usage by a subsequent launch commit criteria. A switch failed in the position required for launch prior to commanding valve to that position will "Deceive" the verifying implementor (i.e., LPS/RSLS) by indicating that the valve did physically transfer to the required position.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Verification of related Launch Commit Criteria utilizing a failed position indicator will be compromised. Loss of redundancy if the valve fails to transfer to the required position.

CAUSES OF EXCEEDING REDLINE:

(9) Valve position indicator (switch) failure.
(10) Data processing system (DPS/LPS) failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

LCC VIOLATION CALL: Orbiter/ET LH2 Disconnect Purge Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41P1977H	LH2 Plate Gap Delta Press No 1L	3	0.026	N/A	psid	CI
V41P1979H	LH2 Plate Gap Delta Press No 2L	of	0.026	N/A	psid	CI
V41P1978H	LH2 Plate Gap Delta Press No 1	4	0.026	N/A	psid	CI
V41P1980H	LH2 Plate Gap Delta Press No 2	(2,3)	0.026	N/A	psid	CI
GLHP5785A	A133020 Orb/ET Carr Plate Press	(3,4)	(5)	350	psig	BU
GLHP5775A	A105977 Orb/ET Carr Plate Press	(3,4)	(5)	350	psig	BU

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 0 of 4 measurements acceptable for confirmed instrumentation failure. (6), (7),(4)
(3) Violations of all minimum pressure readings caused by a complete loss of helium supply for less than 31 cumulative seconds at any point prior to T-31 seconds are acceptable.
(4) For confirmed instrumentation failure of all delta-pressure measurements, use GLHP5785A and GLHP5775A backup measurements. 1 of 2 measurements acceptable for confirmed instrumentation failure. (6)
(5) Supply pressure below 75% of that required to provide 0.5 psid cavity pressure must not be exceeded. Supply pressure versus cavity pressure is determined per OMRSD S00000.032.

PREPLANNED CONTINGENCY PROCEDURE:

(6) Instrumentation failure is confirmed for a measurement indicating off scale high or low, exhibiting a step function change or functioning erratically (inconsistent with other corroborating data). For confirmed instrumentation failure, LCC violation cleared, continue countdown.
(7) For potential instrumentation failure not immediately resolved per (6), corroboration of positive pressure by any of the following indications is satisfactory to confirm instrumentation:
- No change in aft fuselage helium concentration concurrent with anomaly.
- OTV confirmation of active purge.
- Acceptable performance of vent door cycle test per OMRS S00E00.583. (reference S1004)

If any of the above positive pressure checks confirm instrumentation failure, LCC violation cleared, continue countdown.
(8) CAUTION: Cycling the purge OFF then ON should not be performed as it risks ice formation and exposes electrical connectors to low temperatures.

NOTES:

(9) Reference PV&D CIL 01-5-385001-1

REDLINE DERIVATION: CRITICALITY: 1

(10) a. SSID Intent Summary - This requirement assures adequate helium pressure in the Orbiter / ET LH2 umbilical disconnect cavity to prevent ice formation that could affect Orbiter / ET Disconnect actuation or separation and maintain temperatures for the monoball electrical connectors above -150 degrees Fahrenheit. The purge also provides an inert atmosphere to disperse any hydrogen leaking into the cavity and prevents the buildup of oxygen that could allow the hydrogen to ignite. Violations not affecting purge function as verified by parenthetical (2), (3) or (4) are acceptable. The Orbiter / ET LH2 umbilical plate gap purge is zero fault tolerant due to potential ice formation within the cavity and operation of the monoball connectors below their certification limit.

b. Voting Logic - Unconditional acceptance of the first violation is based on an assessment of instrumentation failure as the only credible cause for a single violation out of 4 measurements.

c. Maximum and Minimum Redline Derivation - Minimum redline derivation of the delta pressure measurements is based on the necessity to maintain a positive purge pressure of helium inside the LH2 Orbiter / ET Umbilical Plate Gap Cavity. The redline is derived from the high range delta pressure measurements, as these are lower fidelity than the low range measurements. This ensures a conservative derivation. The maximum redline derivation of the backup measurement is established to protect the structural limits of the LH2 Orbiter / ET Umbilical. The 350 psig requirement was developed during MPTA testing.

Redline development:

Basic Minimum Redline		0.008 psid (positive pressure)
Transducer Error	+	0.010 psid
LPS A/D Error	+	0.008 psid

Redline	=	0.026 psid

Redline development:

Basic Minimum Redline		355 psig
System Error	-	5.0 psig

Redline	=	350 psig

d. Time Effectivity - Ending time effectivity of T-31 seconds was chosen based on the fact that the LH2 ET/Orbiter Disconnect Purge must remain functionally stable until T-31 seconds. Analysis indicates that ice can accumulate if the purge is lost for longer than 31 seconds. Beginning effectivity is based on the need to maintain an inert environment within the LH2 Orbiter / ET Umbilical Plate Gap during cryogenic loading.

e. Requirements - Reference requirement (2), LH2 ET/Orbiter disconnect

REDLINE DERIVATION: (Continued)

purge functionality is retained as long as failure is due to instrumentation only. There are two redundant LH2 ET/Orbiter Plate Gap Delta-pressure Transducers. The signal from each LH2 ET/Orbiter Plate Gap Delta-pressure Transducer is processed through two separate Hardware Interface Module (HIM) Cards providing two measurements for each transducer, a high range and a low range. The V41P1977H and V41P1979H low range measurements have an upper limit of 0.185 psid and a lower limit of -0.185 psid with a bit change of 0.00148 psid. These measurements are specifically designed for cryogenic load operations where the plate gap pressure typically falls from the original set point (0.5 - 0.8 psid) to approximately 0.05 - 0.10 psid. The V41P1978H and V41P1980H high range measurements are processed from the same transducer signal as the low range measurements, but have a higher range and lower fidelity than the low range measurements. The high range measurements have an upper limit of 1.000 psid, lower limit of -1.000 psid and a bit change of 0.008 psid. These measurements are designed for use prior to cryogenic operations when the plate gap pressure is greater than 0.185 psid, however, they do operate in the lower pressure band seen during cryogenic operation and can be used to verify positive plate gap pressure. This is important because two separate HIM Card failures could cause the loss of both low range measurements without affecting these high range measurements.

Reference requirement (3), loss of purge to the ET/Orbiter Plate Gap of less than 31 seconds cumulative will not provide sufficient time for water or N2 ice to form in the cavity and is an acceptable condition.

Reference requirement (4), the GLHP5785A and GLHP5775A backup measurements monitor the GSE supply pressure feeding the plate gap cavity. For instrumentation failures that cause a loss of all the low range and high range measurements, verification that the GSE supply is functional indicates that the plate gap purge supply is being maintained to a plate gap purge system that has already been proven, up to the point of the instrumentation failures, as intact and providing the required purge function.

Reference requirement (5), proper levels of purge flow cannot be assured if the GSE source pressure falls below 75% of the minimum OMRSD set point without the direct monitoring capability provided by the primary measurements.

f. Preplanned Contingency Procedures - These procedures provide means to confirm failure is instrumentation only. Typical instrumentation failure is confirmed for a measurement indicating off scale high or low, exhibiting a step function change, or functioning erratically.

The pressure transducers used to measure the LH2 ET/Orbiter Plate Gap pressure are pressure differential transducers, measuring the difference in pressure between the plate gap and the aft fuselage in order to insure a positive purge of helium within the plate gap. Because of this, a downward drift in one of the transducers can be difficult to identify as an actual failure or simply an instrumentation shift. In order to tell the

REDLINE DERIVATION: (Continued)

difference between a loss of pressure and an instrumentation shift, three methods are available.

First, a loss of helium pressure in the plate gap will also cause a change in aft fuselage helium concentration - helium leaking from the plate gap into the aft fuselage would increase the aft fuselage helium concentration while a leak external to the aft fuselage would decrease it. As other factors can cause a change in aft fuselage helium concentration, expert interpretation of this data by Hazardous Gas Detection System and Main Propulsion System Engineering is required.

Second, any loss of helium pressure in the plate gap would cause a drop in helium exiting from the LH2 ET umbilical purge exit ports. This drop would be readily visible on OTV.

Third, opening one of the aft fuselage vent doors will cause a change in the pressure differential measured by the transducers. This action will cause a drop in the aft fuselage pressure and should result in a corresponding increase on the transducers. Should a transducer not record a pressure increase or gives a reading that is less than the zero point recorded per OMRS S00000.032, the transducer is not functioning properly and its measurements can be considered instrumentation failure.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Buildup of hydrogen gas in the cavity, leading to a potential fire hazard.
(12) Ice formation on the 17" and 4" disconnect mechanisms may prevent the commanded operation (closure) of the valves. These valves are necessary to implement procedures for dealing with fuel leaks and on-pad aborts. In the event of a premature SSME shutdown, closure of the 4" valve is required during ascent to isolate the fuel source from a potential leak. Failure of the 17" valve to close at Orbiter / ET separation could result in re-contact of the orbiter with the ET. Failure to close either the 17" or 4" valves results in loss of helium supply during manifold re-pressurization and possible loss of aft/OMS pods compartment inerting entry purge. Loss of helium supply would result in landing with the LH2 and LO2 manifolds unpressurized, possibly resulting in contamination of the LH2 and LO2 systems.
(13) Exceeding temperature qualification limits of less than -150 degrees Fahrenheit for the Orbiter/ET electrical monoball may cause cracking of the moisture barrier and the dielectric which holds the connector pins in place. This may result in moisture intrusion, connector cracking, and short circuits causing loss or degradation of critical SRB functions (e.g., RGA, ATVC or HPU/MDM power/command failure) or ET functions (e.g., ECO sensors, LL sensors, Pt Sensors, Ullage Press Sensors).
(14) Reference Integrated Hazard Reports IFSI-02 and IMPS-04.

CAUSES OF EXCEEDING REDLINE:

(15) Failure of GSE supply pressure system.
(16) Instrumentation failure.

CAUSES OF EXCEEDING REDLINE: (Continued)

(17) Loss of plate gap integrity, flexhose rupture, or orbiter hard tubing failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	psi	psi	psi						
V41P1977H	0.00148	-0.185	0.185						
V41P1979H	0.00148	-0.185	0.185						
V41P1978H	0.008	-1.000	1.000						
V41P1980H	0.008	-1.000	1.000						
GLHP5785A	4.0	0	1000						
GLHP5775A	4.0	0	1000						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

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LCC VIOLATION CALL: MPS LO2 Outboard Fill and Drain Valve (PV9) Open and Close Power Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1507E	MPS LO2 Otbd F/D Vlv Cl Pwr (LV29)	(3,5)	OFF	NA	Event	CI
V41X1508E	MPS LO2 Otbd F/D Vlv Op Pwr (LV28)	(2,3)	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to LO2 Outboard Fill and Drain Valve commanded closed (approximately T-48 seconds)

REQUIREMENTS: FIGURES/TABLES: MPS-49.1

(2) Valve Open Power failed OFF acceptable for confirmed instrumentation failure. (4)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Caution: Do not establish a configuration that could allow the Outboard Fill and Drain Valve (PV9) to be cycled closed. With either Open Power failed OFF or Close Power failed ON, a closed Outboard Fill and Drain Valve would prohibit LO2 drain.

(4) If Valve Open Power failed OFF, then perform steps per Figure MPS-49.1. If instrumentation failure is confirmed, LCC violation cleared, continue countdown.

(5) If Valve Close Power failed ON, then LCC violation confirmed, No Go for launch. Perform safing as follows:
   a. If prior to Replenish, then perform Stop Flow.
   b. Set Close Inhibit Command to ON.
      PV9 Close Inhibit Command - V41K1518N
   c. Perform bite test 4 on Close Command.
      PV9 Close Command - V41K1515X
   d. Set Close Command to OFF.
   e. Inhibit command issuance on Open Power Command.
      PV9 Open Power Command - V41K1518X

NOTES:

(6) LO2 Outboard Fill and Drain Valve transition from Closed position to Open position is verified by OMRS requirement S00FD0.062 at the beginning of Cryo Loading.

REDLINE DERIVATION: CRITICALITY: 1R

(7) a. SSID Intent Summary - The MPS LO2 Outboard Fill and Drain Valve Open and Close power indicators are a means of determining if the Open and Close commands for the valve are indicating ON or OFF and that proper controlling pneumatics is applied to the valve. The MPS LO2 Outboard Fill and Drain Valve is the interface between the ground and the orbiter

REDLINE DERIVATION: (Continued)

LO2 Fill and Drain Line and must remain open throughout loading operations. During LO2 Terminate replenish the orbiter LO2 Fill and Drain Line and the LO2 TSM lines are drained of propellant. The Outboard Fill and Drain Valve must remain open to ensure LO2 is not trapped between the Inboard and Outboard Fill and Drain Valves. The Outboard Fill and Drain Valve is commanded close at the completion of the fill line drain at T-48 seconds and provides redundant isolation with the LO2 Inboard Fill and Drain Valve against overboard loss of propellant during ascent. Controlling pneumatics for the LO2 Outboard Fill and Drain valve is single fault tolerant as the valve is bi-stable, requiring Open pneumatics to be removed and Close pneumatics to be applied for the valve to cycle closed.

b. Voting Logic - N/A.

c. Maximum and Minimum Redline Derivation - When the LO2 Outboard Fill and Drain Valve is open, the Valve Close Power should indicate OFF and the Valve Open Power should indicate ON. If the valve is cycled closed with either controlling pneumatics failed to the opposite state, the ability to reopen the valve would be lost. This requirement will ensure the capability of the LO2 Outboard Fill and Drain Valve to cycle open in support of drain ops in the event of a launch scrub or abort after the valve is closed at T-48 seconds.

d. Time Period - The time period effectivity for this SSID is from the Start of ET Cryo Tanking to LO2 Outboard Fill and Drain Valve closure at approximately T-48 seconds.

e. Requirements - Valve Open Power indication failed OFF is acceptable for confirmed instrumentation failure as functionality of controlling Open pneumatics may be verified by an alternate means. Instrumentation failure may be verified by setting the Open Command OFF, observing a concurrent increase in aft fuselage helium concentration, setting the Open Command to ON and observing a concurrent demand on the MPS pneumatic regulator outlet pressure.

f. Preplanned Contingency Procedure - For Valve Open Power indication failed OFF, reference Figure MPS-49.1 for steps to confirm instrumentation failure and provide safing should troubleshooting fail to clear the violation. Initial steps safe the LO2 system by performing Stop Flow, if prior to Replenish, and inhibiting command issuance on the valve's Close Command. Stop Flow is performed to reduce the LO2 flow rate. In replenish the LO2 flow rate is already reduced. A helium spike concurrent with loss of Valve Open Power ON indication is monitored to determine if the actuator vented. A Bite Test 4 is performed to determine the state of the Open Command.

If the Open Command indicates ON, instrumentation failure may be verified by setting the Open Command to OFF, observing a concurrent helium spike in the aft fuselage, setting the Open Command to ON and observing a concurrent demand on the MPS pneumatic regulator outlet

REDLINE DERIVATION: (Continued)

pressure. If that is successful, command issuance on valve's Close Command will be activated. Instrumentation failure confirmed, LCC violation cleared, continue countdown.

If the Open Command indicates OFF, the Open Command will be commanded to ON in an attempt to reacquire the Open Power for a safer configuration to support drain. LCC violation confirmed, No Go for launch.

For Valve Close Power indication failed ON preplanned contingency steps are to provide safing only. Initial steps safe the LO2 system by performing Stop Flow, if prior to Replenish, and setting the Close Inhibit Command to ON. Stop Flow is performed to reduce the LO2 flow rate. In replenish the LO2 flow rate is already reduced. A Bite Test 4 is performed to determine the state of the Close Command. The Close Command will be set to OFF and command issuance will be inhibited for the Open Power Command to ensure a safe configuration for drain operations. LCC violation confirmed, No Go for launch.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Failure of the LO2 Outboard Fill and Drain Valve to open for a scrub or abort would prevent LO2 drain operations and could lead to ET isolation should LO2 bleed be compromised.

CAUSES OF EXCEEDING REDLINE:

(9) Instrumentation failure.
(10) Driver failure.
(11) Inadvertent command set to ON or OFF.
(12) Panel R4 Propellant Fill/Drain LO2 Outboard switch incorrectly positioned or failed.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.11 SHEET N/A ZONE B6,C4
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS72-941099 SHEET 41L ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

SUPPORTING DATA:

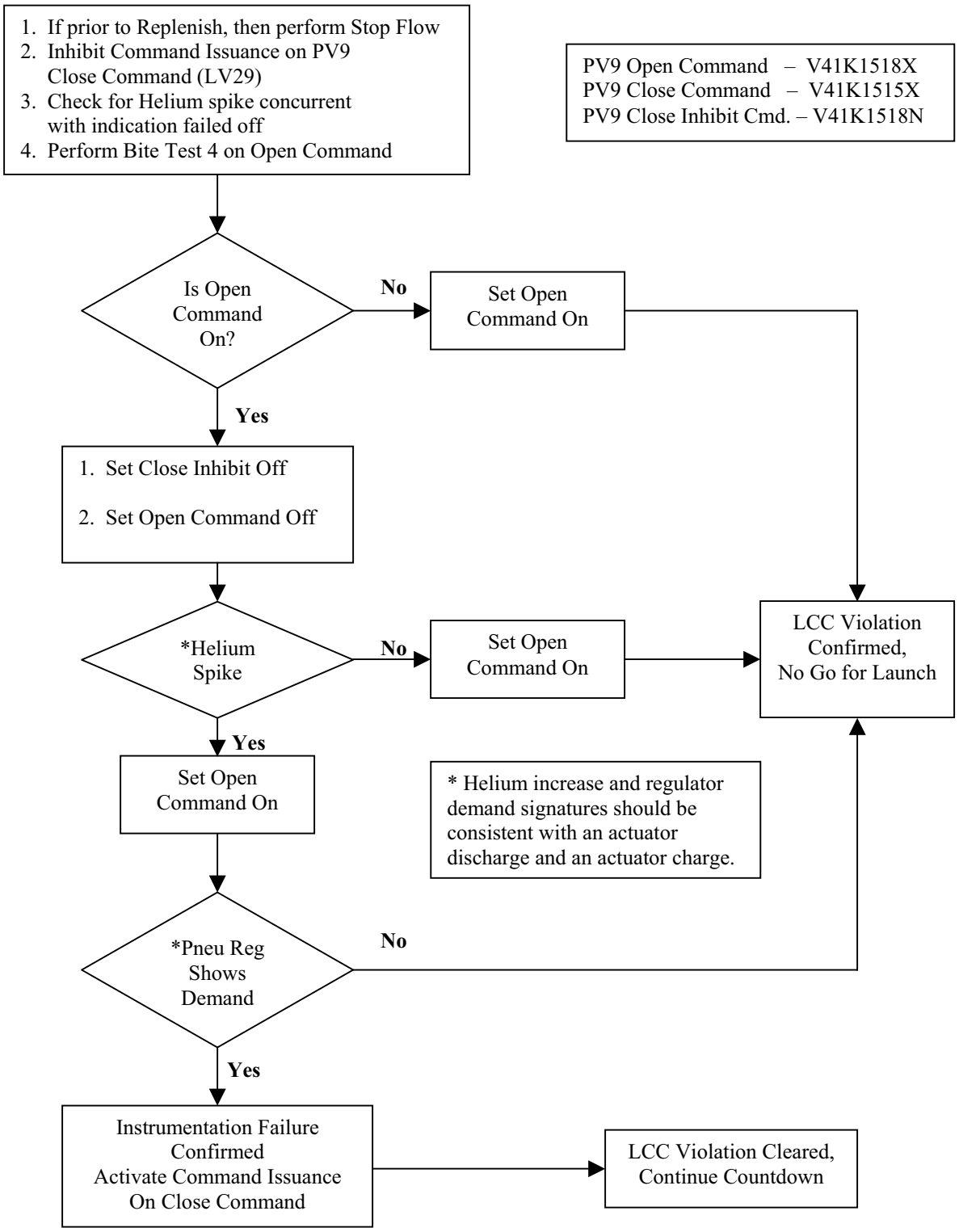

Figure MPS-49.1 – LO2 Outboard Fill and Drain Valve (PV9) Open Power Failed Off Anomaly

LCC VIOLATION CALL: MPS LO2 Inboard Fill and Drain Valve (PV10) Open and Close Power Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1505E	MPS LO2 Inbd F/D Vlv Cl Pwr (LV31)	(3,5)	OFF	NA	Event	CI
V41X1506E	MPS LO2 Inbd F/D Vlv Op Pwr (LV30)	(2,3)	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to LO2 Terminate Replenish (approximately T-4 minutes, 55 seconds)

REQUIREMENTS: FIGURES/TABLES: MPS-50.1

(2) Valve Open Power failed OFF acceptable for confirmed instrumentation failure. (4)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Caution: Do not establish a configuration that could allow the Inboard Fill and Drain Valve (PV10) to be cycled closed. With either Open Power failed OFF or Close Power failed ON, a closed Inboard Fill and Drain Valve would prohibit LO2 drain. Valve cycling in support of critical operations (i.e. LO2 Revert) does not constitute a violation.

(4) If Valve Open Power failed OFF, then perform steps per Figure MPS-50.1. If instrumentation failure is confirmed, then LCC violation cleared, continue countdown.

(5) If Valve Close Power failed ON, then LCC violation confirmed, No Go for launch. Perform safing as follows:
   a. If prior to Replenish, then perform Stop Flow.
   b. Set Close Inhibit Command to ON.
      PV10 Close Inhibit Command - V41K1503N
   c. Perform bite test 4 on Close Command.
      PV10 Close Command - V41K1512X
   d. Set Close Command to OFF.
   e. Inhibit command issuance on Open Power Commands.
      PV10 Open Power Commands - V41K1501X and V41K1502X

NOTES:

(6) LO2 Inboard Fill and Drain Valve is verified Open by OMRS requirement S00FD0.062 at the beginning of Cryo Loading.

REDLINE DERIVATION: CRITICALITY: 1R

(7) a. SSID Intent Summary - The MPS LO2 Inboard Fill and Drain Valve Open and Close Power indicators are a means of determining if the Open and Close Commands for the valve are indicating ON or OFF and that proper controlling pneumatics is applied to the valve. The MPS LO2 Inboard Fill and Drain Valve separates the LO2 Feed System from the LO2 Fill and

REDLINE DERIVATION: (Continued)

Drain Line. The valve is open throughout LO2 loading operations and is commanded closed during Terminate Replenish at approximately T-4 minutes 48 seconds. Once closed the LO2 Fill and Drain Line and the LO2 TSM lines are drained of propellant. The LO2 Inboard Fill and Drain Valve must be verified closed to provide isolation during fill line drain and to provide redundant (with Outboard Fill and Drain Valve) isolation against overboard loss of propellant during ascent. A Valve Close Power indication failed ON or Valve Open Power indication failed OFF would prevent opening the valve in the event of a scrub or abort, preventing LO2 drain. Controlling pneumatics for the LO2 Inboard Fill and Drain Valve is single fault tolerant as the valve is bi-stable, requiring Open pneumatics to be removed and Close pneumatics to be applied for the valve to cycle closed.

b. Voting Logic - N/A.

c. Maximum and Minimum Redline Derivation - When the LO2 Inboard Fill and Drain Valve is open the Valve Close Power indicator should indicate OFF and the Valve Open Power should indicate ON. If the valve is cycled closed with either controlling pneumatics failed to the opposite state, the ability to reopen the valve would be lost. This requirement will ensure the capability of the LO2 Inboard Fill and Drain Valve to cycle open in support of drain ops in the event of a launch scrub or abort after the valve is closed at T-4 minutes 48 seconds.

d. Time Period - The time period effectivity for this SSID is from the Start of ET Cryo Tanking to LO2 Terminate Replenish at approximately T-4 minutes 55 seconds. LO2 Terminate Replenish was chosen because LO2 auto load software sequencing makes implementation at this milestone more efficient than at valve closure.

e. Requirements - Valve Open Power indication failed OFF is acceptable for confirmed instrumentation failure as functionality of controlling Open pneumatics may be verified by an alternate means. Instrumentation failure may be verified by setting the Open Commands to OFF, observing a concurrent increase in aft fuselage helium concentration, setting the Open Commands back to ON and observing a concurrent demand on the MPS pneumatic regulator outlet pressure.

f. Preplanned Contingency Procedure - For Valve Open Power indication failed OFF, reference Figure MPS-50.1 for steps to confirm instrumentation failure and provide safing should troubleshooting fail to clear the violation. Initial steps safe the LO2 system by performing Stop Flow, if prior to Replenish, and inhibiting command issuance on the valve's Close Command. Stop Flow is performed to reduce the LO2 flow rate. In replenish the LO2 flow rate is already reduced. A helium spike concurrent with loss of Valve Open Power ON indication is monitored to determine if the actuator vented. A Bite Test 4 is performed to determine the state of the Open Commands.

If the Open Commands indicate ON, instrumentation failure may be

REDLINE DERIVATION: (Continued)

verified by setting the Open Commands to OFF, observing a concurrent helium spike in the aft fuselage, setting the Open Commands to ON and observing a concurrent demand on the MPS pneumatic regulator outlet pressure. If that is successful, command issuance on valve's Close Command will be activated. Instrumentation failure confirmed, LCC violation cleared, continue countdown.

If the Open Commands indicate OFF, the Open Commands will be commanded to ON on in an attempt to reacquire the Open Power for a safer configuration to support drain. LCC violation confirmed, No Go for launch.

For Valve Close Power indication failed ON, preplanned contingency steps are to provide safing only. Initial steps safe the LO2 system by performing Stop Flow, if prior to Replenish, and setting the Close Inhibit Command to ON. Stop Flow is performed to reduce the LO2 flow rate. In replenish the LO2 flow rate is already reduced. A Bite Test 4 is performed to determine the state of the Close Command. The Close Command will be set to OFF and command issuance will be inhibited for the Open Power Commands to ensure a safe configuration for drain operations. LCC violation confirmed, No Go for launch.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Failure of the LO2 Inboard Fill and Drain Valve to open for a scrub or abort would prevent LO2 drain operations and could lead to ET isolation should LO2 bleed be compromised.

CAUSES OF EXCEEDING REDLINE:

(9) Instrumentation failure.
(10) Driver failure.
(11) Inadvertent command set to ON or OFF.
(12) Panel R4 Propellant Fill/Drain LO2 Inboard switch incorrectly positioned or failed.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.11	SHEET N/A	ZONE C6,C5
	DWG NO	SHEET	ZONE D5
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS72-941099	SHEET 41N	ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

SUPPORTING DATA:

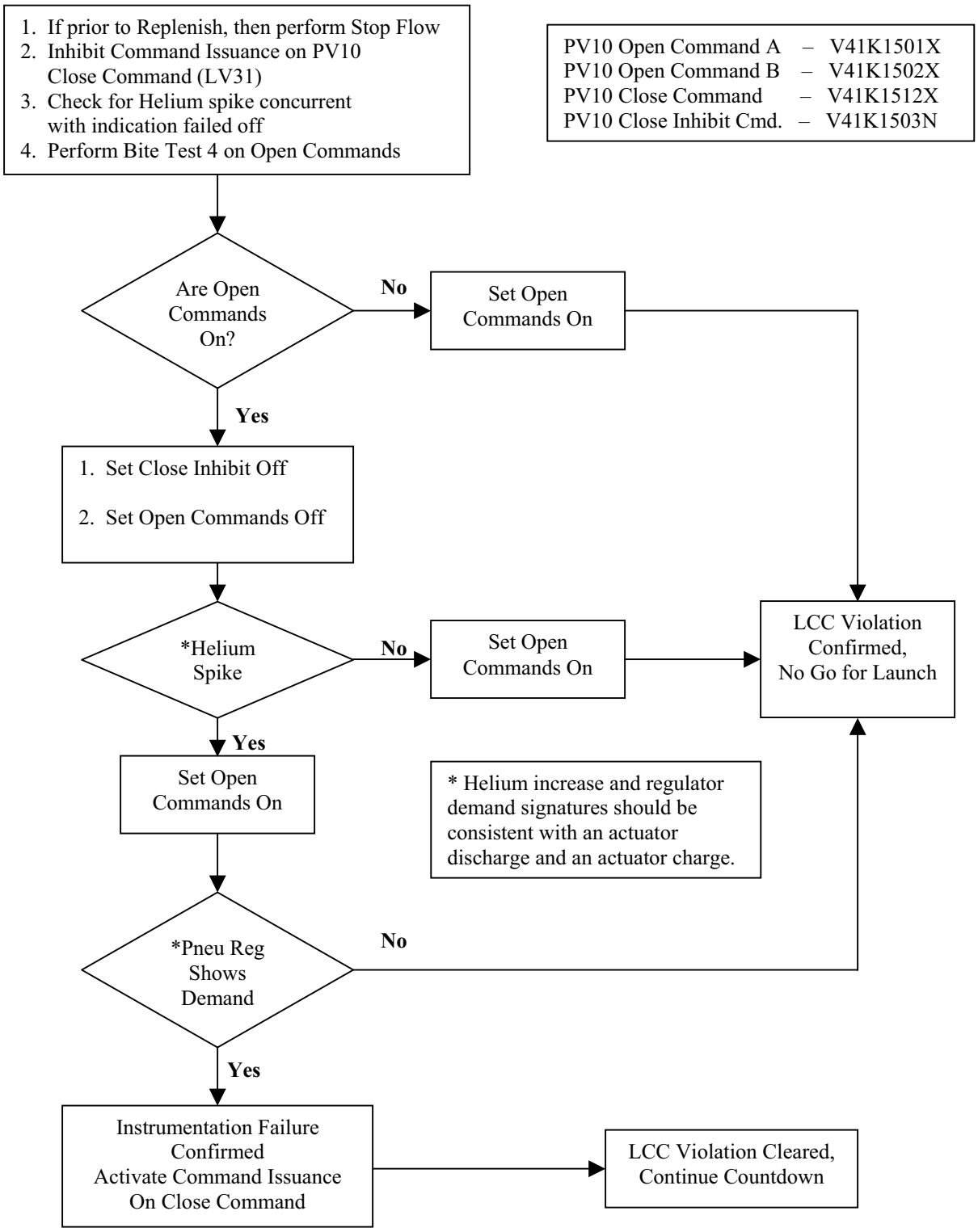

Figure MPS-50.1 – LO2 Inboard Fill and Drain Valve (PV10) Open Power Failed Off Anomaly

LCC VIOLATION CALL: MPS LH2 Outboard Fill and Drain Valve (PV11) Open and Close Power Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1385E	MPS LH2 Otbd F/D Vlv Cl Pwr (LV33)	(3,5)	OFF	NA	Event	CI
V41X1386E	MPS LH2 Otbd F/D Vlv Op Pwr (LV32)	(2,3)	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to LH2 Outboard Fill and Drain Valve commanded closed (approximately T-48 seconds)

REQUIREMENTS: FIGURES/TABLES: MPS-51.1

(2) Valve Open Power failed OFF acceptable for confirmed instrumentation failure. (4)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Caution: Do not establish a configuration that could allow the Outboard Fill and Drain Valve (PV11) to be cycled closed. With either Open power failed OFF or Close power failed ON, a closed Outboard Fill and Drain Valve would prohibit LH2 drain.

(4) If Valve Open Power failed OFF, then perform steps per Figure MPS-51.1. If instrumentation failure is confirmed, then LCC violation cleared, continue countdown.

(5) If Valve Close Power failed ON, then LCC violation confirmed, No Go for launch. Perform safing as follows:
   a. If prior to Replenish, then perform stop flow.
   b. Set Close Inhibit Command to ON.
      PV11 Close Inhibit Command - V41K1391N
   c. Perform bite test 4 on Close Command.
      PV11 Close Command - V41K1393X
   d. Set Close Command to OFF.
   e. Inhibit command issuance on Open Power Command.
      PV11 Open Power Command - V41K1391X

NOTES:

(6) LH2 Outboard Fill and Drain Valve transition from Closed position to Open position is verified by OMRS requirement S00FE0.111 at the beginning of Cryo Loading.

REDLINE DERIVATION: CRITICALITY: 1R

(7) a. SSID Intent Summary - The MPS LH2 Outboard Fill and Drain Valve Open and Close Power indicators are a means of determining if the Open and Close Commands for the valve are indicating ON or OFF and that proper controlling pneumatics is applied to the valve. The MPS LH2 Outboard Fill and Drain Valve is the interface between the ground and the orbiter

REDLINE DERIVATION: (Continued)

LH2 Fill and Drain Line. The valve is open throughout LH2 loading operations. During LH2 Terminate Replenish the orbiter LH2 Fill and Drain Line and the LH2 TSM lines are drained of propellant. The Outboard Fill and Drain Line must remain open during this time to ensure LH2 is not trapped between the Inboard and Outboard Fill and Drain Valves. The Outboard Fill and Drain Valve is commanded close at the completion of the fill line drain at T-48 seconds and provides redundant isolation with the LH2 Inboard Fill and Drain Valve and the LH2 Topping Valve against overboard loss of propellant during ascent. A Valve Close Power indicator failed ON or Valve Open Power failed OFF would prevent opening the valve in the event of a scrub or abort, preventing LH2 topping line drain and subsequent ET LH2 drain. Controlling pneumatics for the LH2 Outboard Fill and Drain Valve is single fault tolerant as the valve is bi-stable, requiring Open pneumatics to be removed and Closing pneumatics to be applied for the valve to cycle closed.

b. Voting Logic - N/A.

c. Maximum and Minimum Redline Derivation - When the LH2 Outboard Fill and Drain Valve is open the Valve Close Power should indicate OFF and the Valve Open Power should indicate ON. If the valve is cycled closed with either controlling pneumatics failed to the opposite state, the ability to reopen the valve would be lost. This requirement will ensure the capability of the LH2 Outboard Fill and Drain Valve to cycle open in support of drain ops in the event of a launch scrub or abort after the valve is closed at T-48 seconds.

d. Time Period - The time period effectivity for this SSID is from the Start of ET Cryo Tanking to LO2 Inboard Fill and Drain Valve closure at approximately T-48 seconds.

e. Requirements - Valve Open Power indication failed OFF is acceptable for confirmed instrumentation failure as functionality of controlling Open pneumatics may be verified by an alternate means. Instrumentation failure may be verified by setting the Open Command to OFF, observing a concurrent increase in aft fuselage helium concentration, setting the Open Command back to ON and observing a concurrent demand on the MPS pneumatic regulator outlet pressure.

f. Preplanned Contingency Procedure - For Valve Open Power indication failed OFF, reference Figure MPS-51.1 for steps to confirm instrumentation failure and provide safing should troubleshooting fail to clear the violation. Initial steps safe the LH2 system by performing Stop Flow, if prior to Replenish, and inhibiting command issuance on the valve's Close Command. Stop Flow is performed to reduce the LH2 flow rate. In replenish the flow rate is already reduced. A helium spike concurrent with loss of Valve Open Power ON indication is monitored to determine if the actuator vented. A Bite Test 4 is performed to determine the state of the Open Command.

If the Open Command indicates ON, instrumentation failure may be

REDLINE DERIVATION: (Continued)

verified by setting the Open Command to OFF, observing a concurrent helium spike in the aft fuselage, setting the Open Command to ON and observing a concurrent demand on the MPS pneumatic regulator outlet pressure. If that is successful, command issuance on valve's Close Command will be activated. Instrumentation failure confirmed, LCC violation cleared, continue countdown.

If the Open Command indicates OFF, the Open Command will be commanded to ON in an attempt to reacquire the Open Power for a safer configuration to support drain. LCC violation confirmed, No Go for launch.

For Valve Close Power indication failed ON, preplanned contingency steps are to provide safing only. Initial steps safe the LH2 system by performing Stop Flow, if prior to Replenish, and setting the Close Inhibit Command to ON. Stop Flow is performed to reduce the LH2 flow rate. In replenish the LH2 flow rate is already reduced. A Bite Test 4 is performed to determine the state of the Close Command. The Close Command will be set to OFF and command issuance will be inhibited for the Open Power Command to ensure a safe configuration for drain operations. LCC violation confirmed, No Go for launch.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Failure of the LH2 Outboard Fill and Drain Valve to open for a scrub or abort would prevent LH2 drain operations.

CAUSES OF EXCEEDING REDLINE:

(9) Instrumentation failure.
(10) Driver failure.
(11) Inadvertent command set to ON or OFF.
(12) Panel R4 Propellant Fill/Drain LH2 Outboard switch incorrectly positioned or failed.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.12 SHEET N/A ZONE B6,B5
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS72-941099 SHEET 41L ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

SUPPORTING DATA:

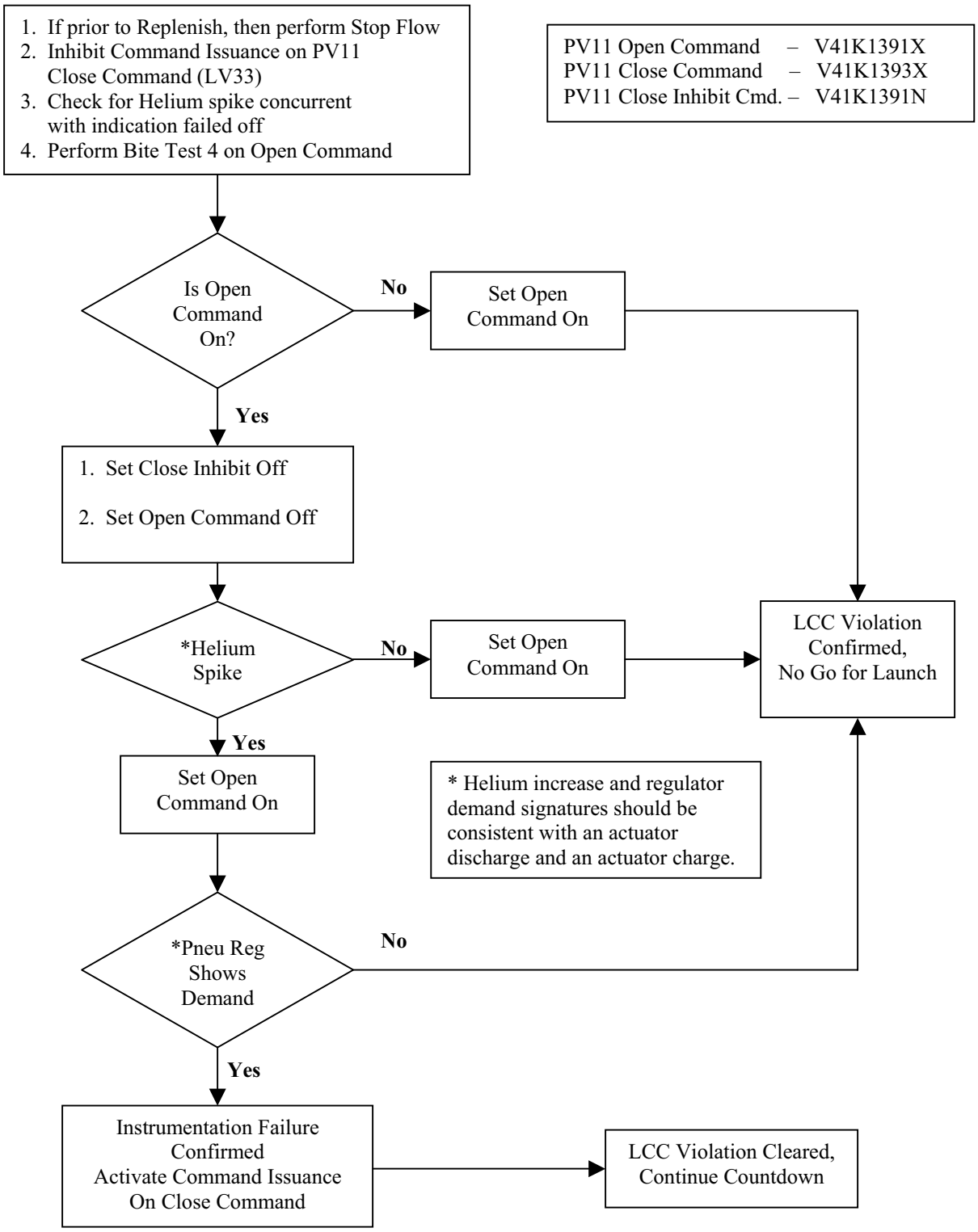

Figure MPS-51.1 – LH2 Outboard Fill and Drain Valve (PV11) Open Power Failed Off Anomaly

LCC VIOLATION CALL: MPS LH2 Inboard Fill and Drain Valve (PV12) Open and Close Power Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V41X1405E	MPS LH2 Inbd F/D Vlv Cl Pwr (LV35)	(3,5)	OFF	NA	Event	CI
V41X1406E	MPS LH2 Inbd F/D Vlv Op Pwr (LV34)	(2,3)	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to LH2 Inboard Fill and Drain Valve commanded closed at Start of Reduced Fast Fill (approximately T-4 hours, 30 minutes)

REQUIREMENTS: FIGURES/TABLES: MPS-52.1

(2) Vlv Op Pwr failed OFF acceptable for confirmed instrumentation failure. (4)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Caution: Do not establish a configuration that could allow the Inboard Fill and Drain Valve (PV12) to be cycled closed. With either Open Power failed OFF or Close Power failed ON, a closed Inboard Fill and Drain Valve would prohibit LH2 drain (a partial, unfiltered drain would be possible through the topping line). Valve cycling in support of critical operations (i.e. LH2 Revert) does not constitute a violation.

(4) If Valve Open Power failed OFF, then perform steps per Figure MPS-52.1. If instrumentation failure is confirmed, then LCC violation cleared, continue countdown.

(5) If Valve Close Power failed ON, then LCC violation confirmed, No Go for launch. perform safing as follows:
   a. Perform stop flow.
   b. Set Close Inhibit Command to ON.
      PV12 Close Inhibit Command - V41K1403N
   c. Perform bite test 4 on Close Command.
      PV12 Close Command - V41K1412X
   d. Set Close Command to OFF.
   e. Inhibit command issuance on Open Power Commands
      PV12 Open Power Commands - V41K1401X and V41K1402X

NOTES:

(6) LH2 Inboard Fill and Drain Valve is verified Open by OMRS requirement S00FB0.090-B at the beginning of Cryo Loading.

REDLINE DERIVATION: CRITICALITY: 1R

(7) a. SSID Intent Summary - The MPS LH2 Inboard Fill and Drain Valve Open and Close Power indicators are a means of determining if the Open and Close commands for the valve are indicating ON or OFF and that proper controlling pneumatics is applied to the valve. The MPS LH2 Inboard

REDLINE DERIVATION: (Continued)

Fill and Drain Valve is used to isolate the LH2 Feed System from the ground during LH2 Terminate Replenish. The valve is commanded closed at the beginning of reduced fast fill (approximately T-4 hours, 30 minutes). A Closed Power indication failed ON or Open Power indication failed OFF would prevent opening the valve in the event of a scrub or abort, preventing nominal LH2 drain. A partial, unfiltered drain would still be possible through the topping line. Controlling pneumatics for the LH2 Inboard Fill and Drain Valve is single fault tolerant as the valve is bi-stable, requiring Open pneumatics to be removed and Closing pneumatics to be applied for the valve to cycle closed.

b. Voting Logic - N/A.

c. Maximum and Minimum Redline Derivation - When the LH2 Inboard Fill and Drain Valve is open the Valve Close Power should indicate OFF and the Valve Open Power should indicate ON. If the valve is cycled closed with either controlling pneumatics failed to the opposite state, the ability to reopen the valve would be lost. This requirement will ensure the capability of the LH2 Inboard Fill and Drain Valve to cycle open in support of drain ops in the event of a launch scrub or abort after the valve is closed at approximately T-4 hours, 30 minutes.

d. Time Period - The time period effectivity for this SSID is from the Start of ET Cryo Tanking to LH2 Inboard Fill and Drain Valve closure at approximately T-4 hours 30 minutes.

e. Requirements - Valve Open Power indication failed OFF is acceptable for confirmed instrumentation failure as functionality of controlling Open pneumatics may be verified by an alternate means. Instrumentation failure may be verified by setting the Open Commands to OFF, observing a concurrent increase in aft fuselage helium concentration, setting the Open Commands back to ON and observing a concurrent demand on the MPS pneumatic regulator outlet pressure.

f. Preplanned Contingency Procedure - For Valve Open Power indication failed OFF, reference Figure MPS-52.1 for steps to confirm instrumentation and provide safing should troubleshooting fail to clear the violation. Initial steps safe the LH2 system by performing Stop Flow and inhibiting command issuance on the valve's Close Command. Stop Flow is performed to reduce the LH2 flow rate. A helium spike concurrent with loss of Valve Open Power ON indication is monitored to determine if the actuator vented. A Bite Test 4 is performed to determine the state of the Open Commands.

If the Open Commands indicate ON, instrumentation failure may be verified by setting the Open Commands to OFF, observing a concurrent helium spike in the aft fuselage, setting the Open Commands to ON and observing a concurrent demand on the MPS pneumatic regulator outlet pressure. If that is successful, command issuance on valve's Close Command will be activated. Instrumentation failure confirmed, LCC violation cleared, continue countdown.

REDLINE DERIVATION: (Continued)

If the Open Commands indicate OFF, the Open Commands will be commanded to On in an attempt to reacquire the Open Power for a safer configuration to support drain. LCC violation confirmed, No Go for launch.

For Valve Close Power indication failed ON preplanned contingency steps are to provide safing only. Initial steps safe the LH2 system by performing Stop Flow and setting the Close Inhibit Command to ON. Stop Flow is performed to reduce the LH2 flow rate. A Bite Test 4 is performed to determine the state of the Close Command. The Close Command will be set to OFF and command issuance will be inhibited for the Open Power Commands to ensure a safe configuration for drain operations. LCC violation confirmed, No Go for launch.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Failure of the LH2 Inboard Fill and Drain Valve to open for a scrub or abort would prevent nominal LH2 drain operations. A partial unfiltered drain would be possible through the topping line.

CAUSES OF EXCEEDING REDLINE:

(9) Instrumentation failure.
(10) Driver failure.
(11) Inadvertent command set to ON or OFF.
(12) Panel R4 Propellant Fill/Drain LH2 Inboard switch incorrectly positioned or failed.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.12	SHEET N/A	ZONE D6,D5
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS72-941099	SHEET 41M	ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

SUPPORTING DATA:

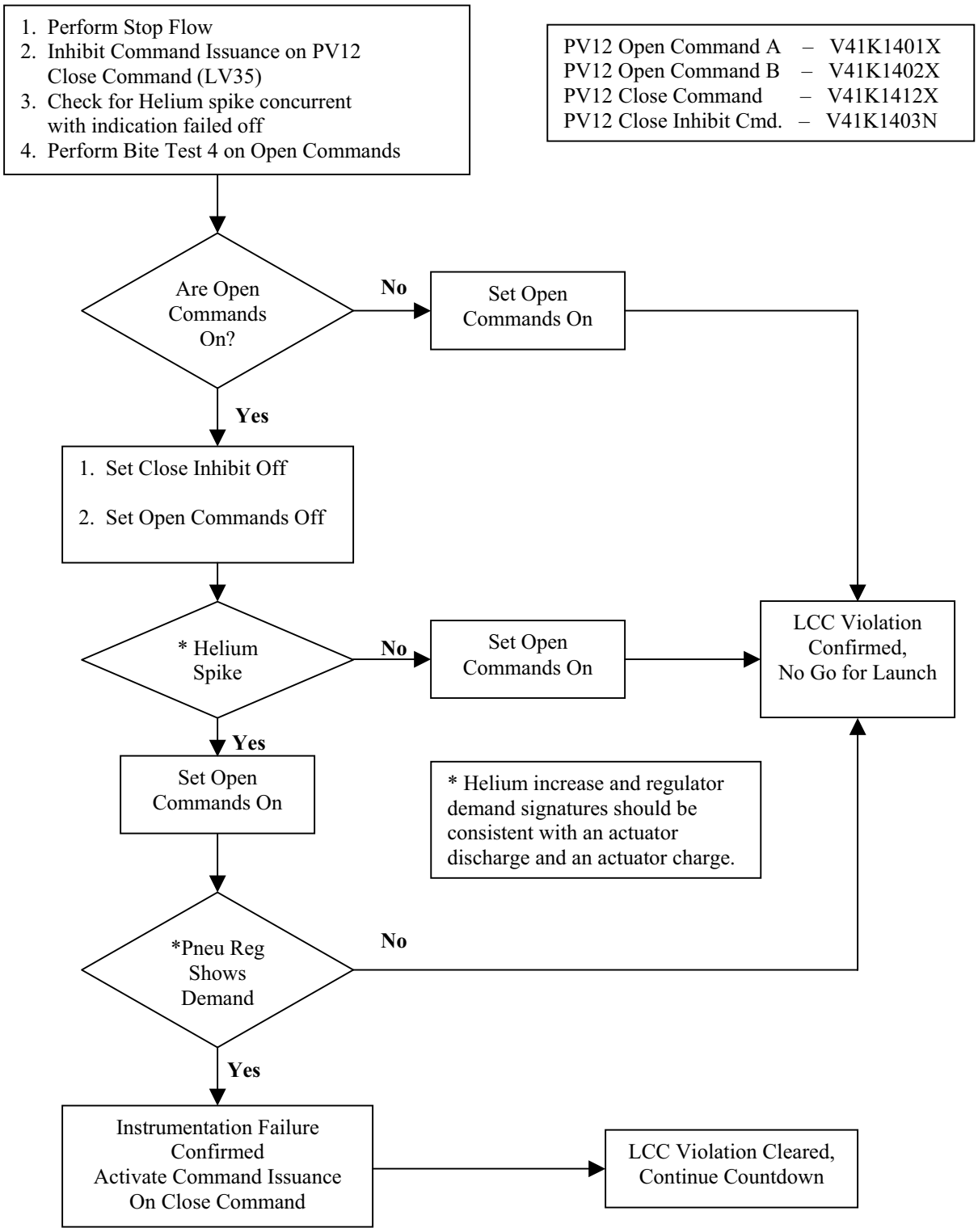

Figure MPS-52.1 – LH2 Inboard Fill and Drain Valve (PV12) Open Power Failed Off Anomaly

LCC VIOLATION CALL: MPS LH2 Low Level Sensor Voltage Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
T41V1930A	ET-LH2 LLCO SENSOR NO 1 VOLT	3	N/A	13.1	Vdc	CI
T41V1931A	ET-LH2 LLCO SENSOR NO 2 VOLT	of	N/A	13.1	Vdc	CI
T41V1932A	ET-LH2 LLCO SENSOR NO 3 VOLT	4	N/A	13.1	Vdc	CI
T41V1933A	ET-LH2 LLCO SENSOR NO 4 VOLT		N/A	13.1	Vdc	CI

TIME PERIOD:

(1) From final removal of ECO SIM Commands (applied per OMRS during T-9 minute hold) to Go For RSLS Start (T-31 seconds). (2)

REQUIREMENTS: FIGURES/TABLES:

(2) This SSID is not applicable if all 4 LH2 Liquid Level Cut-Off (LLCO) sensor circuits are functional (i.e., all 4 discretes have passed all associated OMRS checkout criteria prior to the beginning effectivity of this SSID).
(3) Any voltage measurement associated with a sensor circuit that has been previously determined to be failed based on discretes (ref. all associated File II OMRS and SSID MPS-22), is considered to be failed regardless of its value.
(4) 0 of 4 voltage measurements acceptable for confirmed instrumentation failure. (5,6) Instrumentation failure does not need to be reverified by this SSID if it was previously verified by File II OMRS.

PREPLANNED CONTINGENCY PROCEDURE:

(5) Any voltage measurement greater than 16 Vdc is greater than the maximum output capability of the Point Sensor Electronics Box (PSEB) and confirms instrumentation failure. No other verification is required. LCC violation cleared, continue countdown.
(6) To confirm instrumentation failure not verified by (5):
- Set Sim (All) Dry Command (V41K0021NL) and all four Sim Wet Commands (V41K0022NL, V41K0023NL, V41K0024NL and V41K0031NL) ON.
- Verify that all 3 LH2 LLCO sensor circuit discrete measurements that were not previously identified as failed per OMRS checkout prior to the beginning effectivity of this SSID transition to DRY. Discrete measurement MSIDs - T41X1730X1, T41X1731X1, T41X1732X1 and T41X1733X1.
- Any LH2 LLCO sensor circuit that has been previously determined to be failed based on discretes is still considered to be failed regardless of its voltage or discrete values during the preplanned contingency.
- Voltage violation must be present throughout the time the preplanned contingency procedure is run in order to confirm instrumentation failure.
- Remove simulated commands and verify all discretes indicate WET.

If successful, LCC violation cleared, continue countdown.

NOTES:

(7) Troubleshooting performed per (6) would also detect any failed LO2 Engine Cutoff Sensor circuit which would result in a failure of OMRS S00000.065 and MPS-21 for the LO2 Engine Cutoff system.
(8) The measurements monitored by this SSID utilize a Non-Flight Critical MDM (OI MDM).

REDLINE DERIVATION: CRITICALITY: 1R

(9) a. SSID Intent Summary - Sensors provide engine cutoff for low liquid hydrogen level. Once circuits are armed in flight, two unbypassed dry indications will initiate an all engine shutdown. A functioning SSME Low Level Cutoff capability is required as a backup to the SSME programmed velocity cutoff cue to protect against SSME propellant depletion. Monitoring of the LH2 Voltage measurements allows insight into the health of the LH2 LLCO System once the system is configured for flight during the T-9 minute hold. Most probable sensor circuit failure is failed WET. The LH2 LLCO System is triple fault tolerant, allowing for two LLCO sensor circuits to fail as well as requiring a propellant system depletion failure to drive the need for a LH2 low level cutoff. If LLCO protection is lost due to failed WET circuits, power supply failures, or DSC/MDM failures, then a propellant depletion scenario results in loss of crew or vehicle.

b. Voting Logic - 3 of 4 sensor circuits functional provides adequate redundancy because 2 additional failures are required before the LH2 Low Level Cutoff capability is impacted.

c. Maximum and Minimum Redline Derivation - A sensor circuit failed to the WET (pass) state after the Sim Wet and Dry commands are removed during the T-9 minute hold is only detectable using voltage measurements. If a voltage measurement fails to ~14 Vdc, then the LH2 LLCO sensor circuit could be failed indicating an open circuit in the system somewhere between the sensors in the ET and the splices where voltage instrumentation is connected (e.g., Orbiter wiring, monoballs, and External Tank). For this open-circuit condition, the lowest voltage expected is 13.44 Vdc. The following table shows the maximum redline development.

Basic Redline	13.440 Vdc
Inst. Accuracy (0.84% of value)	-0.113 Vdc
Round down to nearest bit	13.312 Vdc
1 bit flip below accuracy	-0.128 Vdc
Max Allowable	13.184 Vdc
LPS Implementation Truncation	13.1 Vdc

The minimum redline is N/A as the open circuit failure being screened for does not have a lower limit.

d. Time Effectivity - Due to OMRSD checkout requirements, the LCC monitoring start time begins with the final removal of the ECO Sim

REDLINE DERIVATION: (Continued)

Commands during the T-9 minute hold. The ending effectivity of T-31 sec was chosen because it captures the last dynamic change to the LH2 system prior to launch, LH2 Pre-Press (T-1:57). Voltages within limits on the 3 working circuits provide confidence that the prior circuit failure is a single, independent event.

e. Requirements - The purpose of monitoring the LH2 ECO voltage measurements during this timeframe is to determine the health of the LH2 LLCO sensor circuit discrete measurements after the system has been manipulated for the last time before flight. Any voltage measurement corresponding to a failed sensor circuit must be considered an exceedence of the LCC limit regardless of its voltage reading. 0 of 4 confirmed instrumentation failures are acceptable because the voltage measurements are not used during ascent for LH2 Low Level Cutoff protection. Per Program direction this SSID will be effective only if 3 of 4 LH2 LLCO sensor circuits are functional at the beginning of the time effectivity of this SSID.

f. Preplanned Contingency Procedures - If an LH2 LLCO sensor circuit was confirmed functional with a failed voltage measurement prior to the LCC time frame, then the same voltage measurement is confirmed failed during the LCC time frame as well. Any voltage measurement reading greater than the maximum possible output of the PSEB cannot be real and therefore any voltage measurement greater than 16.0 Vdc confirms instrumentation failure. If the response to application of the Sim Dry and Sim Wet Commands by the LH2 LLCO discrete measurements indicate a functioning LH2 LLCO sensor circuit, then the voltage measurement is considered erroneous and acceptable instrumentation failure is confirmed regardless of the instrumentation failure status of any other LH2 LLCO sensor circuits. Any discrete LH2 LLCO sensor circuit indication which does not respond as expected to the PCP ECO SIM commands is unacceptable since this is confirmation of an actual Open-WET LH2 LLCO sensor circuit failure that reduces the number of functional LH2 LLCO sensor circuits to less than the 3 of 4 required.

Based on failure history, an intermittent failure of a sensor circuit could occur, therefore, confirmation of instrumentation failure must be performed while the voltage measurement is out of limits. If the voltage measurement were to return to within specifications prior to completion of the preplanned contingency procedure an intermittent failure of the sensor circuit could be masked. Inability to confirm instrumentation failure is not acceptable since an actual sensor circuit failure affecting in-flight LH2 LLCO system performance may exist and could result in launch with less than 3 functional sensor circuits.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Possible loss of Crew and Vehicle if LH2 LLCO sensor circuits are unable to initiate SSME shut down and SSMEs run to fuel depletion (requires multiple LH2 LLCO sensor circuit failures).

CONSEQUENCES OF EXCEEDING REDLINE: (Continued)

(11) Reference Integrated Hazard Report IMPS-03.

CAUSES OF EXCEEDING REDLINE:

(12) Sensor malfunction.
(13) Failure within the OI MDM, DSC, or associated wiring.
(14) Open in the excitation or return wiring leg of the sensor circuit.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	Vdc								
T41V1930A	0.128	0	32						
T41V1931A	0.128	0	32						
T41V1932A	0.128	0	32						
T41V1933A	0.128	0	32						

METER/DISPLAY RANGE - MSID: LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.10 SHEET 1 ZONE C3
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

SECTION 22

REACTION CONTROL SUBSYSTEM

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SECTION 22: REACTION CONTROL SUBSYSTEM

SSID No.	Description/Violation Call	Page
RCS-01	RCS Helium Tank Anomaly	22-01.1
RCS-02	RCS Propellant Tank Pressure/Temperature Anomaly	22-02.1
RCS-03	RCS Helium Isolation Valve Anomaly	22-03.1
RCS-04	RCS Propellant Tank Isolation Valve Anomaly	22-04.1
RCS-05	RCS Manifold Isolation Valve Anomaly	22-05.1
RCS-06	RCS Thrust Injector Temperature Anomaly	22-06.1
RCS-07	RCS Vernier Thrust Injector Temperature Anomaly	22-07.1
RCS-08	RCS Thrust Chamber Pressure Anomaly	22-08.1
RCS-09	RCS Manifold Pressure Anomaly	22-09.1
RCS-10	RCS Crossfeed Valve Anomaly	22-10.1
RCS-FG01	Figure 22-01 RCS Fuel Tank Ullage/Outlet Pressure Versus Temperature	22-FG01.1
RCS-FG02	Figure 22-02 RCB Oxidizer Tank Ullage/Outlet Pressure Versus Temperature	22-FG02.1

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LCC VIOLATION CALL: RCS Helium Tank Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V42T1100C	RCS Fwd He Ox Tank Temp-1	1 of	(3)	(3)	deg F	CI
V42T1104C	RCS Fwd He Fu Tank Temp-1	2	(3)	(3)	deg F	CI
V42P1110C	RCS Fwd He Ox Tank Press-1	1 of	(2,4)	(2,4)	psia	CI
V42P1112C	RCS Fwd He Ox Tank Press-2	2	(2,4)	(2,4)	psia	CI
V42P1113C	RCS Fwd He Fu Tank Press-1	1 of	(2,4)	(2,4)	psia	CI
V42P1114C	RCS Fwd He Fu Tank Press-2	2	(2,4)	(2,4)	psia	CI
V42T2100C	RCS L Aft He Ox Tank Temp-1	1 of	(3)	(3)	deg F	CI
V42T2104C	RCS L Aft He Fu Tank Temp-1	2	(3)	(3)	deg F	CI
V42P2110C	RCS L Aft He Ox Tank Press-1	1 of	(2,4)	(2,4)	psia	CI
V42P2112C	RCS L Aft He Ox Tank Press-2	2	(2,4)	(2,4)	psia	CI
V42P2113C	RCS L Aft He Fu Tank Press-1	1 of	(2,4)	(2,4)	psia	CI
V42P2114C	RCS L Aft He Fu Tank Press-2	2	(2,4)	(2,4)	psia	CI
V42T3100C	RCS R Aft He Ox Tank Temp-1	1 of	(3)	(3)	deg F	CI
V42T3104C	RCS R Aft He Fu Tank Temp-1	2	(3)	(3)	deg F	CI
V42P3110C	RCS R Aft He Ox Tank Press-1	1 of	(2,4)	(2,4)	psia	CI
V42P3112C	RCS R Aft He Ox Tank Press-2	2	(2,4)	(2,4)	psia	CI
V42P3113C	RCS R Aft He Fu Tank Press-1	1 of	(2,4)	(2,4)	psia	CI
V42P3114C	RCS R Aft He Fu Tank Press-2	2	(2,4)	(2,4)	psia	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) Pressures 1 and 2, on the same tank, with a delta pressure greater than 128 psi must be evaluated. (5)
(3) Oxidizer and fuel tank temperatures, on the same pod/module, with a delta temperature greater than 8 degrees must be evaluated. (6)
(4) Any decrease in tank pressure of 2 data bits (16 psi) without a corresponding temperature change must be evaluated. (7)

PREPLANNED CONTINGENCY PROCEDURE:

(5) For either pressure measurement on a tank indicating high or low, if the corresponding (same tank) pressure measurement is nominal, LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

(6) For a temperature measurement indication high or low, and the temperature measurement on the other tank (same pod/module) is nominal, LCC violation cleared, continue countdown.
(7) Both pressure measurements in a tank trending downward indicates a potential leak. Utilize tank temperature measurements for leak evaluation. If a helium tank temperature measurement is failed, utilize the ambient temperature of the pod for leak evaluation.

NOTES:

(8) A pressure decay of up to 20 psi on the fuel side and 60 psi on the oxidizer side may be attributed to helium absorption into the propellants.

REDLINE DERIVATION: CRITICALITY: 1

(9) Loss of any of the measurements degrades PASS and BFS quantity gauging in the affected module. Degradation or loss of quantity gauging makes the ground mandatory for leak detection.
(10) The measurements are required to determine He and propellant loads, system integrity, and propellant quantity gauging.
(11) Temperature redline development:

Actual delta T	0 deg F
Instr accuracy (3.5 deg/meas)	7 deg F
Bit uncertainty (1 bit/meas)	1 deg F
Redline	8 deg F

(12) Pressure redline development:

Actual delta P	0 psi
Instr accuracy (56 psi/meas)	112 psi
Bit uncertainty (1 bit/meas)	16 psi
Redline	128 psi

CONSEQUENCES OF EXCEEDING REDLINE:

(13) Potential erroneous RCS leak alarm.
(14) System would be launched with leak or incorrect helium load.
(15) Early mission termination because of decreased PVT accuracy.

CAUSES OF EXCEEDING REDLINE:

(16) Failed transducer.
(17) Leak in RCS.
(18) Incorrect RCS helium load.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1 FOR FORWARD RCS, 2 FOR LEFT RCS, AND 3 FOR RIGHT RCS									
UNITS-->	psia								
V42Pn110C	8.0	0	4000						
V42Pn112C	8.0	0	4000					500	
V42Pn113C	8.0	0	4000				9.5% delta		
V42Pn114C	8.0	0	4000					500	
UNITS-->	deg.F								
V42Tn100C	.4968	-73.91	174.5						
V42Tn104C	.4968	-73.91	174.5						

METER/DISPLAY RANGE - MSID: V42Pn110C LOW: 0 HIGH: 4000
V42Pn112C LOW: 0 HIGH: 4000
V42Pn113C LOW: 0 HIGH: 4000
V42Pn114C LOW: 0 HIGH: 4000

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 11.5/11.6 SHEET 1 ZONE ARCS/
DWG NO 11.5/11.6 SHEET 1 ZONE FRCS
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-942099 SHEET 26/37 ZONE (FRCS)
DWG NO VS70-942009 SHEET 40/51 ZONE
DWG NO VS70-943099 SHEET 13/14 ZONE (ARCS)
DWG NO VS70-943099 SHEET 23/24 ZONE

ELEMENT: Orbiter SUBSYSTEM: RCS

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LCC VIOLATION CALL: RCS Propellant Tank Pressure/Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V42P1115C	RCS Fwd Ox Tank Ullage Press	1 of	NA	(2,3)	psia	CI
V42P1210C	RCS Fwd Ox Tank Out Press	2	NA	(2)	psia	CI
V42P1116C	RCS Fwd Fu Tank Ullage Press	1 of	NA	(2,3)	psia	CI
V42P1310C	RCS Fwd Fu Tank Out Press	2	NA	(2)	psia	CI
V42T1200C	RCS Fwd Ox Tank Temp-1	1 of	65 (4)	85 (4)	deg F	CI
V42T1300C	RCS Fwd Fu Tank Temp-1	2	65 (4)	85 (4)	deg F	CI
V42P2115C	RCS L Aft Ox Tank Ullage Press	1 of	NA	(2,3)	psia	CI
V42P2210C	RCS L Aft Ox Tank Out Press	2	NA	(2)	psia	CI
V42P2116C	RCS L Aft Fu Tank Ullage Press	1 of	NA	(2,3)	psia	CI
V42P2310C	RCS L Aft Fu Tank Out Press	2	NA	(2)	psia	CI
V42T2200C	RCS L Aft Ox Tank Temp-1	1 of	76 (4)	85 (4)	deg F	CI
V42T2300C	RCS L Aft Fu Tank Temp-1	2	76 (4)	85 (4)	deg F	CI
V42P3115C	RCS R Aft Ox Tank Ullage Press	1 of	NA	(2,3)	psia	CI
V42P3210C	RCS R Aft Ox Tank Out Press	2	NA	(2)	psia	CI
V42P3116C	RCS R Aft Fu Tank Ullage Press	1 of	NA	(2,3)	psia	CI
V42P3310C	RCS R Aft Fu Tank Out Press	2	NA	(2)	psia	CI
V42T3200C	RCS R Aft Ox Tank Temp-1	1 of	76 (4)	85 (4)	deg F	CI
V42T3300C	RCS R Aft Fu Tank Temp-1	2	76 (4)	85 (4)	deg F	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES: Figures 22-01, -02

(2) Tank ullage and outlet pressures, on the same tank, with a delta pressure greater than 15.3 psi must be evaluated. (5)
(3) Tank ullage pressure may increase to 311 psia only if there has been a corresponding temperature change.
(4) Oxidizer and fuel tank temperatures, on the same pod/module, with a delta temperature greater than 15.4 deg. F. must be evaluated. (6)

PREPLANNED CONTINGENCY PROCEDURE:

(5) For either pressure measurement (ullage/outlet) on a tank indicating high or low, if the corresponding (same tank) pressure measurement is nominal, LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

(6) For a temperature measurement indication high or low, if the corresponding (same pod/module) temperature measurement is nominal, LCC violation cleared, continue countdown.
(7) Both pressure measurements in a tank trending downward indicates a potential leak. Utilize tank temperature measurements for leak evaluation. Manifold pressure can be utilized, but its use results in degraded quantity accuracy. Outlet pressure must be adjusted for head pressure.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(8) Loss of any of these measurements degrades PASS and BFS quantity gauging in the affected module. Degradation or loss of quantity gauging makes the ground mandatory for leak detection.
(9) The measurements are required to determine system integrity, regulator integrity, propellant temperatures, and propellant quantity gauging.
(10) The 311 psia protects (by 1 psi) against a C&W alarm at 312 psia by tank ullage pressure. System integrity is maintained until burst disk rupture at 318 psia (rupture pressure 324 minus 6 psia instrumentation error). The burst disk is referenced to atmosphere; therefore, the burst disk pressure must be decreased to account for vacuum condition after lift-off.
(11) ARCS redline development:

Minimum propellant value during entry	70 deg F
Flight cooldown allowance	+ 4 deg F
Instrumentation allowance	+ 2 deg F
Redline	76 deg F

(12) FRCS redline development:

Minimum propellant value during entry	60 deg F
Flight cooldown allowance	+ 3 deg F
Instrumentation allowance	+ 2 deg F
Redline	65 deg F

(13) RCS redline development:

Maximum propellant value during ascent/abort	87 deg F
Instrumentation allowance	- 2 deg F
Redline	85 deg F

(14) Ullage/Tank Out Delta pressure redline development:

Act. delta P	2.5 psi
Instr (5.6 psi/meas)	+11.2 psi
Bit uncert	+ 1.6 psi
Redline	15.3 psi

(15) Delta temperature redline development:

Act. delta T	10.0 deg F
Instr (2.4 deg. F/meas)	+ 4.8 deg F
Bit uncertainty	+ 0.6 deg F
Redline	15.4 deg F

CONSEQUENCES OF EXCEEDING REDLINE:

(16) Failure of primary regulator may cause loss of FO/FS redundancy. Next regulator failure will cause overpressure rupture of burst disk and activate relief valve, which may not reseat. Regulator leakage may cause C&W alarm, rupture burst disk, and loss of helium.
(17) Failed measurement causes loss of BFS quantity gauging because the BFS quantity gauging has no fault-down logic.
(18) Potential erroneous RCS leak alarm.
(19) Early mission termination because of decreased PVT accuracy.
(20) Violation of temperature limits would cause loss of protection against injector detonations (Zots-ARCS only) during entry, cold engine valve leakage, and improper propellant tank performance.

CAUSES OF EXCEEDING REDLINE:

(21) Failed regulator(s).
(22) Failed transducer.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
n = 1 FOR FORWARD RCS, 2 FOR LEFT RCS, AND 3 FOR RIGHT RCS									
UNITS-->	psia								
V42Pn115C	0.8	0	400	200	312	200	312		
V42Pn116C	0.8	0	400	200	312	200	312		
V42Pn210C	0.8	0	400						
V42Pn310C	0.8	0	400						
UNITS-->	deg.F								
V42Tn200C	0.32	-0.368	159.7						
V42Tn300C	0.32	-0.368	159.7						

METER/DISPLAY RANGE - MSID: V42Pn115C LOW: 0 HIGH: 400
V42Pn116C LOW: 0 HIGH: 400
V42Pn210C LOW: 0 HIGH: 400
V42Pn310C LOW: 0 HIGH: 400

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 11.5 ARCS SHEET 1 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO 11.6 FRCS SHEET 1 ZONE
DWG NO VS70-942099 SHEET 26/27/ ZONE (FRCS)
DWG NO VS70-942099 SHEET 38/52 ZONE
DWG NO VS70-943099 SHEET 13/14 ZONE (ARCS)
DWG NO VS70-943099 SHEET 23/24 ZONE

ELEMENT: Orbiter SUBSYSTEM: RCS

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LCC VIOLATION CALL: RCS Helium Isolation Valve Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V42X1120X	RCS Fwd He Ox Press Vlv-A Op		ON	NA	Event	CI
V42X1122X	RCS Fwd He Ox Press Vlv-B Op		ON	NA	Event	CI
V42X1124X	RCS Fwd He Fu Press Vlv-A Op		ON	NA	Event	CI
V42X1126X	RCS Fwd He Fu Press Vlv-B Op		ON	NA	Event	CI
V42X2120X	RCS L Aft He Ox Press Vlv-A Op		ON	NA	Event	CI
V42X2122X	RCS L Aft He Ox Press Vlv-B Op		ON	NA	Event	CI
V42X2124X	RCS L Aft He Fu Press Vlv-A Op		ON	NA	Event	CI
V42X2126X	RCS L Aft He Fu Press Vlv-B Op		ON	NA	Event	CI
V42X3120X	RCS R Aft He Ox Press Vlv-A Op		ON	NA	Event	CI
V42X3122X	RCS R Aft He Ox Press Vlv-B Op		ON	NA	Event	CI
V42X3124X	RCS R Aft He Fu Press Vlv-A Op		ON	NA	Event	CI
V42X3126X	RCS R Aft He Fu Press Vlv-B Op		ON	NA	Event	CI

TIME PERIOD:

(1) Verify Prior to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) All panel switches and valves must be in OPEN position.(3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Lack of OPEN - If onboard talkback indicates OPEN, verify panel switch is in the OPEN position (by crew or V42S1151E/1153E/2151E/2153E/3151E/3153E) LCC violation cleared, continue countdown (instrumentation failure). Valve may be cycled to see if problem clears. If TB is BP or CLOSED, failure mechanism must be understood and valve must be functional before launch.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R2

(4) Panel switches must be in the OPEN position to ensure active RCS pressurization for mated coast and ET separation.
(5) Valve positions must be positively known.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) MDM failures may cause loss of helium supply pressure during critical mated coast or ET separation maneuvers (abort or normal mission). Unexpected valve closures from shock or vibration would not be automatically reopened.

CONSEQUENCES OF EXCEEDING REDLINE: (Continued)

(7) Loss of ET separation capability on RTLS if valves are not open. System may not be single-failure tolerant for RTLS or two-failure tolerance for normal mission.

CAUSES OF EXCEEDING REDLINE:

(8) Panel switch in wrong position or instrumentation failure.
(9) Valve failure, procedural error, instrumentation failure, or valve control electronics failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 11.5	SHEET 1	ZONE
	DWG NO 11.6	SHEET 1	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-942099	SHEET 26/40	ZONE (FRCS)
	DWG NO VS70-943099	SHEET 6/7	ZONE (ARCS)

ELEMENT: Orbiter SUBSYSTEM: RCS

LCC VIOLATION CALL: RCS Propellant Tank Isolation Valve Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V42X1220X	RCS Fwd Ox Tank Isln Vlv-1/2 Op		ON (3)	NA	Event	CI
V42X1221X	RCS Fwd Ox Tank Isln Vlv-1/2 Cl		OFF (3)	NA	Event	CI
V42X1222X	RCS Fwd Ox Tank Isln Vlv-3/4/5 Op		ON (3)	NA	Event	CI
V42X1223X	RCS Fwd Ox Tank Isln Vlv-3/4/5 Cl		OFF (3)	NA	Event	CI
V42X1320X	RCS Fwd Fu Tank Isln Vlv-1/2 Op		ON (3)	NA	Event	CI
V42X1321X	RCS Fwd Fu Tank Isln Vlv-1/2 Cl		OFF (3)	NA	Event	CI
V42X1322X	RCS Fwd Fu Tank Isln Vlv-3/4/5 Op		ON (3)	NA	Event	CI
V42X1323X	RCS Fwd Fu Tank Isln Vlv-3/4/5 Cl		OFF (3)	NA	Event	CI
V42X2220X	RCS L Aft Ox Tank Isln Vlv-1/2 Op	(2)	ON (4)	NA	Event	CI
V42X2221X	RCS L Aft Ox Tank Isln Vlv-1/2 Cl		OFF (4)	NA	Event	CI
V42X2222X	RCS L Aft Ox Tk Isln Vlv-3/4/5A Op		ON (4)	NA	Event	CI
V42X2223X	RCS L Aft Ox Tk Isln Vlv-3/4/5A Cl		OFF (4)	NA	Event	CI
V42X2224X	RCS L Aft Ox Tk Isln Vlv-3/4/5B Op		ON (4)	NA	Event	CI
V42X2225X	RCS L Aft Ox Tk Isln Vlv-3/4/5B Cl		OFF (4)	NA	Event	CI
V42X2320X	RCS L Aft Fu Tank Isln Vlv-1/2 Op	(2)	ON (4)	NA	Event	CI
V42X2321X	RCS L Aft Fu Tank Isln Vlv-1/2 Cl		OFF (4)	NA	Event	CI
V42X2322X	RCS L Aft Fu Tk Isln Vlv-3/4/5A Op		ON (4)	NA	Event	CI
V42X2323X	RCS L Aft Fu Tk Isln Vlv-3/4/5A Cl		OFF (4)	NA	Event	CI
V42X2324X	RCS L Aft Fu Tk Isln Vlv-3/4/5B Op		ON (4)	NA	Event	CI
V42X2325X	RCS L Aft Fu Tk Isln Vlv-3/4/5B Cl		OFF (4)	NA	Event	CI
V42X3220X	RCS R Aft Ox Tank Isln Vlv 1/2 Op	(2)	ON (4)	NA	Event	CI
V42X3221X	RCS R Aft Ox Tank Isln Vlv 1/2 Cl		OFF (4)	NA	Event	CI
V42X3222X	RCS R Aft Ox Tk Isln Vlv 3/4/5A Op		ON (4)	NA	Event	CI
V42X3223X	RCS R Aft Ox Tk Isln Vlv 3/4/5A Cl		OFF (4)	NA	Event	CI
V42X3224X	RCS R Aft Ox Tk Isln Vlv 3/4/5B Op		ON (4)	NA	Event	CI
V42X3225X	RCS R Aft Ox Tk Isln Vlv 3/4/5B Cl		OFF (4)	NA	Event	CI
V42X3320X	RCS R Aft Fu Tank Isln Vlv-1/2 Op	(2)	ON (4)	NA	Event	CI
V42X3321X	RCS R Aft Fu Tank Isln Vlv-1/2 Cl		OFF (4)	NA	Event	CI
V42X3322X	RCS R Aft Fu Tk Isln Vlv-3/4/5A Op		ON (4)	NA	Event	CI
V42X3323X	RCS R Aft Fu Tk Isln Vlv-3/4/5A Cl		OFF (4)	NA	Event	CI
V42X3324X	RCS R Aft Fu Tk Isln Vlv-3/4/5B Op		ON (4)	NA	Event	CI
V42X3325X	RCS R Aft Fu Tk Isln Vlv-3/4/5B Cl		OFF (4)	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) If both Ox and Fuel Aft RCS 1/2 tank isolation valve OPEN indications in one pod are OFF, both Ox and Fuel Aft RCS 1/2 tank isolation valve CLOSE indications must function. (5)

PREPLANNED CONTINGENCY PROCEDURE:

(3) FRCS Tank Iso Valves.
   A. For OPEN indication OFF, should be ON: If onboard Talkback (TB) indicates OPEN, and panel switches are verified in GPC (by crew or V42S1344E/1348E) then LCC violation cleared, continue countdown (instrumentation failure). If TB is Barberpole (BP) or CLOSE, cycle valve to attempt to clear problem. If valve functions properly and cycling is successful in regaining correct position indications, LCC violation cleared, continue countdown. If cockpit switch was used to cycle valve, return switch to GPC position.
   B. For CLOSED indication ON, should be OFF: Cycle valve to attempt to clear problem. If valve functions properly and cycling is successful in regaining correct position indications, LCC violation cleared, continue countdown. If cockpit switch was used to cycle valve, return switch to GPC position.

(4) ARCS Tank Iso Valves.
   A. For OPEN indication OFF, should be ON (Valves 1/2): If onboard TB indicates OPEN, and panel switch is verified in GPC (by crew or V42S2340E/2351E/3340E/3351E) then LCC violation cleared, continue countdown (instrumentation failure). If TB is BP or CLOSE, cycle valve to attempt to clear problem. If valve functions properly and cycling is successful in regaining correct position indications, LCC violation cleared, continue countdown. If cockpit switch was used to cycle valve, return switch to GPC position.
   B. For OPEN indication OFF, should be ON (Valves 3/4/5 A and B): If onboard TB indicates OPEN, and panel switch is verified in GPC (by crew or V42S2345E/2356E/2348E/2359E/3345E/3356E/3348E/3359E) then LCC violation cleared, continue countdown (instrumentation failure). If TB is BP or CLOSE, cycle valve to attempt to clear problem. If valve functions properly and cycling is successful in regaining correct position indications, LCC violation cleared, continue countdown. If cockpit switch was used to cycle valve, return switch to GPC position.
   C. For CLOSE indication ON, should be OFF (Valves 1/2): Cycle valve to attempt to clear problem. If valve functions properly and cycling is successful in regaining correct position indications, LCC violation cleared, continue countdown. If cockpit switch was used to cycle valve, return switch to GPC position.
   D. For CLOSE indication ON, should be OFF (Valves 3/4/5 A and B): If onboard TB and telemetry (TLM) indicate OPEN, and panel switch is verified in GPC (by crew or V42S2345E/2348E/2356E/2359E/3345E/3348E/3356E/3359E) then LCC violation cleared, continue countdown (instrumentation failure).

(5) If both fuel and oxidizer ARCS Tank 1/2 Iso Valve OPEN indications on one pod are failed OFF, associated onboard TBs indicate OPEN, and panel switches are verified in GPC (by crew or V42S2340E/2351E/3340E/3351E), a power loss to the microswitches must be cleared. Cycle the valves and note the telemetered indications for both valves. If both TLM OPEN and CLOSED indications for these valves are OFF, LCC violation confirmed, no go for launch. Otherwise, valve position indication failures were not caused by power loss to the microswitches so each indication failure must be individually cleared. (4)

NOTES:

(6) If aft 1/2 tank iso TB indicates BP but TLM indicates correctly, valve function is not affected; no LCC violation.

REDLINE DERIVATION: CRITICALITY: 1R3

(7) a. SSID Intent Summary - This SSID ensures that RCS Propellant Tank Isolation Valves are properly configured for launch, or confirms that loss of required position indications will not affect flight use of the valves. Instrumentation failures not affecting valve function (as verified by onboard valve position indication) are acceptable. The RCS propellant tank isolation valve indicators are used in the motor controller assembly (MCA) logic to control valve operation. Microswitches must operate properly or valves will not function. Valve positions must be positively known to enable leak isolation. Additionally, the Aft RCS propellant tank valve indicators are used by the abort software to determine the feasibility of an interconnected abort dump or RCS auto-crossfeed in ascent. Aft RCS switches must be in GPC position to allow the auto-functions required for abort dump interconnect or autocrossfeed in ascent. Launch is allowed for a confirmed instrumentation failure that does not affect valve function (by cockpit switch and during automatic abort dump), thus maintaining two-fault tolerance for launch.

b. Voting Logic - NA

c. Minimum Redline Development - The redline defines the nominal valve configurations for launch.

d. Time Effectivity - Ending time effectivity of T-9 minutes was chosen based on the fact that the RCS is configured for launch and functionally stable prior to T-9 minutes.

e. Requirements - A single-point failure can cause power loss to four position switches. This failure would cause abort software to inhibit use of this RCS leg.

f. Preplanned Contingency Procedures - In cases where instrumentation failures are permitted, these procedures provide means to confirm failure is instrumentation only by comparison with onboard talkbacks. If onboard talkback confirms the anomaly or is indeterminate, then valve cycling is attempted to clear the failure. Rationale for each of the cases is given below:

Single OPEN microswitch failed OFF: Onboard TB used to verify failure is instrumentation only. If onboard TB confirms valve position, then the LCC violation is cleared. Otherwise, valve is cycled in an attempt to clear the failure.

Dual OPEN microswitch failed OFF: If both the OX and FU ARCS 1/2 TK ISOL OPEN indications are OFF and the associated onboard TB indicates OPEN, the failure is indicative of a power fail to the microswitches that would cause an (otherwise functioning) propellant leg to be

REDLINE DERIVATION: (Continued)

declared unusable by the abort interconnect software. This failure can be confirmed by cycling the valves and noting both TLM OPEN and CLOSED indications remain OFF. If this failure is present, the software will not interconnect the OMS to that RCS leg for abort interconnected dumps or single engine roll control. If OPEN indication failures are confirmed to not be caused by power failure, PCP reverts to two single-failure cases.

CLOSED microswitch failed ON:
FRCS Tank Iso Valves and ARCS Tank Iso Valves 1/2: Valve will not close if microswitch failed. Valve cycling allowed in attempt to clear failure. If unsuccessful, system not two-fault tolerant for leakage isolation.

ARCS Tank Iso Valves 3/4/5 A and B: Onboard TB used to verify failure is instrumentation only. If onboard TB confirms valve position, the LCC violation is cleared. For these valves, a Closed microswitch failure will prevent valve from closing only if the problem valve is much slower than its companion valve on the other propellant tank. Thus, instrumentation failure is allowed in this case.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Inability to perform abort dump properly or to crossfeed in ascent.
(9) Engines may be commanded without propellant supply. System may not be single-failure tolerant for RTLS or two-failure tolerant for normal mission.

CAUSES OF EXCEEDING REDLINE:

(10) Switch in wrong position or instrumentation failure.
(11) Valve failure, procedural error, or valve control electronics failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 11.5 ARCS	SHEET 1	ZONE
	DWG NO 11.6 FRCS	SHEET 1	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-943099	SHEET 27/28	ZONE (LRCS)
	DWG NO VS70-943099	SHEET 41/42	ZONE (RRCS)
	DWG NO VS70-942099	SHEET 8/9	ZONE (FRCS)

ELEMENT: Orbiter SUBSYSTEM: RCS

LCC VIOLATION CALL: RCS Manifold Isolation Valve Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V42X1224X	RCS Fwd Ox Manf Isln Vlv-1 Op		ON	NA	Event	CI
V42X1225X	RCS Fwd Ox Manf Isln Vlv-1 Cl		OFF	NA	Event	CI
V42X1226X	RCS Fwd Ox Manf Isln Vlv-2 Op		ON	NA	Event	CI
V42X1227X	RCS Fwd Ox Manf Isln Vlv-2 Cl		OFF	NA	Event	CI
V42X1228X	RCS Fwd Ox Manf Isln Vlv-3 Op		ON	NA	Event	CI
V42X1229X	RCS Fwd Ox Manf Isln Vlv-3 Cl		OFF	NA	Event	CI
V42X1230X	RCS Fwd Ox Manf Isln Vlv-4 Op		ON	NA	Event	CI
V42X1231X	RCS Fwd Ox Manf Isln Vlv-4 Cl		OFF	NA	Event	CI
V42X1232X	RCS Fwd Ox Manf Isln Vlv-5 Op	(4)	ON	NA	Event	CI
V42X1233X	RCS Fwd Ox Manf Isln Vlv-5 Cl	(4)	OFF	NA	Event	CI
V42X1324X	RCS Fwd Fu Manf Isln Vlv-1 Op		ON	NA	Event	CI
V42X1325X	RCS Fwd Fu Manf Isln Vlv-1 Cl		OFF	NA	Event	CI
V42X1326X	RCS Fwd Fu Manf Isln Vlv 2 Op		ON	NA	Event	CI
V42X1327X	RCS Fwd Fu Manf Isln Vlv-2 Cl		OFF	NA	Event	CI
V42X1328X	RCS Fwd Fu Manf Isln Vlv 3 Op		ON	NA	Event	CI
V42X1329X	RCS Fwd Fu Manf Isln Vlv-3 Cl		OFF	NA	Event	CI
V42X1330X	RCS Fwd Fu Manf Isln Vlv 4 Op		ON	NA	Event	CI
V42X1331X	RCS Fwd Fu Manf Isln Vlv-4 Cl		OFF	NA	Event	CI
V42X1332X	RCS Fwd Fu Manf Isln Vlv-5 Op	(4)	ON	NA	Event	CI
V42X1333X	RCS Fwd Fu Manf Isln Vlv-5 Cl	(4)	OFF	NA	Event	CI
V42X2226X	RCS L Aft Ox Manf Isln Vlv-1 Op		ON	NA	Event	CI
V42X2227X	RCS-L Aft Ox Manf Isln Vlv-1 Cl		OFF	NA	Event	CI
V42X2228X	RCS L Aft Ox Manf Isln Vlv-2 Op		ON	NA	Event	CI
V42X2229X	RCS-L Aft Ox Manf Isln Vlv-2 Cl		OFF	NA	Event	CI
V42X2230X	RCS L Aft Ox Manf Isln Vlv-3 Op		ON	NA	Event	CI
V42X2231X	RCS-L Aft Ox Manf Isln Vlv-3 Cl		OFF	NA	Event	CI
V42X2232X	RCS L Aft Ox Manf Isln Vlv-4 Op		ON	NA	Event	CI
V42X2233X	RCS-L Aft Ox Manf Isln Vlv-4 Cl		OFF	NA	Event	CI
V42X2234X	RCS L Aft Ox Manf Isln Vlv-5 Op	(4)	ON	NA	Event	CI
V42X2235X	RCS-L Aft Fx Manf Isln Vlv-5 Cl	(4)	OFF	NA	Event	CI
V42X2326X	RCS L Aft Fu Manf Isln Vlv-1 Op		ON	NA	Event	CI
V42X2327X	RCS-L Aft Fu Manf Isln Vlv-1 Cl		OFF	NA	Event	CI
V42X2328X	RCS L Aft Fu Manf Isln Vlv-2 Op		ON	NA	Event	CI
V42X2329X	RCS-L Aft Fu Manf Isln Vlv-2 Cl		OFF	NA	Event	CI
V42X2330X	RCS L Aft Fu Manf Isln Vlv-3 Op		ON	NA	Event	CI
V42X2331X	RCS-L Aft Fu Manf Isln Vlv-3 Cl		OFF	NA	Event	CI
V42X2332X	RCS L Aft Fu Manf Isln Vlv-4 Op		ON	NA	Event	CI
V42X2333X	RCS-L Aft Fu Manf Isln Vlv-4 Cl		OFF	NA	Event	CI
V42X2334X	RCS L Aft Fu Manf Isln Vlv-5 Op	(4)	ON	NA	Event	CI
V42X2335X	RCS-L Aft Fu Manf Isln Vlv-5 Cl	(4)	OFF	NA	Event	CI

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	(Concluded)					
V42X3226X	RCS R Aft Ox Manf Isln Vlv-1 Op		ON	NA	Event	CI
V42X3227X	RCS-R Aft Ox Manf Isln Vlv-1 Cl		OFF	NA	Event	CI
V42X3228X	RCS R Aft Ox Manf Isln Vlv-2 Op		ON	NA	Event	CI
V42X3229X	RCS-R Aft Ox Manf Isln Vlv-2 Cl		OFF	NA	Event	CI
V42X3230X	RCS R Aft Ox Manf Isln Vlv-3 Op		ON	NA	Event	CI
V42X3231X	RCS-R Aft Ox Manf Isln Vlv-3 Cl		OFF	NA	Event	CI
V42X3232X	RCS R Aft Ox Manf Isln Vlv-4 Op		ON	NA	Event	CI
V42X3233X	RCS-R Aft Ox Manf Isln Vlv-4 Cl		OFF	NA	Event	CI
V42X3234X	RCS R Aft Ox Manf Isln Vlv-5 Op	(4)	ON	NA	Event	CI
V42X3235X	RCS-R Aft Ox Manf Isln Vlv-5 Cl	(4)	OFF	NA	Event	CI
V42X3326X	RCS R Aft Fu Manf Isln Vlv-1 Op		ON	NA	Event	CI
V42X3327X	RCS-R Aft Fu Manf Isln Vlv-1 Cl		OFF	NA	Event	CI
V42X3328X	RCS R Aft Fu Manf Isln Vlv-2 Op		ON	NA	Event	CI
V42X3329X	RCS-R Aft Fu Manf Isln Vlv-2 Cl		OFF	NA	Event	CI
V42X3330X	RCS R Aft Fu Manf Isln Vlv-3 Op		ON	NA	Event	CI
V42X3331X	RCS-R Aft Fu Manf Isln Vlv-3 Cl		OFF	NA	Event	CI
V42X3332X	RCS R Aft Fu Manf Isln Vlv-4 Op		ON	NA	Event	CI
V42X3333X	RCS-R Aft Fu Manf Isln Vlv-4 Cl		OFF	NA	Event	CI
V42X3334X	RCS R Aft Fu Manf Isln Vlv-5 Op	(4)	ON	NA	Event	CI
V42X3335X	RCS-R Aft Fu Manf Isln Vlv-5 Cl	(4)	OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) Lack of OPEN indication - If onboard talkback (TB) indicates OPEN, verify panel switch is in GPC position (by crew or V42S1362E/1364E/1366E/1368E/2362E/2364E/2366E/2368E/3362E/3364E/3366E/3368E). Cycle panel switch to CLOSE and back to OPEN.
   A. An OPEN onboard TB indicates the problem is instrumentation failure. If problem does not clear, the onboard GPCs will recognize the manifold status as CLOSED. Manifold will be unavailable unless status is overridden by the crew in OPS 101. This condition is acceptable for launch, LCC violation cleared, continue countdown.
   B. If TB is barberpole (BP) or CLOSED, failure mechanism must be understood and valve must be functional before launch.

(3) Presence of CLOSE indication - Verify switch is in GPC position (by crew or V42S1372E/1374E/1376E/1378E/2372E/2374E/2376E/2378E/3372E/3374E/3376E/3378E) and check position of the onboard TB. Cycle panel switch to CLOSE and back to OPEN.
   A. If problem does not clear, check onboard TB. If TB is OPEN, assume instrumentation failure, LCC violation cleared, continue countdown.
   B. If TB is BP or CLOSED, failure mechanism must be understood and valve must be functional before launch.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

(4) Lack of OPEN indication - If manifold 5 circuit breaker is engaged, cycle valve switch to CLOSE and back to OPEN.
   A. If problem does not clear, check onboard TB. If TB is OPEN, assume instrumentation failure, LCC violation cleared, continue countdown.
   B. If TB is BP or CLOSED, failure mechanism must be understood prior to launch.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R3

(5) Valve positions must be positively known to confirm jet availability.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) System may not be one-fault tolerant for RTLS abort or two-fault tolerant for normal mission.

CAUSES OF EXCEEDING REDLINE:

(7) Panel switch in wrong position or instrumentation failure.
(8) Valve failure, procedural error, instrumentation failure, or valve control electronics failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 11.5	SHEET 2	ZONE	
	DWG NO 11.6	SHEET 2	ZONE	
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-942099	SHEET 10/11	ZONE	(FRCS)
	DWG NO VS70-942099	SHEET /12	ZONE	
	DWG NO VS70-943099	SHEET 30/31	ZONE	(ARCS)
	DWG NO VS70-943099	SHEET /32	ZONE	
	DWG NO VS70-943099	SHEET 44/45	ZONE	
	DWG NO VS70-943099	SHEET /46	ZONE	

ELEMENT: Orbiter SUBSYSTEM: RCS

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LCC VIOLATION CALL: RCS Thrust Injector Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V42T2501C	RCS-L Aft Ox Thrust Inj Temp-L1A	(2)	65	NA	deg F	CI
V42T2502C	RCS-L Aft Fu Thrust Inj Temp-L1A	(2)	65	NA	deg F	CI
V42T2503C	RCS-L Aft Ox Thrust Inj Temp-L3A	(2)	65	NA	deg F	CI
V42T2504C	RCS-L Aft Fu Thrust Inj Temp-L3A	(2)	65	NA	deg F	CI
V42T3501C	RCS-R Aft Ox Thrust Inj Temp-R1A	(2)	65	NA	deg F	CI
V42T3502C	RCS-R Aft Fu Thrust Inj Temp-R1A	(2)	65	NA	deg F	CI
V42T3503C	RCS-R Aft Ox Thrust Inj Temp-R3A	(2)	65	NA	deg F	CI
V42T3504C	RCS-R Aft Fu Thrust Inj Temp-R3A	(2)	65	NA	deg F	CI
V42T1501C	RCS-Fwd Ox Thrust Inj Temp-F1F	(3)	65	NA	deg F	CI
V42T1502C	RCS-Fwd Fu Thrust Inj Temp-F1F	(3)	65	NA	deg F	CI
V42T1503C	RCS-Fwd Ox Thrust Inj Temp-F2F	(3)	65	NA	deg F	CI
V42T1504C	RCS-Fwd Fu Thrust Inj Temp-F2F	(3)	65	NA	deg F	CI
V42T1505C	RCS-Fwd Ox Thrust Inj Temp-F3F	(3)	65	NA	deg F	CI
V42T1506C	RCS-Fwd Fu Thrust Inj Temp-F3F	(3)	65	NA	deg F	CI
V42T1515C	RCS-Fwd Ox Thrust Inj Temp-F1U	(3)	65	NA	deg F	CI
V42T1516C	RCS-Fwd Fu Thrust Inj Temp-F1U	(3)	65	NA	deg F	CI
V42T1517C	RCS-Fwd Ox Thrust Inj Temp-F2U	(3)	65	NA	deg F	CI
V42T1518C	RCS-Fwd Fu Thrust Inj Temp-F2U	(3)	65	NA	deg F	CI
V42T1519C	RCS-Fwd Ox Thrust Inj Temp-F3U	(3)	65	NA	deg F	CI
V42T1520C	RCS-Fwd Fu Thrust Inj Temp-F3U	(3)	65	NA	deg F	CI
V42T2513C	RCS-L Aft Ox Thrust Inj Temp-L1U	(3)	65	NA	deg F	CI
V42T2514C	RCS-L Aft Fu Thrust Inj Temp-L1U	(3)	65	NA	deg F	CI
V42T2515C	RCS-L Aft Ox Thrust Inj Temp-L2U	(3)	65	NA	deg F	CI
V42T2516C	RCS-L Aft Fu Thrust Inj Temp-L2U	(3)	65	NA	deg F	CI
V42T2517C	RCS-L Aft Ox Thrust Inj Temp-L4U	(3)	65	NA	deg F	CI
V42T2518C	RCS-L Aft Fu Thrust Inj Temp-L4U	(3)	65	NA	deg F	CI
V42T3513C	RCS-R Aft Ox Thrust Inj Temp-R1U	(3)	65	NA	deg F	CI
V42T3514C	RCS-R Aft Fu Thrust Inj Temp-R1U	(3)	65	NA	deg F	CI
V42T3515C	RCS-R Aft Ox Thrust Inj Temp-R2U	(3)	65	NA	deg F	CI
V42T3516C	RCS-R Aft Fu Thrust Inj Temp-R2U	(3)	65	NA	deg F	CI
V42T3517C	RCS-R Aft Ox Thrust Inj Temp-R4U	(3)	65	NA	deg F	CI
V42T3518C	RCS-R Aft Fu Thrust Inj Temp-R4U	(3)	65	NA	deg F	CI
V42T1507C	RCS-Fwd Ox Thrust Inj Temp-F1L	(2)	65	NA	deg F	CI
V42T1508C	RCS-Fwd Fu Thrust Inj Temp-F1L	(2)	65	NA	deg F	CI
V42T1511C	RCS-Fwd Ox Thrust Inj Temp-F3L	(2)	65	NA	deg F	CI
V42T1512C	RCS-Fwd Fu Thrust Inj Temp-F3L	(2)	65	NA	deg F	CI
V42T1509C	RCS-Fwd Ox Thrust Inj Temp-F2R	(2)	65	NA	deg F	CI
V42T1510C	RCS-Fwd Fu Thrust Inj Temp-F2R	(2)	65	NA	deg F	CI
V42T1513C	RCS-Fwd Ox Thrust Inj Temp-F4R	(2)	65	NA	deg F	CI
V42T1514C	RCS-Fwd Fu Thrust Inj Temp-F4R	(2)	65	NA	deg F	CI

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	(Concluded)					
V42T2505C	RCS-L Aft Ox Thrust Inj Temp-L1L	(4)	65	NA	deg F	CI
V42T2506C	RCS-L Aft Fu Thrust Inj Temp-L1L	(4)	65	NA	deg F	CI
V42T2507C	RCS-L Aft Ox Thrust Inj Temp-L2L	(4)	65	NA	deg F	CI
V42T2508C	RCS-L Aft Fu Thrust Inj Temp-L2L	(4)	65	NA	deg F	CI
V42T2509C	RCS-L Aft Ox Thrust Inj Temp-L3L	(4)	65	NA	deg F	CI
V42T2510C	RCS-L Aft Fu Thrust Inj Temp-L3L	(4)	65	NA	deg F	CI
V42T2511C	RCS-L Aft Ox Thrust Inj Temp-L4L	(4)	65	NA	deg F	CI
V42T2512C	RCS-L Aft Fu Thrust Inj Temp-L4L	(4)	65	NA	deg F	CI
V42T3505C	RCS-R Aft Ox Thrust Inj Temp-R1R	(4)	65	NA	deg F	CI
V42T3506C	RCS-R Aft Fu Thrust Inj Temp-R1R	(4)	65	NA	deg F	CI
V42T3507C	RCS-R Aft Ox Thrust Inj Temp-R2R	(4)	65	NA	deg f	CI
V42T3508C	RCS-R Aft Fu Thrust Inj Temp-R2R	(4)	65	NA	deg F	CI
V42T3509C	RCS-R Aft Ox Thrust Inj Temp-R3R	(4)	65	NA	deg F	CI
V42T3510C	RCS-R Aft Fu Thrust Inj Temp-R3R	(4)	65	NA	deg F	CI
V42T3511C	RCS-R Aft Ox Thrust Inj Temp-R4R	(4)	65	NA	deg F	CI
V42T3512C	RCS-R Aft Fu Thrust Inj Temp-R4R	(4)	65	NA	deg F	CI
V42T1521C	RCS-Fwd Ox Thrust Inj Temp-F1D	(4)	65	NA	deg F	CI
V42T1522C	RCS-Fwd Fu Thrust Inj Temp-F1D	(4)	65	NA	deg F	CI
V42T1523C	RCS-Fwd Ox Thrust Inj Temp-F2D	(4)	65	NA	deg F	CI
V42T1524C	RCS-Fwd Fu Thrust Inj Temp-F2D	(4)	65	NA	deg F	CI
V42T1525C	RCS-Fwd Ox Thrust Inj Temp-F3D	(4)	65	NA	deg F	CI
V42T1526C	RCS-Fwd Fu Thrust Inj Temp-F3D	(4)	65	NA	deg F	CI
V42T1527C	RCS-Fwd Ox Thrust Inj Temp-F4D	(4)	65	NA	deg F	CI
V42T1528C	RCS-Fwd Fu Thrust Inj Temp-F4D	(4)	65	NA	deg F	CI
V42T2519C	RCS-L Aft Ox Thrust Inj Temp-L2D	(3)	65	NA	deg F	CI
V42T2520C	RCS-L Aft Fu Thrust Inj Temp-L2D	(3)	65	NA	deg F	CI
V42T2521C	RCS-L Aft Ox Thrust Inj Temp-L3D	(3)	65	NA	deg F	CI
V42T2522C	RCS-L Aft Fu Thrust Inj Temp-L3D	(3)	65	NA	deg F	CI
V42T2523C	RCS-L Aft Ox Thrust Inj Temp-L4D	(3)	65	NA	deg F	CI
V42T2524C	RCS-L Aft Fu Thrust Inj Temp-L4D	(3)	65	NA	deg F	CI
V42T3519C	RCS-R Aft Ox Thrust Inj Temp-R2D	(3)	65	NA	deg F	CI
V42T3520C	RCS-R Aft Fu Thrust Inj Temp-R2D	(3)	65	NA	deg F	CI
V42T3521C	RCS-R Aft Ox Thrust Inj Temp-R3D	(3)	65	NA	deg F	CI
V42T3522C	RCS-R Aft Fu Thrust Inj Temp-R3D	(3)	65	NA	deg F	CI
V42T3523C	RCS-R Aft Ox Thrust Inj Temp-R4D	(3)	65	NA	deg F	CI
V42T3524C	RCS-R Aft Fu Thrust Inj Temp-R4D	(3)	65	NA	deg F	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) 3 of 4 acceptable for confirmed instrumentation failure only. (6)
(3) 5 of 6 acceptable for confirmed instrumentation failure only. (6)

REQUIREMENTS: (Continued)

(4) 7 of 8 acceptable for confirmed instrumentation failure only. (6)
(5) Oxidizer and fuel temperatures on the same thruster must be within 11 degrees F of each other to ensure that measurement is operational. (6)

PREPLANNED CONTINGENCY PROCEDURE:

(6) Instrumentation failure is confirmed for a measurement indicating off scale high or low, exhibiting a step function change, functioning erratically, or for a previously documented instrumentation anomaly. If instrumentation failure is confirmed, then perform steps A) through C) as required.
   A) All actions must be performed in OPS 1.
   B) For a failed or biased low injector temperature, deselect inhibit once, and reselect jet if required, to keep jet in availability table and to reprioritize to last priority. Deselect inhibit is required for first instrumentation failure in each group. For successful jet reprioritization, LCC violation cleared, continue countdown.
   C) For an injector temperature failed or biased high, deselect inhibit jet twice to reprioritize to last priority. Deselect inhibit is required for first instrumentation failure on all jets except +X jets, L1A, L3A, R1A, and R3A. For successful jet reprioritization, or for confirmed instrumentation failures of +X jets, L1A, L3A, R1A, and R3A, then LCC violation cleared, continue countdown.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R3

(7) a. SSID Intent Summary - This SSID serves two purposes. First, experience with the primary RCS thruster valves has shown that valve exposure to temperatures below 60 degrees F can cause subsequent leakage on ascent or on orbit; the minimum redline protects against causing leaky thruster(s). Second, the SSID protects thruster redundancy due to confirmed instrumentation failure. This instrumentation is used by RCS Redundancy Management (RM) to evaluate thruster health during firings. RM compares thruster oxidizer and fuel injector temperatures with temperatures indicative of a propellant leak to detect a leaking thruster (Failed LEAK). For confirmed instrumentation failure, the LCC has the thruster placed in last priority and left in a state where RM will not inhibit a commanded firing due to the instrumentation failure. Being in last priority minimizes the chance of firing the thruster without valve-leak insight while maintaining at least two-fault tolerance for launch

b. Voting Logic - The confirmed instrumentation failure of a single injector temperature per thruster group is acceptable because the thruster will still be functional. The reprioritization minimizes the likelihood of firing a thruster without direct insight into one thruster valve's health per thruster. Failure of both injector temperature measurements on a thruster makes all but gross leakage undetectable. Multiple injector temperature instrumentation failures per thruster group are out of family

REDLINE DERIVATION: (Continued)

and would significantly impact in-flight insight into the affected groups.

c. Minimum Redline Development -

Lower limit to prevent engine valve leakage	60 deg F
Instrumentation accuracy	+5 deg F
Redline	65 deg F

d. Oxidizer/Fuel Delta Temperature Redline Development -

Actual delta T	0 deg F
Instr error (5 deg/meas)	10 deg F
Bit uncertainty (1 bit/meas)	1 deg F
Redline	11 deg F

e. Time Effectivity - Ending time effectivity of T-9 minutes was chosen based on the fact that the RCS is configured for launch and functionally stable prior to T-9 minutes.

f. Requirements - Thruster redundancy is retained as long as failure is due to instrumentation only. The oxidizer/fuel delta temperature defines worst-case, but nominally operating temperature instrumentation.

g. Preplanned Contingency Procedures - These procedures provide directions on reprioritizing thrusters based on the type of instrumentation failure. In all cases, the thruster is left in last priority and a state such that RCS RM will not prevent firing the thruster. For low violations, the thruster is deselect-inhibited once. This maintains the thruster in the availability table, reprioritizes it to last, and inhibits RM auto-deselection of the thruster. For high violations, the thruster is deselect-inhibited twice. This maintains the thruster in the availability table, reprioritizes it to last, but maintains the limited RM protection still available for the thruster (auto-deselection for Fail OFF, auto-deselection for Fail LEAK detected by the remaining sensor on thruster, and identification/annunciation of thruster Fail ON). Instrumentation failure that only fails the delta temperature requirement would not trip the Fail-LEAK logic so the thruster is deselect-inhibited twice. The deselect-inhibit-twice requirement is not levied on the +X thrusters because in OPS 1, 3, and 6, all +X thrusters are fired when a +X command is given, so a change of priority has no practical effect. Thus, if required for the +X thrusters, any reprioritization can be delayed until OPS 2.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Failed measurement may prevent leak detection.
(9) Engine damage from firing engine with a leaky valve.
(10) Temperatures below 60 degrees F may cause engine valve leakage.
(11) Temperatures below 30 degrees F oxidizer or 20 degrees F fuel will cause a leak alarm and remove the jet from the availability table.

CAUSES OF EXCEEDING REDLINE:

(12) Minimum: A. Failed measurement
B. Oxidizer leak
C. Inadequate thermal control on launch pad.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
n = 1 FOR FORWARD RCS, 2 FOR LEFT RCS, AND 3 FOR RIGHT RCS									
UNITS-->	deg.F								
V42Tn501C	.4998	-.7958	249.1	30					
V42Tn502C	.4998	-.7958	249.1	20					
V42Tn503C	.4998	-.7958	249.1	30					
V42Tn504C	.4998	-.7958	249.1	20					
V42Tn505C	.4998	-.7958	249.1	30					
V42Tn506C	.4998	-.7958	249.1	20					
V42Tn507C	.4998	-.7958	249.1	30					
V42Tn508C	.4998	-.7958	249.1	20					
V42Tn509C	.4998	-.7958	249.1	30					
V42Tn510C	.4998	-.7958	249.1	20					
V42Tn511C	.4998	-.7958	249.1	30					
V42Tn512C	.4998	-.7958	249.1	20					
V42Tn513C	.4998	-.7958	249.1	30					
V42Tn514C	.4998	-.7958	249.1	20					
V42Tn515C	.4998	-.7958	249.1	30					
V42Tn516C	.4998	-.7958	249.1	20					
V42Tn517C	.4998	-.7958	249.1	30					
V42Tn518C	.4998	-.7958	249.1	20					
V42Tn519C	.4998	-.7958	249.1	30					
V42Tn520C	.4998	-.7958	249.1	20					
V42Tn521C	.4998	-.7958	249.1	30					
V42Tn522C	.4998	-.7958	249.1	20					
V42Tn523C	.4998	-.7958	249.1	30					
V42Tn524C	.4998	-.7958	249.1	20					
V42T1525C	.4998	-.7958	249.1	30					
V42T1526C	.4998	-.7958	249.1	20					
V42T1527C	.4998	-.7958	249.1	30					
V42T1528C	.4998	-.7958	249.1	20					

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 11.5	SHEET 2	ZONE
	DWG NO 11.6	SHEET 2	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-942099	SHEET 19/20	ZONE (FRCS)
	DWG NO VS70-943099	SHEET 35	ZONE (LRCS)
	DWG NO VS70-943099	SHEET 49	ZONE (RRCS)

ELEMENT: Orbiter SUBSYSTEM: RCS

LCC VIOLATION CALL: RCS Vernier Thrust Injector Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V42T1529C	RCS-Fwd Ox Thrust Inj Temp-F5L	2 of	65	NA	deg F	CI
V42T1531C	RCS-Fwd Ox Thrust Inj Temp-F5R	2 (3)	65	NA	deg F	CI
	-OR-					
V42T1530C	RCS-Fwd Fu Thrust Inj Temp-F5L	2 of	65	NA	deg F	CI
V42T1532C	RCS-Fwd Fu Thrust Inj Temp-F5R	2 (3)	65	NA	deg F	CI
V42T2525C	RCS-L Aft Ox Thrust Inj Temp-L5D	2 of	65	NA	deg F	CI
V42T2527C	RCS-L Aft Ox Thrust Inj Temp-L5L	2 (3)	65	NA	deg F	CI
	-OR-					
V42T2526C	RCS-L Aft Fu Thrust Inj Temp-L5D	2 of	65	NA	deg F	CI
V42T2528C	RCS-L Aft Fu Thrust Inj Temp-L5L	2 (3)	65	NA	deg F	CI
V42T3525C	RCS-R Aft Ox Thrust Inj Temp-R5D	2 of	65	NA	deg F	CI
V42T3527C	RCS-R Aft Ox Thrust Inj Temp-R5R	2 (3)	65	NA	deg F	CI
	-OR-					
V42T3526C	RCS-R Aft Fu Thrust Inj Temp-R5D	2 of	65	NA	deg F	CI
V42T3528C	RCS-R Aft Fu Thrust Inj Temp-R5R	2 (3)	65	NA	deg F	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to OPS 1 Transition (T-20 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) Mission Dependent. This SSID is applicable only if vernier thrusters are required for mission success. (Reference Appendix H)

(3) 0 of 2 are acceptable for confirmed instrumentation failure(s) provided either both oxidizer or both fuel injector temperatures in that pod/module are operational. (4)

PREPLANNED CONTINGENCY PROCEDURE:

(4) Instrumentation failure is confirmed for a measurement indicating off scale high or low, exhibiting a step function change, functioning erratically or for a previously documented instrumentation anomaly. If instrumentation failure is confirmed, LCC violation cleared, continue countdown.

NOTES:

(5) In the event of instrumentation failure signature that will violate the on-orbit Redundancy Management (RM) minimum limit, a general purpose computer memory read/write (GMEM) is required to recover on-orbit vernier jet capability.

NOTES: (Continued)

(6) A delta temperature between oxidizer and fuel injectors on the same thruster of greater than 20 deg F (forward RCS) or 17 deg F (aft RCS) indicates a degradation of temperature sensor performance but is not a constraint to launch. The close proximity of the two sensors means that a leak will have the same effect on both sensors.

Verniers with heater on:	Fwd RCS	Aft RCS
Instr Error (5 deg/meas)	10 deg F	10 deg F
Location Delta	10 deg F	7 deg F
Max Experienced Delta Temp	20 deg F	17 deg F

REDLINE DERIVATION: CRITICALITY: 1R3

(7) a. SSID Intent Summary - This SSID serves two purposes. First, experience with the vernier RCS thruster valves has shown that valve exposure to temperatures below 60 degrees F can cause subsequent leakage on ascent or on orbit; the minimum redline protects against causing leaky thruster(s). Second, the SSID protects vernier thruster capability due to instrumentation failure. This instrumentation is used by RCS Redundancy Management (RM) to evaluate thruster health during firings. On-orbit (OPS 2 & 8), RM detects a fuel or oxidizer leak when the respective sensor indicates a temperature below 130 deg F (Failed LEAK). For a confirmed instrumentation failure, the LCC allows for launch if limited leak detection can be enabled on-orbit (OPS 2 and 8). An instrumentation failure that is expected to produce a temperature indication below 130 deg F requires a GMEM to lower the limit on that propellant so that RM will not deselect the thruster due to the instrumentation failure.

b. Voting Logic - The confirmed instrumentation failure of up to two injector temperatures for one propellant per pod is acceptable because the thruster will still be functional, and automatic leak protection can still be enabled for the pod as long as both of the injector temperatures for the other propellant are functional. Failure of one oxidizer injector temperature measurement and one fuel injector temperature measurement in a single pod/module (that is, each reading less than 130 deg F) disables onboard vernier leak RM protection in that pod/module. Mission Control Center (MCC) insight will be required to detect anything but gross leakage from vernier thrusters in that pod/module.

c. Minimum Redline Development -

Lower limit to prevent engine valve leakage	60 deg F
Instrumentation accuracy	+5 deg F
Redline	65 deg F

d. Time Effectivity - Ending time effectivity of OPS 1 transition (T-20 minutes) was chosen because vernier injector temperatures are unavailable in OPS 1 (no ground or crew insight; RM still monitors for thruster leaks).

e. Requirements - Vernier thrusters are not required for safe mission

REDLINE DERIVATION: (Continued)

completion but may be required to satisfy all mission objectives. Fail-LEAK auto-deselection protection is lost for that propellant and pod/module combination corresponding to the failed injector temperature instrumentation. The close proximity of the oxidizer and fuel sensors in each vernier thruster means that both sensors will detect a leak from either valve. 0 of 2 sensors for one propellant in a pod/module is allowed because RM leak protection is still provided by sensors for the other propellant.

f. Preplanned Contingency Procedures - The procedure states how instrumentation failure is confirmed. No other preflight actions are required; however, a flight- and failure-specific GMEM will be required (for failure indication expected to produce temperatures of less than 130 deg F) to recover vernier thrusters on orbit. Such a GMEM is not normally available preflight and requires at least 24 hours to prepare and verify.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Failed measurement may prevent leak detection.
(9) Engine damage from firing engine with a leaky valve.
(10) Temperatures below 60 degrees F may cause engine valve leakage.
(11) Temperatures below 30 degrees F oxidizer or 20 degrees F fuel will cause leak alarm and remove jet from the availability table.

CAUSES OF EXCEEDING REDLINE:

(12) Minimum: A. Failed measurement.
B. Oxidizer leak.
C. Inadequate thermal control on launch pad.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 2 FOR LEFT RCS, AND 3 FOR RIGHT RCS									
UNITS-->	deg.F								
V42Tn525C	.4998	-.7958	249.1	30					
V42Tn526C	.4998	-.7958	249.1	20					
V42Tn527C	.4998	-.7958	249.1	30					
V42Tn528C	.4998	-.7958	249.1	20					
V42T1529C	.4998	-.7958	249.1	30					
V42T1530C	.4998	-.7958	249.1	20					
V42T1531C	.4998	-.7958	249.1	30					
V42T1532C	.4998	-.7958	249.1	20					

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 11.5	SHEET 2	ZONE
	DWG NO 11.6	SHEET 2	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-942099	SHEET 19/20	ZONE (FRCS)
	DWG NO VS70-943099	SHEET 35	ZONE (LRCS)
	DWG NO VS70-943099	SHEET 49	ZONE (RRCS)

ELEMENT: Orbiter SUBSYSTEM: RCS

LCC VIOLATION CALL: RCS Thrust Chamber Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V42P1551A	RCS-Fwd Thrust Chmbr Press-F1D	(3)	5	25	psia	CI
V42P1553A	RCS-Fwd Thrust Chmbr Press-F3D	(3)	5	25	psia	CI
V42P1552A	RCS-Fwd Thrust Chmbr Press-F2D	(3)	5	25	psia	CI
V42P1554A	RCS-Fwd Thrust Chmbr Press-F4D	(3)	5	25	psia	CI
V42P2550A	RCS-L Aft Thrust Chmbr Press-L2D	(3)	5	25	psia	CI
V42P2551A	RCS-L Aft Thrust Chmbr Press-L3D	(3)	5	25	psia	CI
V42P2552A	RCS-L Aft Thrust Chmbr Press-L4D	(3)	5	25	psia	CI
V42P3550A	RCS-R Aft Thrust Chmbr Press-R2D	(3)	5	25	psia	CI
V42P3551A	RCS-R Aft Thrust Chmbr Press-R3D	(3)	5	25	psia	CI
V42P3552A	RCS-R Aft Thrust Chmbr Press-R4D	(3)	5	25	psia	CI
V42P2547A	RCS-L Aft Thrust Chmbr Press-L1U	(3)	5	25	psia	CI
V42P2548A	RCS-L Aft Thrust Chmbr Press-L2U	(3)	5	25	psia	CI
V42P2549A	RCS-L Aft Thrust Chmbr Press-L4U	(3)	5	25	psia	CI
V42P3547A	RCS-R Aft Thrust Chmbr Press-R1U	(3)	5	25	psia	CI
V42P3548A	RCS-R Aft Thrust Chmbr Press-R2U	(3)	5	25	psia	CI
V42P3549A	RCS-R Aft Thrust Chmbr Press-R4U	(3)	5	25	psia	CI
V42P1548A	RCS-Fwd Thrust Chmbr Press-F1U	(3)	5	25	psia	CI
V42P1549A	RCS-Fwd Thrust Chmbr Press-F2U	(3)	5	25	psia	CI
V42P1550A	RCS-Fwd Thrust Chmbr Press-F3U	(3)	5	25	psia	CI
V42P1544A	RCS-Fwd Thrust Chmbr Press-F1L	(3)	5	25	psia	CI
V42P1546A	RCS-Fwd Thrust Chmbr Press-F3L	(3)	5	25	psia	CI
V42P1545A	RCS-Fwd Thrust Chmbr Press-F2R	(3)	5	25	psia	CI
V42P1547A	RCS-Fwd Thrust Chmbr Press-F4R	(3)	5	25	psia	CI
V42P2543A	RCS-L Aft Thrust Chmbr Press-L1L	(3)	5	25	psia	CI
V42P2544A	RCS-L Aft Thrust Chmbr Press-L2L	(3)	5	25	psia	CI
V42P2545A	RCS-L Aft Thrust Chmbr Press-L3L	(3)	5	25	psia	CI
V42P2546A	RCS-L Aft Thrust Chmbr Press-L4L	(3)	5	25	psia	CI
V42P3543A	RCS-R Aft Thrust Chmbr Press-R1R	(3)	5	25	psia	CI
V42P3544A	RCS-R Aft Thrust Chmbr Press-R2R	(3)	5	25	psia	CI
V42P3545A	RCS-R Aft Thrust Chmbr Press-R3R	(3)	5	25	psia	CI
V42P3546A	RCS-R Aft Thrust Chmbr Press-R4R	(3)	5	25	psia	CI
V42P2541A	RCS-L Aft Thrust Chmbr Press-L1A	(3)	5	25	psia	CI
V42P2542A	RCS-L Aft Thrust Chmbr Press-L3A	(3)	5	25	psia	CI
V42P3541A	RCS-R Aft Thrust Chmbr Press-R1A	(3)	5	25	psia	CI
V42P3542A	RCS-R Aft Thrust Chmbr Press-R3A	(3)	5	25	psia	CI

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	(Concluded)					
V42P1541A	RCS-Fwd Thrust Chmbr Press-F1F	(4)	5	25	psia	CI
V42P1542A	RCS-Fwd Thrust Chmbr Press-F2F	(4)	5	25	psia	CI
V42P1543A	RCS-Fwd Thrust Chmbr Press-F3F	(4)	5	25	psia	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) For documented loss of transducer vacuum chamber reference pressure for any thruster, LCC violation cleared, continue countdown.
(3) For first violation only per group: (5). For subsequent measurement out of limits, LCC violation confirmed, No Go for launch.
(4) For first violation only per group: (6). For subsequent measurement out of limits, LCC violation confirmed, No Go for launch.

PREPLANNED CONTINGENCY PROCEDURE:

(5) For violation low, deselect inhibit once on failed jet to keep jet in availability table and reprioritize to last priority. For violation high, deselect inhibit twice on failed jet to reprioritize to last priority. Deselect inhibit must be performed prior to thruster group usage in-flight. If sufficient time exists prior to T-0 (i.e., does not threaten the launch window), deselect inhibit must be performed. If sufficient time does not exist prior to T-0, deselect inhibit can be performed on ascent prior to thruster group usage. LCC violation cleared, continue countdown.
(6) For violation low, deselect inhibit once on failed jet to keep jet in availability table and reprioritize to last priority. For violation high, deselect inhibit twice on failed jet to reprioritize to last priority. The -X thrusters are not for rotational control and so are not ordinarily used pre-ET Separation. This means the prelaunch deselect inhibits are a prudent, but not mandatory, action that can be performed if sufficient time is available. Deselect inhibit action during ascent, however, is not preferable, and can be performed post-MECO, prior to thruster group usage. LCC violation cleared, continue countdown.

NOTES:

(7) Deselect inhibit performed by GNC in OPS 1 (Ref: S0007 Vol. 5, GNC-45)
(8) A failed chamber pressure measurement implies that the associated chamber pressure indication is also failed (Reference LCC SSID: GNC-45).
(9) Instrumentation required to detect failed jet.

REDLINE DERIVATION: CRITICALITY: 1R3

(10) a. SSID Intent Summary - This instrumentation is used by RCS Redundancy Management (RM) to evaluate thruster health during firings. RM compares

REDLINE DERIVATION: (Continued)

thruster chamber pressure (Pc) indication with firing commands to detect a thruster that has Failed OFF (low Pc when firing commanded). PASS RM compares reaction jet driver (RJD) output present with no GPC firing command to detect a thruster Failed ON (firing when not commanded); BFS RM uses Pc to detect a Failed-ON thruster. For an apparent instrumentation failure, the LCC has the thruster placed in last priority and left in a state where RM will not inhibit a commanded firing due to the instrumentation failure. Being in last priority minimizes the chance of firing a thruster without performance insight while maintaining at least two-fault tolerance for launch.

b. Voting Logic - A single thrust chamber pressure violation per group is acceptable based on the likelihood that the violation is the result of an instrumentation failure only and therefore the thruster will still be functional. The reprioritization minimizes the likelihood of firing a thruster without insight into thruster health/performance. Multiple thrust chamber pressure violations per grouping are out of family and would significantly impact in-flight insight into the affected groups.

c. Minimum and Maximum Redline Development -

	Minimum	Maximum
Ambient Pressure	15 psi	15 psi
Instr. Accuracy	-10 psi	+10 psi
	5 psi	25 psi

d. Time Effectivity - Ending time effectivity of T-9 minutes was chosen based on the fact that the RCS is configured for launch and functionally stable prior to T-9 minutes.

e. Requirements - Thrust chamber pressure transducers which exhibit the characteristics of a loss of vacuum chamber reference pressure, and which have been documented as exhibiting the characteristics of a loss of vacuum chamber reference pressure on a PR or IPR, are considered acceptable for flight since the loss results in a prelaunch transducer bias which is easily accommodated when monitoring for Minimum and Maximum violations. A loss of vacuum chamber reference pressure has no effect on flight use of the associated thruster.

f. Preplanned Contingency Procedures - These procedures provide directions on reprioritizing thrusters based on the type of failure. In either case, the thruster is left in last priority and a state such that RCS RM will not prevent firing the thruster due to the instrumentation failure. For low violations, the thruster is deselect-inhibited once. This maintains the thruster in the availability table, reprioritizes it to last, and inhibits RM auto-deselection of the thruster. For high violations, the thruster is deselect-inhibited twice. This maintains the thruster in the availability table, reprioritizes it to last, but maintains the limited RM protection still available for the thruster (fail leak auto-deselection and fail on identification/annunciation).

REDLINE DERIVATION: (Continued)

Although otherwise identical, a second specific preplanned contingency procedure is provided for the -X thrusters in order to indicate that while deselect inhibit may be deferred until ascent, it is preferred to be performed post-MECO and prior to thruster group usage.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Digital Auto Pilot (DAP) does not know correct engine status.
(12) Maximum: OFF failure cannot be detected and DAP will continue to command engine. This may result in degraded vehicle control since DAP will not recognize a real OFF failure. BFS would indicate an ON failure. Continued use without OFF failure detection may result in vehicle control issues on orbit and/or excessive propellant usage during entry if there is a hardware failure.
(13) Minimum: Engine will be failed OFF during initial usage. RCS will not be one-failure tolerant for RTLS or two-failure tolerant for normal flight.

CAUSES OF EXCEEDING REDLINE:

(14) Failed measurement.
(15) Loss of transducer vacuum chamber reference pressure.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
n = 1 FOR FORWARD RCS, 2 FOR LEFT RCS, AND 3 FOR RIGHT RCS									
UNITS-->	psia								
V42Pn541A	0.8	0	200	36					
V42Pn542A	0.8	0	200	36					
V42Pn543A	0.8	0	200	36					
V42Pn544A	0.8	0	200	36					
V42Pn545A	0.8	0	200	36					
V42Pn546A	0.8	0	200	36					
V42Pn547A	0.8	0	200	36					
V42Pn548A	0.8	0	200	36					
V42Pn549A	0.8	0	200	36					
V42Pn550A	0.8	0	200	36					
V42Pn551A	0.8	0	200	36					
V42Pn552A	0.8	0	200	36					
V42Pn553A	0.8	0	200	36					
V42Pn554A	0.8	0	200	36					

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 11.5 ARCS	SHEET 2	ZONE
	DWG NO 11.6 FRCS	SHEET 2	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-942099	SHEET 17/18	ZONE (FRCS)
	DWG NO VS70-943099	SHEET 34/48	ZONE (ARCS)

ELEMENT: Orbiter SUBSYSTEM: RCS

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LCC VIOLATION CALL: RCS Manifold Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V42P1212C	RCS-Fwd Ox Manf Press-1	1 of	(2)	(2)	psia	CI
V42P1214C	RCS-Fwd Ox Manf Press-2	2	(2)	(2)	psia	CI
V42P1216C	RCS-Fwd Ox Manf Press-3	1 of	(2)	(2)	psia	CI
V42P1218C	RCS-Fwd Ox Manf Press-4	2	(2)	(2)	psia	CI
V42P1312C	RCS-Fwd Fu Manf Press-1	1 of	(3)	(3)	psia	CI
V42P1314C	RCS-Fwd Fu Manf Press-2	2	(3)	(3)	psia	CI
V42P1316C	RCS-Fwd Fu Manf Press-3	1 of	(3)	(3)	psia	CI
V42P1318C	RCS-Fwd Fu Manf Press-4	2	(3)	(3)	psia	CI
V42P2212C	RCS-L Aft Ox Manf Press-1	1 of	(2)	(2)	psia	CI
V42P2214C	RCS-L Aft Ox Manf Press 2	2	(2)	(2)	psia	CI
V42P2216C	RCS-L Aft Ox Manf Press-3	1 of	(2)	(2)	psia	CI
V42P2218C	RCS-L Aft Ox Manf Press 4	2	(2)	(2)	psia	CI
V42P2312C	RCS-L Aft Fu Manf Press 1	1 of	(3)	(3)	psia	CI
V42P2314C	RCS-L Aft Fu Manf Press 2	2	(3)	(3)	psia	CI
V42P2316C	RCS-L Aft Fu Manf Press 3	1 of	(3)	(3)	psia	CI
V42P2318C	RCS-L Aft Fu Manf Press 4	2	(3)	(3)	psia	CI
V42P3212C	RCS-R Aft Ox Manf Press 1	1 of	(2)	(2)	psia	CI
V42P3214C	RCS-R Aft Ox Manf Press 2	2	(2)	(2)	psia	CI
V42P3216C	RCS-R Aft Ox Manf Press 3	1 of	(2)	(2)	psia	CI
V42P3218C	RCS-R Aft Ox Manf Press 4	2	(2)	(2)	psia	CI
V42P3312C	RCS-R Aft Fu Manf Press 1	1 of	(3)	(3)	psia	CI
V42P3314C	RCS-R Aft Fu Manf Press 2	2	(3)	(3)	psia	CI
V42P3316C	RCS-R Aft Fu Manf Press 3	1 of	(3)	(3)	psia	CI
V42P3318C	RCS-R Aft Fu Manf Press 4	2	(3)	(3)	psia	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) Oxidizer Manifold Pressure must be within +50/-30 psi of the Oxidizer Tank Ullage Pressure (V42P1115C, 2115C, 3115C) and Oxidizer Tank Out Pressure (V42P1210C, 2210C, 3210C) when the system is activated (when the tank and manifold valves are open).

REQUIREMENTS: (Continued)

(3) Fuel Manifold Pressure must be within +46/-34 psi of the Fuel Tank Ullage Pressure (V42P1116C, 2116C, 3116C) and Fuel Tank Out Pressure (V42P1310C, 2310C, 3310C) when the system is activated (when the tank and manifold valves are open).

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(4) Instrumentation Accuracy:

Manf Press	0-1000 =	+/-34 psi (3.4%)
Tank In/Tank Out	0-400 =	+/- 6 psi (1.4%)
		+/-40 psi

(5) Redline development:

	Fuel	Oxid
Head delta P	+6 psi	+10 psi
Instr Accuracy	+/-40 psi	+/-40 psi
Redline	-34/+46 psi	-30/+50 psi

CONSEQUENCES OF EXCEEDING REDLINE:

(6) First transducer failure - No consequence.
(7) Second transducer failure - Loss of leak detection capability leading to potential degraded vehicle control during entry.

CAUSES OF EXCEEDING REDLINE:

(8) Failed transducer.
(9) Valve failed closed.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1 FOR FORWARD RCS, 2 FOR LEFT RCS, AND 3 FOR RIGHT RCS									
UNITS-->	psia								
V42Pn212C	2.0	0	1000						
V42Pn214C	2.0	0	1000						
V42Pn216C	2.0	0	1000						
V42Pn218C	2.0	0	1000						
V42Pn312C	2.0	0	1000						
V42Pn314C	2.0	0	1000						
V42Pn316C	2.0	0	1000						
V42Pn318C	2.0	0	1000						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 11.6 SHEET 2 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-943099 SHEET 30/42 ZONE

ELEMENT: Orbiter SUBSYSTEM: RCS

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LCC VIOLATION CALL: RCS Crossfeed Valve Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V42X2236X	RCS-L Aft Ox Xfd Vlv-1/2 Op	3	OFF(3)	NA	Event	CI
V42X2336X	RCS-L Aft Fu Xfd Vlv-1/2 Op	of	OFF(3)	NA	Event	CI
V42X2252X	RCS-R Ox/Fu Xfd Vlv-1/2 Op - TB	3	OFF	NA	Event	CI
	-OR-	-OR-				
V42X3236X	RCS-R Aft Ox Xfd Vlv-1/2 Op	3	OFF(3)	NA	Event	CI
V42X3336X	RCS-R Aft Fu Xfd Vlv-1/2 Op	of	OFF(3)	NA	Event	CI
V42X2251X	RCS-L Ox/Fu Xfd Vlv 1/2 Op - TB	3	OFF	NA	Event	CI
V42X2238X	RCS-L Aft Ox Xfd Vlv-3/4/5 Op	3	OFF(3)	NA	Event	CI
V42X2338X	RCS-L Aft Fu Xfd Vlv-3/4/5 Op	of	OFF(3)	NA	Event	CI
V42X2254X	RCS-R Ox/Fu Xfd Vlv-3/4/5 Op - TB	3	OFF	NA	Event	CI
	-OR-	-OR-				
V42X3238X	RCS-R Aft Ox Xfd Vlv-3/4/5 Op	3	OFF(3)	NA	Event	CI
V42X3338X	RCS-R Aft Fu Xfd Vlv-3/4/5 Op	of	OFF(3)	NA	Event	CI
V42X2253X	RCS-L Ox/Fu Xfd Vlv 3/4/5 Op - TB	3	OFF	NA	Event	CI
V42X2237X	RCS-L Aft Ox Xfd Vlv-1/2 Cl		ON(4)	NA	Event	CI
V42X2239X	RCS-L Aft Ox Xfd Vlv-3/4/5 Cl		ON(4)	NA	Event	CI
V42X2337X	RCS-L Aft Fu Xfd Vlv-1/2 Cl		ON(4)	NA	Event	CI
V42X2339X	RCS-L Aft Fu Xfd Vlv-3/4/5 Cl		ON(4)	NA	Event	CI
V42X3237X	RCS-R Aft Ox Xfd Vlv-1/2 Cl		ON(4)	NA	Event	CI
V42X3239X	RCS-R Aft Ox Xfd Vlv-3/4/5 Cl		ON(4)	NA	Event	CI
V42X3337X	RCS-R Aft Fu Xfd Vlv-1/2 Cl		ON(4)	NA	Event	CI
V42X3339X	RCS-R Aft Fu Xfd Vlv-3/4/5 Cl		ON(4)	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) All valves must be functional and in the CLOSE position.

PREPLANNED CONTINGENCY PROCEDURE:

(3) Presence of OPEN indication - Verify switch is in GPC position (by crew or V42S2400E/2406E/2412E/2424E/3400E/3406E/3412E/3424E) and check position of the onboard TB. Close the Left OMS Crossfeed B valves and cycle suspect valve to clear the failure. Failure mechanism must be understood and valve must be functional before launch.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

(4) Lack of CLOSE indication - Verify panel switch is in GPC position (by crew or V42S2400E/2406E/2412E/2424E/3400E/3406E/3412E/3424E) and check position of the onboard talkback (TB).
   A. If TB indicates CLOSE, cause is assumed to be instrumentation failure, LCC violation cleared, continue countdown.
   B. If TB is barberpole (BP) or OPEN, close the Left OMS Crossfeed B valves and cycle suspect valve to clear the failure. Failure mechanism must be understood and valve must be functional before launch.

NOTES:

(5) The Abort Interconnect Sequence uses a combination of TB and microswitch (MS) indications to verify valve position. Presence of OPEN TB indication (V42X2251X/2253X/2252X/2254X) does not affect valve functionality.

REDLINE DERIVATION: CRITICALITY: 1R3

(6) Valve positions must be positively known. Microswitches must operate properly or valves may not function.
(7) Panel switches must be in GPC position to allow performance of auto-function required for abort dump interconnect or autocrossfeed during ascent.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Valve failed - Inability to perform abort dump properly or to crossfeed during ascent.
(9) Valve in wrong position - potential for transfer of propellant between OMS and RCS when OMS is in crossfeed.
(10) OPEN MS or TB failed -
   - Failed high MS results in loss of valve open redundancy.
   - Failed high MS or TB will not affect abort sequence operation.
   - Failed low MS will cause continuous valve power when valve commanded OPEN by panel switch or GPC.
   - Failed low MS or TB indication will cause the remaining valid measurement set for that valve to be single fault tolerant for 24 jet interconnected abort dump. If second failure occurs, which will not allow the RCS XFEED (1/2 or 3/4/5) valve to open, the smart interconnect capability will provide a 10 jet interconnected abort dump.
   - Crew insight to valve position may be affected.
(11) CLOSE MS failed -
   - CLOSE MS are not used by the Abort Interconnect Sequence.
   - Failed high MS will prevent valve from closing.
   - Failed low MS will not affect valve function, but valve will have continuous power when valve commanded CLOSE by panel switch or GPC.
(12) May not be two-failure tolerant for normal mission.

CAUSES OF EXCEEDING REDLINE:

(13) Panel switch in wrong position or instrumentation failure.

CAUSES OF EXCEEDING REDLINE: (Continued)

(14) Valve failure, procedural error, instrumentation failure, or valve control electronics failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 11.4	SHEET 1	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-943099	SHEET 29/43	ZONE

ELEMENT: Orbiter SUBSYSTEM: RCS

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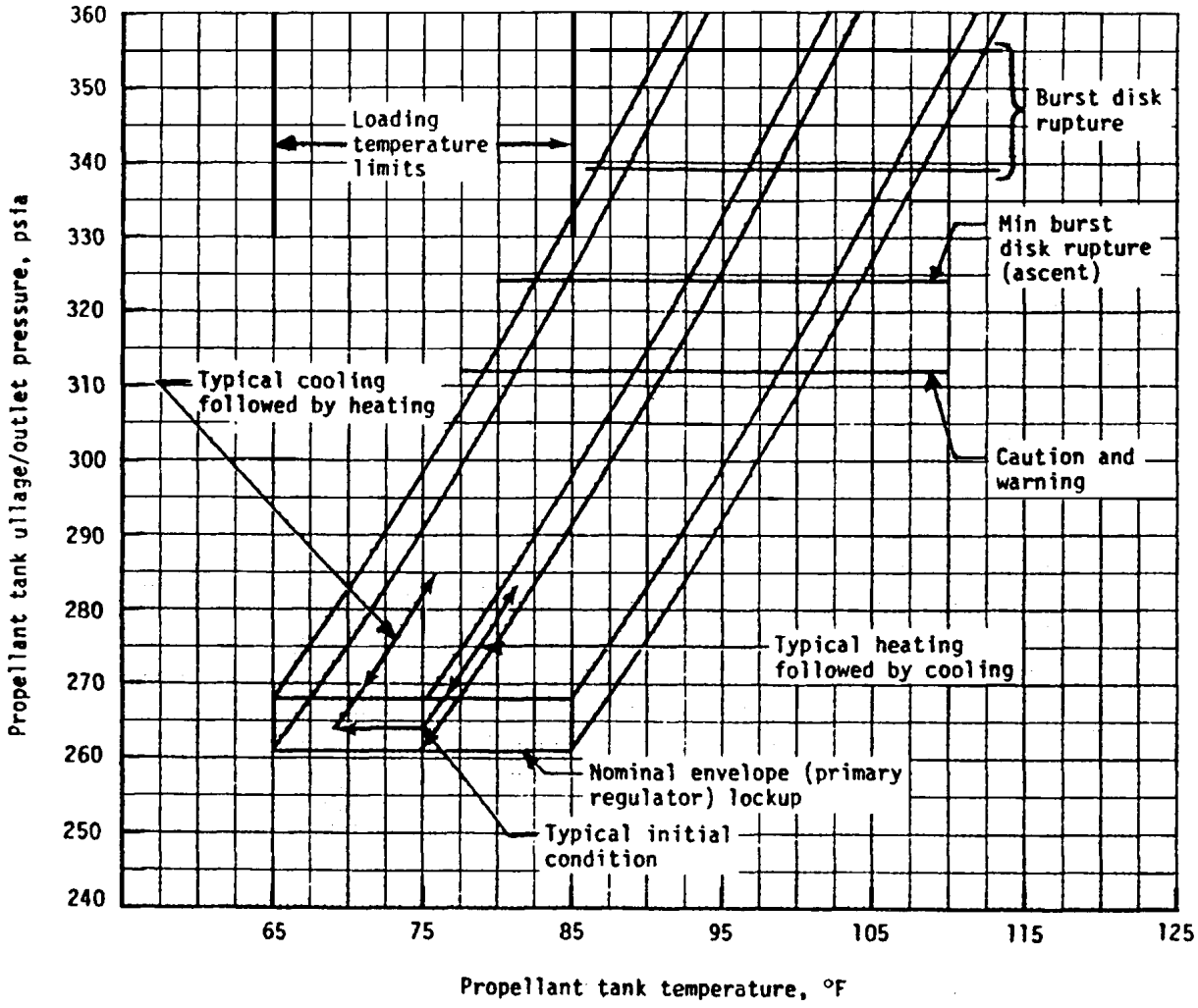

INFO ONLY

Fuel Tank Pressure Measurement		Fuel Tank Temperature Measurement	
Forward	V42P1116C (ullage)	Forward	V42T1300C
	V42P1310C (outlet)	Right Aft	V42T3300C
Right Aft	V42P3116C (ullage)	Left Aft	V42T2300C
	V42P3310C (outlet) DU		
Left Aft	V42P2116C (ullage)		
	V42P2310C (outlet)		

Figure 22-01 RCS Fuel Tank Ullage/Outlet Pressure Versus Temperature

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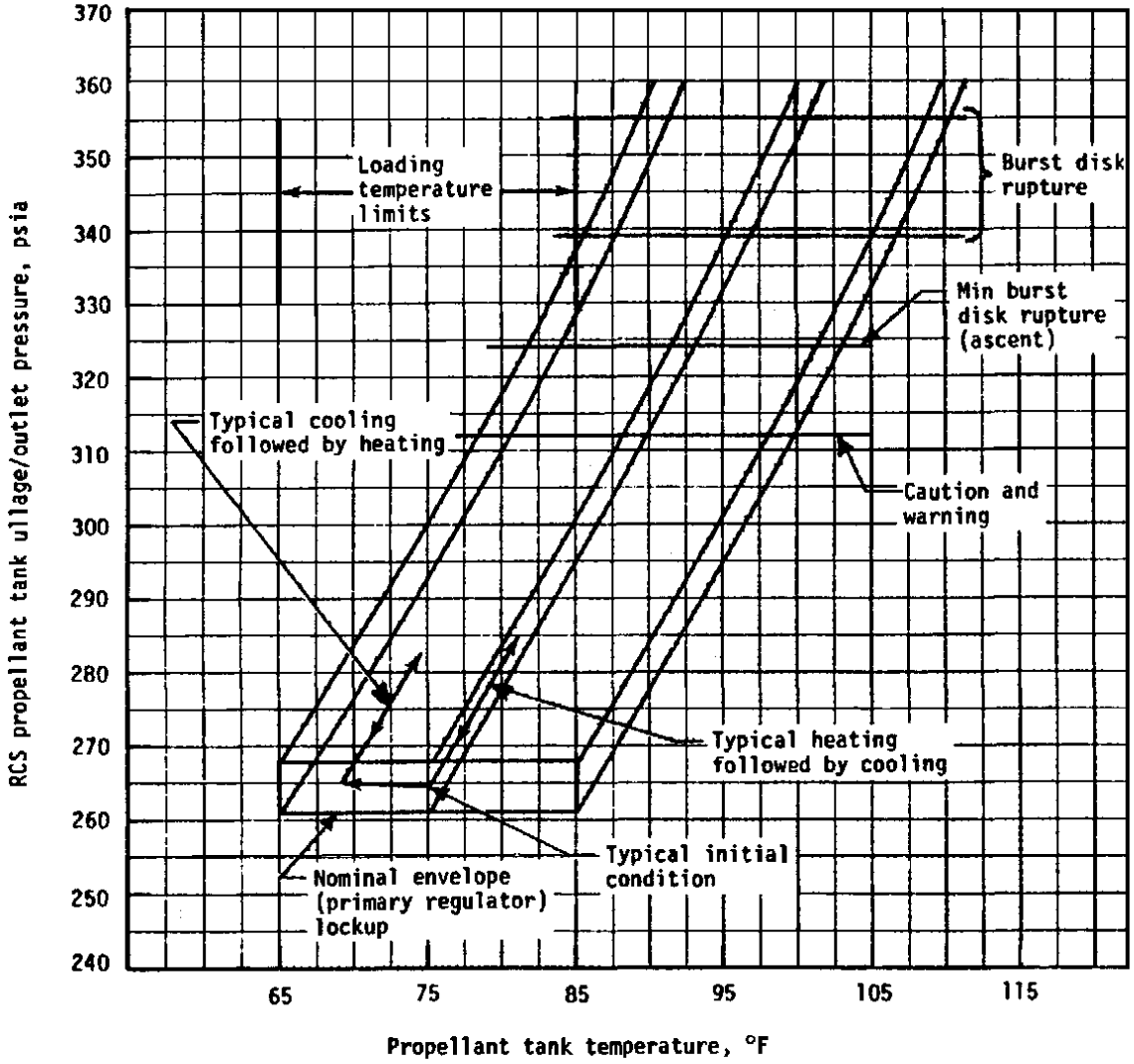

INFO ONLY

Oxidizer Tank	Pressure Measurement
Forward	V42P1115C (ullage)
	V42P1210C (outlet)
Right Aft	V42P3115C (ullage)
	V42P3210C (outlet)
Left Aft	V42P2115C (ullage)
	V42P2210C (outlet)

Oxidizer Tank	Temperature Measurement
Forward	V42T1200C
Right Aft	V42T3200C
Left Aft	V42T2200C

Figure 22-02 RCS Oxidizer Tank Ullage/Outlet Pressure Versus Temperature

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SECTION 23

ORBITAL MANEUVERING SYSTEM

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SECTION 23: ORBITAL MANEUVERING SYSTEM

SSID No.	Description/Violation Call	Page
OMS-01	OMS Helium Tank Pressure Anomaly	23-01.1
OMS-02	OMS Helium Isolation Valve Anomaly	23-02.1
OMS-03	OMS Vapor Isolation Valve Anomaly	23-03.1
OMS-04	OMS Engine Feedline Temperature Anomaly	23-04.1
OMS-05	OMS Ullage Pressure Anomaly	23-05.1
OMS-06	OMS Propellant Tank Isolation Valve Anomaly	23-06.1
OMS-07	OMS Crossfeed Valves Anomaly	23-07.1
OMS-08	OMS GN2 Tank Pressure Anomaly	23-08.1
OMS-09	OMS GN2 Regulator Pressure Anomaly	23-09.1
OMS-10	OMS GN2 Pressurization Valve Position Anomaly	23-10.1
OMS-11	OMS Engine Purge Valve Anomaly	23-11.1
OMS-12	OMS Engine Injector Temperature Anomaly	23-12.1
OMS-13	OMS Engine Inlet Pressure Anomaly	23-13.1
OMS-14	OMS Engine Chamber Pressure Anomaly	23-14.1
OMS-15	OMS Engine Bi-Propellant Valve Anomaly	23-15.1
OMS-16	OMS Pod Temperature Measurement Anomaly	23-16.1
OMS-17	OMS Crossfeed Temperature Measurement Anomaly	23-17.1
OMS-18	OMS Aft Gaging Probe Anomaly (REQUIREMENT DELETED)	23-18.1
OMS-FG01	Figure 23-01 OMS Pressure Correction vs. Propellant Load	23-FG01.1

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LCC VIOLATION CALL: OMS Helium Tank Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V43P4121C	OMS-L Pod He Tank Press 1		(3)	NA	psia	CI
V43P4122C	OMS-L Pod He Tank Press 2		(3)	NA	psia	CI
V43P5121C	OMS-R Pod He Tank Press 1		(3)	NA	psia	CI
V43P5122C	OMS-R Pod He Tank Press 2		(3)	NA	psia	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) To Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) One of two tank pressure measurements per pod acceptable for confirmed instrumentation failure. (4)
(3) Any decrease in tank pressure greater than 2 data bits (20 psi) without a corresponding temperature change must be evaluated. (5)

PREPLANNED CONTINGENCY PROCEDURE:

(4) For either pressure measurement in a tank indicating high or low, a nominal pressure indication from the corresponding measurement confirms instrumentation failure, LCC violation cleared, continue countdown.
(5) Both pressure measurements in a tank trending downward indicates a potential leak. Utilize tank temperature measurements, V43T4111C (left pod) or V43T5111C (right pod), for leak evaluation. Pod structural measurements, adjusted for thermal lag, may also be used for leak evaluation.

NOTES:

(6) Systems Management (SM) crew alert on pressure 2 measurement only.
(7) Ullage repressurization may result in helium tank temperature transient that may mask leak detection capability.

REDLINE DERIVATION: CRITICALITY: 1

(8) The redline detects helium tank leakage via pressure sensors located downstream of each tank in each pod. It ensures that adequate helium pressurant is available to complete a mission and provide system management capability.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Insufficient helium to complete mission.

CAUSES OF EXCEEDING REDLINE:

(10) Leakage upstream of helium isolation valve.
(11) Low ambient temperature.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 4 FOR LEFT OMS, 5 FOR RIGHT OMS									
UNITS-->	psia								
V43Pn121C	10.0	0	5000						
V43Pn122C	10.0	0	5000					1500	

METER/DISPLAY RANGE - MSID: V43Pn121C LOW: 0 HIGH: 5000
V43Pn122C LOW: 0 HIGH: 5000

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 11.3 SHEET 2 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-943099 SHEET 7/12/ ZONE OMS
DWG NO VS70-943099 SHEET 18/23 ZONE

ELEMENT: Orbiter SUBSYSTEM: OMS

LCC VIOLATION CALL: OMS Helium Isolation Valve Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V43X4152X	OMS-L Pod He Isln Vlv A Posn Op	(2)	OFF (3)	NA	Event	CI
V43X4154X	OMS-L Pod He Isln Vlv B Posn Op	(2)	OFF (3)	NA	Event	CI
V43X5152X	OMS-R Pod He Isln Vlv A Posn Op	(2)	OFF (3)	NA	Event	CI
V43X5154X	OMS-R Pod He Isln Vlv B Posn Op	(2)	OFF (3)	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) To Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown.
(3) If repressurization is in progress, valve position OP shall be ON. Cockpit switch should be in GPC position.

PREPLANNED CONTINGENCY PROCEDURE:

(4) An inadvertent OPEN by accidental switch to OPEN by crew or LPS command to the GPC is acceptable provided the configuration is corrected prior to launch.
(5) Ullage pressure (V43P4221C, 4321C, 5221C, 5321C) is a backup. If ullage pressure is less than lockup, false open indication can be detected. If ullage pressure does not increase during repressurization, failed closed valve can be detected.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(6) Valves A and B are operated individually if ullage repressurization is required. This is the only time a failed valve/measurement can be detected.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Valve failed open:
A. Loss of redundancy.
B. Loss of leak isolation capability.
C. Loss of ability to isolate dual failed-open regulators.

(8) Valve failed closed:
A. Loss of redundancy.
B. One remaining flow path for propellant tank pressurization.

CAUSES OF EXCEEDING REDLINE:

(9) Failed valve or valve control electronics.
(10) Failed measurement.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 11.3	SHEET 2	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-943099	SHEET 7/18	ZONE

ELEMENT: Orbiter SUBSYSTEM: OMS

LCC VIOLATION CALL: OMS Vapor Isolation Valve Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V43X4156X	OMS-L Pod Vapor Isln Vlv 1 Posn Op	(2)	OFF (3)	NA	Event	CI
V43X4158X	OMS-L Pod Vapor Isln Vlv 2 Posn Op	(2)	OFF (3)	NA	Event	CI
V43X5156X	OMS-R Pod Vapor Isln Vlv 1 Posn Op	(2)	OFF (3)	NA	Event	CI
V43X5158X	OMS-R Pod Vapor Isln Vlv 2 Posn Op	(2)	OFF (3)	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) To Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure or valve failed OPEN, LCC violation cleared, continue countdown. (4)
(3) If repressurization is in progress, valve position OP shall be ON.

PREPLANNED CONTINGENCY PROCEDURE:

(4) An inadvertent OPEN by accidental switch to OPEN by crew or LPS command to the GPC is acceptable provided the configuration is corrected prior to launch.
(5) Ullage pressure (V43P4221C, 5221C) is backup. If oxidizer ullage pressure rises during repressurization, valve function is verified. If ullage pressure does not increase during repressurization, failed closed valve can be detected.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(6) Valves 1 and 2 are operated individually if ullage repressurization is required. A single failed valve/measurement may be detected during this time.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Valve Failed Closed: A. Loss of redundancy.
B. One remaining path for oxidizer propellant pressurization.
(8) Valve Failed Open: No mission impact - continue.

CAUSES OF EXCEEDING REDLINE:

(9) Failed valve or valve control electronics.
(10) Failed measurement.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 11.3	SHEET 2	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-943099	SHEET 7/18	ZONE OMS

ELEMENT: Orbiter SUBSYSTEM: OMS

LCC VIOLATION CALL: OMS Engine Feedline Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V43T4641A	OMS-L Eng Ox Vlv Temp	(2)	38	117	deg F	CI
V43T4216A	OMS-L Pod Oxdzr Eng Inlet Temp	(2)	38	117	deg F	CI
V43T4642A	OMS-L Eng Fu Feedline Temp	(2)	38	117	deg F	CI
V43T5641A	OMS-R Eng Ox Vlv Temp	(2)	38	117	deg F	CI
V43T5216A	OMS-R Pod Oxdzr Eng Inlet Temp	(2)	38	117	deg F	CI
V43T5642A	OMS-R Eng Fu Feedline Temp	(2)	38	117	deg F	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) To Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) One of three acceptable for confirmed instrumentation failure. (3, 4)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Actual temperature may be verified by correlation to ambient internal purge/pod temperature.

NOTES:

(4) For heater operation, requirement for fuel and oxidizer inlet temperature is one of two mandatory (see LCC OMS-16).

REDLINE DERIVATION: CRITICALITY: 3

(5) Redline development:

	Minimum	Maximum
Engine qual limit for start		
Engine spec max temp	30 deg F	125 deg F
Instr error +/-5%	+ 8 deg F	- 8 deg F
Redline	38 deg F	117 deg F

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Violate engine specification limit.

CAUSES OF EXCEEDING REDLINE:

(7) Exposure to high or low temperature source.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 4 FOR LEFT OMS, 5 FOR RIGHT OMS									
UNITS-->	deg.F								
V43Tn641A	.6402	-.3684	159.7						
V43Tn216A	.6402	-.3684	159.7						
V43Tn642A	.6402	-.3684	159.7						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 11.3	SHEET 2	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-943009	SHEET 10/14/	ZONE
	DWG NO VS70-943009	SHEET 21/25	ZONE

ELEMENT: Orbiter SUBSYSTEM: OMS

LCC VIOLATION CALL: OMS Ullage Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V43P4221C	OMS-L Pod Oxdzr Tank Ullage Press	(2)	253	288	psia	CI
V43P4321C	OMS-L Pod Fuel Tank Ullage Press	(2)	253	288	psia	CI
V43P5221C	OMS-R Pod Oxdzr Tank Ullage Press	(2)	253	288	psia	CI
V43P5321C	OMS-R Pod FU Tank Ullage Press	(2)	253	288	psia	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) To Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) One of two measurements acceptable for confirmed instrumentation failure only. (6)
(3) Oxidizer/fuel measurements delta P limit (max) is 15 psi. (Instrumentation tolerance will not protect this limit.) (7)
(4) Burst disc rupture is not acceptable for launch. (9)
(5) Any pressure change of greater than 2 data bits without a corresponding temperature change indicates a leak and must be evaluated prior to launch.

PREPLANNED CONTINGENCY PROCEDURE:

(6) Inlet pressure (corrected for pressure head) are backup measurements prior to launch. (V43P4645C, 4646C, 5645C, 5646C)

NOTES:

(7) Use average of ullage and inlet (corrected for head pressure) pressures to reduce instrumentation tolerance. (Reference: Figure 23-01.)
(8) Ullage pressures are used for the following:
    A. The transducers are used in the automatic repressurization function for the OMS/RCS interconnect mode.
    B. The OMS FDA (Fault Detection and Annunciation) uses output from the transducers to provide C&W alert for tank leaks or overpressure. The alternative is constant crew monitoring.
    C. These measurements are necessary to determine the OMS system performance during crossfeed/interconnect operations.
(9) Burst disc rupture would leave relief valves as a single-point failure from being unable to use the propellant in the affected pod. (4)

REDLINE DERIVATION: CRITICALITY: 1

		Minimum		Maximum
(10)	Redline development			
	Min press for OMS eng start	238 psia	Min burst disc rupture	303 psia
	Instr error (+/- 3.74%)	+15 psia	Instr. error (+/-3.74%)	-15 psia
	Redline	253 psia		288 psia
	Ox/Fu delta P for Start Box	+/- 15 psi		
	Instr. tolerance	N/A (7)		
	Redline	15 psi		

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Maximum: Possible burst disc rupture allowing relief valve operation. (9)
(12) Minimum: Insufficient pressure for engine start.

CAUSES OF EXCEEDING REDLINE:

(13) Maximum: Solar heating - high ambient temperature. He isolation valve/ regulator leakage.
(14) Minimum: He/propellant leakage, helium absorption, low ambient temperature.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
n = 4 FOR LEFT OMS, 5 FOR RIGHT OMS									
UNITS-->	psia								
V43Pn221C	0.8	0	400	232	288	234	288		
V43Pn321C	0.8	0	400	232	288	234	288		

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 11.3 SHEET 2 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-943099 SHEET 7/12/ ZONE
DWG NO VS70-943099 SHEET 18/23 ZONE

ELEMENT: Orbiter SUBSYSTEM: OMS

LCC VIOLATION CALL: OMS Propellant Tank Isolation Valve Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V43X4252X	OMS-L Pod Ox Isln Vlv A Posn Op	(2)	ON (5)	NA	Event	CI
V43X4253X	OMS-L Pod Ox Isln Vlv A Posn Cl		OFF (4)	NA	Event	CI
V43X4254X	OMS-L Pod Ox Isln Vlv B Posn Op	(2)	ON (5)	NA	Event	CI
V43X4255X	OMS-L Pod Ox Isln Vlv B Posn Cl		OFF (4)	NA	Event	CI
V43X4352X	OMS-L Pod Fu Isln Vlv A Posn Op	(2)	ON (5)	NA	Event	CI
V43X4353X	OMS-L Pod Fu Isln Vlv A Posn Cl		OFF (4)	NA	Event	CI
V43X4354X	OMS-L Pod Fu Isln Vlv B Posn Op	(2)	ON (5)	NA	Event	CI
V43X4355X	OMS-L Pod Fu Isln Vlv B Posn Cl		OFF (4)	NA	Event	CI
V43X5252X	OMS-R Pod Ox Isln Vlv A Posn Op	(2)	ON (5)	NA	Event	CI
V43X5253X	OMS-R Pod Ox Isln Vlv A Posn Cl		OFF (4)	NA	Event	CI
V43X5254X	OMS-R Pod Ox Isln Vlv B Posn Op	(2)	ON (5)	NA	Event	CI
V43X5255X	OMS-R Pod Ox Isln Vlv B Posn Cl		OFF (4)	NA	Event	CI
V43X5352X	OMS-R Pod Fu Isln Vlv A Posn Op	(2)	ON (5)	NA	Event	CI
V43X5353X	OMS-R Pod Fu Isln Vlv A Posn Cl		OFF (4)	NA	Event	CI
V43X5354X	OMS-R Pod Fu Isln Vlv B Posn Op	(2)	ON (5)	NA	Event	CI
V43X5355X	OMS-R Pod Fu Isln Vlv B Posn Cl		OFF (4)	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) To Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown. (5)
(3) Valves must be functional. Cockpit switch should be in GPC position.

PREPLANNED CONTINGENCY PROCEDURE:

(4) Presence of CLOSED: fault must be cleared before launch. Attempt to cycle valve. If valve functions as required, place valve in OPEN position, LCC violation cleared, continue countdown. Valve will not operate with a failed-ON microswitch. Return switch to GPC position.
(5) Lack of OPEN: if switch is GPC and talkback is open, leave switch in GPC, LCC violation cleared, continue countdown (instrumentation failure).

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(6) Valve position indicators are used in the MCA logic to control valve operation. Redline protects against an instrumentation failure that leads to a hardware failure or inadvertent valve action.

CONSEQUENCES OF EXCEEDING REDLINE:

(7)	Failed on OPEN indication:	Loss of redundancy and potential loss of ability to open valve.
(8)	Failed off OPEN indication:	Continuous power to valve with switch in manual open position.
(9)	Failed on CLOSE indication:	Loss of ability to close valve.
(10)	Failed off CLOSE indication:	Continuous power to valve with switch in manual close position.
(11)	Failed open valve:	Unable to isolate propellant tank for crossfeed from other pod in case of engine failure; inability to crossfeed could result in insufficient propellant for deorbit.
(12)	Failed closed valve:	One failure away from loss of propellant supply.

CAUSES OF EXCEEDING REDLINE:

(13) Failed valve or valve control electronics.
(14) Failed measurement.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 11.3	SHEET 1	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-943099	SHEET 8/19	ZONE

ELEMENT: Orbiter SUBSYSTEM: OMS

LCC VIOLATION CALL: OMS Crossfeed Valves Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V43X4256X	OMS-L Pod Ox Xfd Vlv A Posn Op		OFF (3)	NA	Event	CI
V43X4257X	OMS-L Pod Ox Xfd Vlv A Posn Cl		ON (2)	NA	Event	CI
V43X4258X	OMS-L Pod Ox Xfd Vlv B Posn Op		(4)	NA	Event	CI
V43X4259X	OMS-L Pod Ox Xfd Vlv B Posn Cl		(4)	NA	Event	CI
V43X4356X	OMS-L Pod Fu Xfd Vlv A Posn Op		OFF (3)	NA	Event	CI
V43X4357X	OMS-L Pod Fu Xfd Vlv A Posn Cl		ON (2)	NA	Event	CI
V43X4358X	OMS-L Pod Fu Xfd Vlv B Posn Op		(4)	NA	Event	CI
V43X4359X	OMS-L Pod Fu Xfd Vlv B Posn Cl		(4)	NA	Event	CI
V43X5256X	OMS-R Pod Ox Xfd Vlv A Posn Op		OFF (3)	NA	Event	CI
V43X5257X	OMS-R Pod Ox Xfd Vlv A Posn Cl		ON (2)	NA	Event	CI
V43X5258X	OMS-R Pod Ox Xfd Vlv B Posn Op		OFF (3)	NA	Event	CI
V43X5259X	OMS-R Pod Ox Xfd Vlv B Posn Cl		ON (2)	NA	Event	CI
V43X5356X	OMS-R Pod Fu Xfd Vlv A Posn Op		OFF (3)	NA	Event	CI
V43X5357X	OMS-R Pod Fu Xfd Vlv A Posn Cl		ON (2)	NA	Event	CI
V43X5358X	OMS-R Pod Fu Xfd Vlv B Posn Op		OFF (3)	NA	Event	CI
V43X5359X	OMS-R Pod Fu Xfd Vlv B Posn Cl		ON (2)	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) To Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) CL (closed) microswitch failed OFF acceptable for confirmed instrumentation failure. (7)
(3) OP (open) microswitch failed ON acceptable for confirmed instrumentation failure. (8)
(4) Required configuration dependent on point in countdown:

	From T-6 Hrs. to closure at T-3 Hrs. and counting	From closure at T-3 Hrs. and counting to T-9 min.
OMS-L Pod Ox Xfd Vlv B Posn Op	ON (5)	OFF*(3)
OMS-L Pod Ox Xfd Vlv B Posn Cl	OFF(6)	ON**(2)
OMS-L Pod Fu Xfd Vlv B Posn Op	ON (5)	OFF*(3)
OMS-L Pod Fu Xfd Vlv B Posn Cl	OFF(6)	ON**(2)

* ON if the valve has been opened due to a failed microswitch on the other valve of the same pair.
** OFF if the valve has been opened due to a failed microswitch on either valve of the same pair.

REQUIREMENTS: (Continued)

(5) For confirmed instrumentation failure, set the corresponding OMS B Mask Flag. One and only one mask may be set. (9)
(6) CL (closed) microswitch failed ON acceptable for confirmed instrumentation failure. (10)

PREPLANNED CONTINGENCY PROCEDURE:

(7) If onboard talkback (panel O8) indicates proper valve position (CLOSED), instrumentation failure is confirmed, LCC violation cleared, continue countdown. If onboard talkback is BARBERPOLE (BP) or OPEN, cycle valve open and then back to closed in an attempt to clear failure and verify valve operation. Valve operation can be verified by monitoring Motor Control Assembly (MCA) status. If valve operation is confirmed, LCC violation cleared, continue countdown.
(8) If onboard talkback (panel O8) indicates proper valve position (CLOSED), instrumentation failure is confirmed, LCC violation cleared, continue countdown. If onboard talkback is BP or OPEN, cycle valve open and then back to closed in an attempt to clear failure and verify valve operation. Valve operation can be verified by monitoring MCA status. If valve operation is confirmed and microswitch indicates OP when valve is open, then place valve in OPEN position and return switch to GPC. LCC violation cleared, continue countdown.
(9) If onboard talkback (panel O8) indicates proper valve position (OPEN), instrumentation failure is confirmed. If onboard talkback is BARBERPOLE (BP) or CLOSED, cycle valve closed and then back to open in an attempt to clear failure and verify valve operation. Valve operation can be verified by monitoring Motor Control Assembly (MCA) status. If valve operation is confirmed but the valve position discrete still indicates a failed condition, set the corresponding OMS B Mask Flag for the failed discrete using a Launch Sequence Command to PASS G9 software, and transfer to the BFS via the One-Shot Data Transfer. Only one OMS B Mask flag may be set to allow the software to use the correct valve position for the valve with the faulty microswitch. Leave the valve pair with the failed microswitch OPEN (with cockpit switch in GPC) for launch. LCC violation cleared, continue countdown.
(10) Cycle valve to closed and back to open, confirming valve operation by monitoring MCA status. Valve will not operate with a failed-on microswitch. If MCA status indicates proper valve operation then instrumentation failure is confirmed, LCC violation cleared, continue countdown.

NOTES:

(11) Prior to T-3 hours and counting, the LH Pod B leg valves will be OPEN to provide ullage for the crossfeed line. After T-3 hours and counting, the LH Pod B leg valves will be closed for launch. For the case of OPEN microswitch failed OFF, the valve is left in the OPEN position to retain one-fault tolerance on the OPEN function.

REDLINE DERIVATION: CRITICALITY: 1R

(12) a. SSID Intent Summary - The OMS crossfeed valve indicators are used in the MCA logic to control valve operation. The OMS crossfeed valve OPEN indicators are also used by the abort software to determine the feasibility of an interconnected dump. Launch is allowed for a confirmed instrumentation failure that does not affect valve function (by cockpit switch and during automatic abort dump), thus maintaining one-fault tolerance for launch.

b. Voting Logic - NA

c. Minimum Redline Development - The redline defines the nominal valve configurations for launch.

d. Time Effectivity - Ending time effectivity of T-9 minutes was chosen based on the fact that the OMS is configured for launch and functionally stable prior to T-9 minutes.

e. Requirements - All OMS crossfeed valves must operate. Valve position indicator failures are allowed under some circumstances as described below.

OPEN microswitch failed ON: Indicates loss of redundant microswitch and potential loss of valve function if other microswitch fails.

OPEN microswitch failed OFF: Abort interconnect system commands OMS crossfeed valves open and monitors whether both valves (1 oxidizer, 1 fuel) open. If either valve does not indicate open, abort system considers valve set as non-operational, leaving system zero-fault tolerant. Setting the corresponding OMS B Mask Flag, once the valve function has been verified and the valve opened for launch, will retain redundancy.

CLOSED microswitch failed ON: Failure of microswitch itself could prevent MCA from closing valve. Other causes of indication that preserve valve function are allowed.

CLOSED microswitch failed OFF: Failure of microswitch has minimal impact on operations if valve is functional.

f. Preplanned Contingency Procedures - In cases where instrumentation failures are permitted, these procedures provide means to confirm that valve operates and failure is of instrumentation only. For the case of OPEN microswitch failed ON, the valve is left in the OPEN position to retain one-fault tolerance on the OPEN function.

CONSEQUENCES OF EXCEEDING REDLINE:

(13)	Failed ON open indication:	Loss of redundancy and potential loss of ability to open valve.
(14)	Failed OFF open indication:	Abort interconnect will not see valve as open and will consider that valve set as non-operational. Redundancy may be retained by setting the OMS B Mask. 1 fault tolerance required.

CONSEQUENCES OF EXCEEDING REDLINE: (Continued)

(15) Failed ON close indication: Loss of ability to close valve.
(16) Failed OFF close indication: Continuous power to valve with switch in manual close position.
(17) Failed open valve: Must use tank valves to isolate OMS and RCS.
(18) Failed closed valve: Loss of system redundancy for abort dump.
(19) Reference Orbiter Hazard Report ORBI-165, ORBI-183, ORBI-501.

CAUSES OF EXCEEDING REDLINE:

(20) Failed valve or valve control electronics.
(21) Failed measurement.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 11.4	SHEET 1	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-943099	SHEET 9/20	ZONE

ELEMENT: Orbiter SUBSYSTEM: OMS

LCC VIOLATION CALL: OMS GN2 Tank Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V43P4547C	OMS-L Eng Pneu Supply Press 1	(2)	(3)	NA	psia	CI
V43P4548C	OMS-L Eng Pneu Supply Press 2	(2)	(3)	NA	psia	CI
V43P5547C	OMS-R Eng Pneu Supply Press 1	(2)	(3)	NA	psia	CI
V43P5548C	OMS-R Eng Pneu Supply Press 2	(2)	(3)	NA	psia	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) To Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) One of two measurements per group acceptable for confirmed instrumentation failure only. (4)
(3) Any pressure change of greater than 2 data bits without a corresponding temperature change indicates a potential leak and must be evaluated prior to launch. A pressure drop during OMS activation at T-30 minutes is expected and acceptable. (5)

PREPLANNED CONTINGENCY PROCEDURE:

(4) For measurements indicating off scale high or low, functioning erratically or exhibiting a step function change, and there is a nominal pressure indication from a corresponding measurement, instrumentation failure is confirmed, LCC violation cleared, continue countdown.
(5) Utilize fuel injector temperature (V43T4643A and V43T5643A) and/or oxidizer valve temperatures (V43T4641A and V43T5641A) for indication of engine compartment temperature for tank leak evaluation. For pressure changes attributable to a drop in temperature, LCC violation cleared, continue countdown.

NOTES:

(6) Systems Management (SM) crew alert on pressure 2 measurement only.
(7) Activation at T-30 minutes will cause approximately 110 psi pressure decrease and a temperature transient that may mask minor leakage.
(8) Tank pressure of no less than 1900 psia provides at least 10 engine starts/purges.

REDLINE DERIVATION: CRITICALITY: 1R

(9) a. SSID Intent Summary - This instrumentation is used to determine the gaseous nitrogen (GN2) quantity available for performing OMS engine starts and purges. Monitoring GN2 supply pressure allows for leak detection. The LCC protects against launching with a leak in the GN2 supply bottle, thereby ensuring adequate GN2 pressurant for mission completion. (GN2 supply requirement is mission-dependent). For confirmed instrumentation

REDLINE DERIVATION: (Continued)

failure, the remaining redundant sensor provides insight into the GN2 supply pressure.

b. Voting Logic - Insight into GN2 supply pressure is retained after failure of first GN2 supply pressure instrumentation per engine.

c. Minimum Redline Development - The two-bit minimum change filters out insignificant instrumentation errors ("bit-flipping"). Since the GN2 system is a closed system, external temperature changes will produce corresponding pressure changes. Pressure changes corresponding to such temperature changes are allowed. The expected pressure drop that occurs when the GN2 isolation valve is opened at T-30 minutes is specifically allowed.

d. Time Effectivity - Ending time effectivity of T-9 minutes was chosen based on the fact that the OMS is configured for launch and functionally stable prior to T-9 minutes.

e. Requirements - A pressure change due to external temperature change or OMS activation at T-30 minutes is acceptable. A pressure drop due to GN2 leakage is not.

f. Preplanned Contingency Procedures - These procedures provide directions for identifying instrumentation failures and guidance for determining whether a pressure change is due to external temperature change. If neither PCP is satisfied, a GN2 leak has been identified.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Insufficient GN2 to complete mission.

CAUSES OF EXCEEDING REDLINE:

(11) Pneumatic system Leak.
(12) Instrumentation failure.
(13) Exposure to low ambient temperature.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
n = 4 FOR LEFT OMS, 5 FOR RIGHT OMS									
UNITS-->	psia								
V43Pn548C	10	0	5000					1200	
V43Pn547C	10	0	5000						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 11.3	SHEET 2	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-943099	SHEET 10/12/	ZONE
	DWG NO VS70-943099	SHEET 21/23	ZONE

ELEMENT: Orbiter SUBSYSTEM: OMS

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LCC VIOLATION CALL: OMS GN2 Regulator Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V43P4549C	OMS-L Eng Rgltr Out Press	(2)	314	391	psia	CI
V43P5549C	OMS-R Eng Rgltr Out Press	(2)	314	391	psia	CI

TIME PERIOD:

(1) From Engine "Arm for Launch" (T-30 minutes) To Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown. (4)

PREPLANNED CONTINGENCY PROCEDURE:

(3) For loss of either measurement, it is required that the accumulator be dumped for a launch recycle.
(4) Backup is GN2 bottle pressure. Check delta P at activation. (See SSID OMS-08 for GN2 bottle pressure measurement numbers.)

NOTES:

(5) Pressure greater than 449 psia indicates loss of GN2 through relief valve.

REDLINE DERIVATION: CRITICALITY: 1R

(6) To determine regulator operations:

	Maximum		Minimum
Max regulator lockup	360 psig	Min regulator set point	315 psig
Instrumentation error	+16 psi	Instrumentation error	-16 psi
Ambient pressure	+15 psia	Ambient pressure	+15 psia
Redline	391 psia	Redline	314 psia

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Maximum: A. Indicates regulator malfunction. (5)
B. Loss of GN2 through the relief valve.
(8) Minimum: A. Indicates regulator malfunction.
B. Insufficient pressure to operate engine valves.

CAUSES OF EXCEEDING REDLINE:

(9) Maximum: A. Failed regulator.
B. Failed measurement.
(10) Minimum: A. Failed regulator.
B. Failed measurement.
C. Blocked flow path.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	psia								
V43P4549C	1.0	0	500					299	434
V43P5549C	1.0	0	500					299	434

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 11.3 SHEET 2 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-943099 SHEET 10/21 ZONE

ELEMENT: Orbiter SUBSYSTEM: OMS

LCC VIOLATION CALL: OMS GN2 Pressurization Valve Position Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V43X4552X	OMS-L Eng Press Vlv Posn Op	(2)	ON	NA	Event	CI
V43X5552X	OMS-R Eng Press Vlv Posn Op	(2)	ON	NA	Event	CI

TIME PERIOD:

(1) From Engine "Arm for Launch" (T-30 minutes) To Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Verify regulator outlet pressure increased at activation. (See SSID OMS-09 for measurement numbers.)

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(4) To verify valve operation.
(5) If the valve has failed CLOSED, no rise in pressure will occur in the downstream manifold during prelaunch pressurization.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Valve failed closed: Maximum of one engine start remaining; no start available if regulator outlet pressure did not increase.

CAUSES OF EXCEEDING REDLINE:

(7) Failed valve or valve control electronics.
(8) Failed measurement.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 11.3 SHEET 1 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-943099 SHEET 10/21 ZONE

ELEMENT: Orbiter SUBSYSTEM: OMS

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LCC VIOLATION CALL: OMS Engine Purge Valve Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V43X4558X	OMS-L Eng Purge Vlv 1 Posn Op	(2)	OFF (4)	NA	Event	CI
V43X4559X	OMS-L Eng Purge Vlv 2 Posn Op	(2)	OFF (4)	NA	Event	CI
V43X5558X	OMS-R Eng Purge Vlv 1 Posn Op	(2)	OFF (4)	NA	Event	CI
V43X5559X	OMS-R Eng Purge Vlv 2 Posn Op	(2)	OFF (4)	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) To Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown.
(3) Both valves are required to be CLOSED before launch.

PREPLANNED CONTINGENCY PROCEDURE:

(4) If indication changes to ON with no ON CMD, check for valve or instrumentation failure by opening other valve and check for purge. If no purge, instrumentation is failed, LCC violation cleared, continue countdown. If purge valve failed OPEN, repair prior to launch. This is valid only when in OPS-9 configuration.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1

(5) Redline required to protect against loss of GN2 pressurant for operation of engine ball valves.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Valve failed open: Failure of other purge valve OPEN - loss of GN2 and use of engine.
(7) Valve Failed close: Criticality 1 for aborts requiring post-MECO dump (inability to restart without purge). For normal operations, constrained to 10 minute coast between burns.

CAUSES OF EXCEEDING REDLINE:

(8) Failed valve or valve control electronics.
(9) Failed measurements.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 11.3	SHEET 2	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-943099	SHEET 10/21	ZONE

ELEMENT: Orbiter SUBSYSTEM: OMS

LCC VIOLATION CALL: OMS Engine Injector Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V43T4643A	OMS-L Eng Fuel Injector Temp		(2)	(3)	deg F	CI
V43T5643A	OMS-R Eng Fuel Injector Temp		(4)	(5)	deg F	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) To Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) Avg of V43T4641A, 4642A, 4216A as available less 19 degrees instrumentation error. (6)
(3) Avg of V43T4641A, 4642A, 4216A as available plus 19 degrees instrumentation error. (6)
(4) Avg of V43T5641A, 5642A, 5216A as available less 19 degrees instrumentation error. (6)
(5) Avg of V43T5641A, 5642A, 5216A as available plus 19 degrees instrumentation error. (6)

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(6) These values are guidelines for indication of instrumentation failure. (7)

REDLINE DERIVATION: CRITICALITY: 1

(7) The measurements are required because:
A. Mission rules require a manual OME shutdown if temperatures violate safe operating limits.
B. Excessive injector temperature indicates impending uncontained engine damage.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Maximum: Inability to use engine or unnecessary shutdown of a good engine.
(9) Minimum: Inability to use engine or possible engine damage from failure to shutdown failed engine.

CAUSES OF EXCEEDING REDLINE:

(10) Failed measurement.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	deg.F								
V43T4643A	1.499	-76.65	298.1						260
V43T5643A	1.499	-76.65	298.1						260

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 11.3 SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-943099 SHEET 11/22 ZONE

ELEMENT: Orbiter SUBSYSTEM: OMS

LCC VIOLATION CALL: OMS Engine Inlet Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V43P4645C	OMS-L Eng Ox Inlet Press		NA	NA	psia	CI
V43P4646C	OMS-L Eng Fu Inlet Press		NA	NA	psia	CI
V43P5645C	OMS-R Eng Ox Inlet Pressure		NA	NA	psia	CI
V43P5646C	OMS-R Eng Fu Inlet Pressure		NA	NA	psia	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) A change in OMS Eng Inlet Pressure of more than 2 data bits (1 bit = 0.8 psi) without a corresponding change in Pod Tank Ullage Pressure indicates instrumentation failure and must be evaluated. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) For confirmed instrumentation failure, if the performance of the associated OMS engine during the previous flight was nominal and there has been no subsequent intrusion into associated propellant tank or feedline to the Orbiter Maneuvering Engine (OME), LCC violation cleared, continue countdown.

NOTES:

(4) Reference SSID: OMS-05 for Pod Tank Ullage Pressure MSIDs.

REDLINE DERIVATION: CRITICALITY: 1

(5) This SSID ensures that the OMS Inlet Pressure measurements are functioning properly.
(6) There is no other measurement to backup inlet pressure during an OMS burn. Crew action will be required if the inlet pressures exceed the redlines.
(7) Nominal flight OME performance confirms that no foreign materials large enough to block the propellant supply are in the system. If the propellant system is not opened for maintenance between flights, then blockage is not credible and the inlet pressure measurement is not required. The crew should assume "engine fail" during diagnostic procedures that normally use the failed measurement for fault isolation.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Will be unable to properly monitor OME operation on orbit.
(9) Unable to distinguish between propellant and engine fail during OMS burn.

CAUSES OF EXCEEDING REDLINE:

(10) Failed measurement.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 4 FOR LEFT OMS, 5 FOR RIGHT OMS									
UNITS-->	psia								
V43Pn645C	0.8	0	400						
V43Pn646C	0.8	0	400						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 11.3 SHEET 2 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-943099 SHEET 10/12/ ZONE
DWG NO VS70-943099 SHEET 21/23 ZONE

ELEMENT: Orbiter SUBSYSTEM: OMS

LCC VIOLATION CALL: OMS Engine Chamber Pressure Anomaly | EMERG COND:

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V43P4649C	OMS-L Eng Chamber Pressure		6.6	17.4	%	CI
V43P5649C	OMS-R Eng Chamber Pressure		6.6	17.4	%	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) To Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) These measurements are required because:
A. OMS Pc is the primary cue to detect OME failure during an abort dump. Continued use of a failed OME may cause uncontained engine damage.
B. On orbit, the OMS Pc is the primary method of detecting a failure during an OMS burn, and the crew is trained to monitor this measurement (although there are backups).
C. A failed measurement (high or low) will cause a false alarm each time an engine is fired.
D. Per mission rules, an OME with a Pc transducer failed to greater than 80% will not be used for noncritical burns.
E. Pc is the primary measurement used in evaluating engine performance.

REDLINE DERIVATION: CRITICALITY: 1

(3) Maximum/Minimum: Incorrect information to OMS engine (failure detection and identification) (FDI).

(4) Redline development:

	Maximum	Minimum
Atmospheric pressure	12 %	12 %
Instrumentation error (3.38% FS)	+ 5.4%	- 5.4%
Redline	17.4%	6.6%

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Maximum: Possible engine damage from failure to shutdown engine.
(6) Minimum: Unnecessary shutdown of good engine.

CAUSES OF EXCEEDING REDLINE:

(7) Failed measurement.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	pcnt								
V43P4649C	0.32	0	160			80%			
V43P5649C	0.32	0	160			80%			

METER/DISPLAY RANGE - MSID: V43P4649 LOW: 0 HIGH: 160
V43P5649 LOW: 0 HIGH: 160

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 11.3 SHEET 2 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-943099 SHEET 11/12/ ZONE
DWG NO VS70-943099 SHEET 22/23 ZONE

ELEMENT: Orbiter SUBSYSTEM: OMS

LCC VIOLATION CALL: OMS Engine Bi-Propellant Valve Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V43H4655C	OMS-L Eng Bi-Prop Vlv 1 Posn Op		NA	NA	%	CI
V43H4656C	OMS-L Eng Bi-Prop Vlv 2 Posn Op		NA	NA	%	CI
V43H5655C	OMS-R Eng Bi-Prop Vlv 1 Posn Op		NA	NA	%	CI
V43H5656C	OMS-R Eng Bi-Prop Vlv 2 Posn Op		NA	NA	%	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) To Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) No change to the calibrated CLOSED position greater than 2 data bits (0.4%).

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) Failed CLOSED will not be detected before launch because valve is not cycled.
(4) To support flight mission rule - an OME with a failed OPEN ball valve (5%-8% post burn) will not be used unless the remaining OME has failed and only for the deorbit burn. This applies post OMS-1.

REDLINE DERIVATION: CRITICALITY: 1R

(5) This redline ensures that the ball valves are in the closed position. Since the system is stable, any change in ball valve position indicates a problem with the OME which should be evaluated.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Failed OPEN ball valve: Engine in affected pod is unusable.

CAUSES OF EXCEEDING REDLINE:

(7) Failed OPEN valve.
(8) Failed measurement.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 4 FOR LEFT OMS, 5 FOR RIGHT OMS									
UNITS-->	pcnt								
V43Hn655C	.2376	-.1864	100.1						
V43Hn656C	.2376	-.1864	100.1						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 11.3 SHEET 2 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-943099 SHEET 10/21 ZONE

ELEMENT: Orbiter SUBSYSTEM: OMS

LCC VIOLATION CALL: OMS Pod Temperature Measurement Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V43T5700A	OMS-R Pod RCS Press Pnl Sprt Tmp 1	1 of	67	98	deg F	CI
V43T5710A	OMS-R Pod RCS Press Pnl Sprt Tmp 2	2	67	98	deg F	CI
V43T5702A	OMS R Pod Upper Y-Web Otbd Temp	1 of	67	98	deg F	CI
V43T5703A	OMS R Pod Upper Y-Web Inbd Temp	2	67	98	deg F	CI
V43T5704A	OMS-R Pod Ox Drain Pnl T-1 Dsc OR1	1 of	67	98	deg F	CI
V43T5705A	OMS-R Pod Ox Drain Pnl Temp 2	2	67	98	deg F	CI
V43T5708A	OMS-R Pod Ox/He TP Ftg T-1 Dsc OR1	1 of	67	98	deg F	CI
V43T5718A	OMS-R Pod Ox/He Test Port Ftg T 2	2	67	98	deg F	CI
V42T3304A	RCS-R Aft Hsg Therm SW T-1 DSC OR2	1 of	67(3)	98(3)	deg F	CI
V42T3305A	RCS-R Aft Housing Therm Sw Temp 2	2	67(3)	98(3)	deg F	CI
V43T5701A	OMS-R Pod RCS Hsg Vernier Cmpt T 1	1 of	67	98	deg F	CI
V43T5711A	OMS-R RCS Hsg Ver Cmpt T-2 Dsc OR2	2	67	98	deg F	CI
V43T5706A	OMR-R Pod GSE Service Pnl Temp		67	98	deg F	CI
V43T5707A	OMS-R Pod Eng Svc Pnl Temp Dsc OR2		67	98	deg F	CI
V43T5642A	OMS R Eng Fu Feedline Temp	1 of	67	98	deg F	CI
V43T5216A	OMS-R Pod Oxdzr Eng Inlet Temp	3	67	98	deg F	CI
V43T5720A	OMS-R Eng Cvr Thermostat Temp		67	98	deg F	CI
V43T4701A	OMS-L Pod RCS Hsg Vernier Cmpt T 1	1 of	67	98	deg F	CI
V43T4711A	OMS-L Pod RCS Hsg Vernier Cmpt T 2	2	67	98	deg F	CI
V42T2304A	RCS-L Aft Hsg Therm Sw T-1 Dsc OL2	1 of	67(3)	98(3)	deg F	CI
V42T2305A	RCS-L Aft Hsg Therm Sw T-2 Dsc OL2	2	67(3)	98(3)	deg F	CI
V43T4700A	OMS-L Pod RCS Press Pnl Sprt Tmp 1	1 of	67	98	deg F	CI
V43T4710A	OMS-L Pod RCS Press Pnl Sprt Tmp 2	2	67	98	deg F	CI
V43T4702A	OMS L Pod Upper Y-Web Otbd Temp	1 of	67	98	deg F	CI
V43T4703A	OMS L Pod Upper Y-Web Inbd Temp	2	67	98	deg F	CI
V43T4704A	OMS-L Pod Ox Drain Pnl T-1 Dsc OL1	1 of	67	98	deg F	CI
V43T4705A	OMS-L Pod Ox Drain Pnl Temp 2	2	67	98	deg F	CI
V43T4706A	OMS L Pod GSE Service Pnl Temp		67	98	deg F	CI
V43T4707A	OMS-L Pod Eng Svc Pnl Temp Dsc OL2		67	98	deg F	CI

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	(Concluded)					
V43T4708A	OMS-L Pod Ox/He TP Ftg T-1 Dsc OL1	1 of	67	98	deg F	CI
V43T4718A	OMS-L Pod Ox/He Test Port Ftg T 2	2	67	98	deg F	CI
V43T4642A	OMS L Eng Fu Feedline Temp	1 of	67	98	deg F	CI
V43T4216A	OMS-L Pod Oxdzr Eng Inlet Temp	3	67	98	deg F	CI
V43T4720A	OMS-L Pod Eng Cvr Thermostat Temp		67	98	deg F	CI

TIME PERIOD:

(1) From Start of Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) If redline is exceeded as a result of GSE purge gas temperature out of tolerance, then there are no consequences for pod heater operation, LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) RCS measurements V42T3304A, 3305A, 2304A, and 2305A are included here because they are part of the pod heater system.

REDLINE DERIVATION: CRITICALITY: 2R

(4) Measurements are required for monitoring heater performance on orbit.

(5) Redline development:

	Minimum	Maximum
Temperature with active purge	75 deg F	90 deg F
Instrumentation error	-8	+8
Redline	67 deg F	98 deg F

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Inability to monitor heater operation in-flight. System temperature limits may be violated.

CAUSES OF EXCEEDING REDLINE:

(7) Instrumentation failure or purge gas temperature out of tolerance.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 4 FOR LEFT OMS, 5 FOR RIGHT OMS									
UNITS-->	deg.F								
V43Tn720A	.6402	-.3684	159.7						
V43Tn700A	.6402	-.3684	159.7						
V43Tn710A	.9935	-73.91	174.5						
V43Tn702A	.6402	-.3684	159.7						
V43Tn703A	.6402	-.3684	159.7						
V43Tn704A	.6402	-.3684	159.7						
V43Tn705A	.6402	-.3684	159.7						
V43Tn216A	.6402	-.3684	159.7						
V43Tn642A	.6402	-.3684	159.7						
V43Tn708A	.9935	-73.91	174.5						
V43Tn718A	.9935	-73.91	174.5						
V43Tn701A	.6402	-.3684	159.7						
V43Tn707A	.6402	-.3684	159.7						
V43Tn711A	1.0	-.7958	249.1						
n = 2 FOR LEFT RCS, AND 3 FOR RIGHT RCS									
V42Tn304A	.6402	-.3684	159.7						
V42Tn305A	.9935	-73.91	174.5						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 11.8 SHEET ZONE P5
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-943099 SHEET 14/25 ZONE

ELEMENT: Orbiter SUBSYSTEM: OMS

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LCC VIOLATION CALL: OMS Crossfeed Temperature Measurement Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	Bleed and Drainline Heaters					
V43T6230A	OMS QD PNL Ox Hi Pt Bld Ln Temp	(2,3	43	107	deg F	CI
V43T6234A	OMS Bhd Fu Hi Pt Bleed Ln Temp	(2,3	43	107	deg F	CI
V43T6235A	OMS Bhd Ox Hi Pt Bleed Ln Temp	(2,3	43	107	deg F	CI
V43T6238A	OMS-Aft Fuslg Fu Hi Pt Bl Ln Temp	(2,3	43	107	deg F	CI
V43T6239A	OMS-Aft Fuslg Ox Hi Pt Bl Ln Temp	(2,3	43	107	deg F	CI
V43T6236A	OMS-Aft Fuslg Low Pt Ox Drn Ln T-L	(3)	43	107	deg F	CI
V43T6237A	OMS-Aft Fuslg Low Pt Ox Drn Ln T-R	(3)	43	107	deg F	CI
	Crossfeed Line Heaters					
V43T6218A	OMS-Aft Xfd L Temp	(4)	47	98	deg F	CI
V43T6219A	OMS-Aft Xfd R Temp	(4)	47	98	deg F	CI
V43T6242A	OMS-Aft Fuslg Xfd Ox Ln-Ctr Temp	(4)	47	98	deg F	CI
V43T6243A	OMS-Aft Fuslg Ox Xfd Line L Temp	(4)	47	98	deg F	CI
V43T6244A	OMS-Aft Fuslg Ox Xfd Line R Temp	(4)	47	98	deg F	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) Measurements are applicable for Orbiters with OMS High Point Bleed Lines installed.
(3) For confirmed instrumentation failure, LCC violation cleared, continue countdown. (5)
(4) 4 of 5 measurements acceptable for confirmed instrumentation failure. (5)

PREPLANNED CONTINGENCY PROCEDURE:

(5) Instrumentation failure is defined as a measurement indicating off-scale high, low or erratically.
(6) If a minimum value is exceeded, verify heater switch positions. If switches are OFF, place in AUTO, LCC violation cleared, continue countdown. If switches are already in AUTO, LCC violation confirmed, No Go for launch.
(7) If a maximum value is exceeded, determine failed crossfeed line heater system by placing system A to OFF and monitoring for a downward temperature trend. If downward trend occurs, LCC violation cleared, continue countdown. If downward trend does not occur, place system A to AUTO and system B to OFF, monitor for a temperature trend. If downward trend occurs, LCC violation cleared, continue countdown otherwise, LCC violation confirmed, No Go for launch.

NOTES:

(8) 1 of 2 crossfeed line heater systems (A or B) required for launch.
(9) Single failed-OPEN thermostat cannot be detected prelaunch because both the A and B heater switches are in AUTO.

NOTES: (Continued)

(10) Control thermostat range: 55 to 75 degrees F.
Overtemperature thermostat range: 70 to 90 degrees F.

REDLINE DERIVATION: CRITICALITY: 2R

(11) Subsystem redline limits are used to detect a heater system failure.
(12) Max reason: To detect a failed-CLOSED overtemperature thermostat.
(13) Min reason: To detect a failed-OPEN control thermostat.

(14) Redline development:

	Bleed & Drain Ln Htrs*		Crossfeed Line Htrs**	
	Minimum***	Maximum****	Minimum***	Maximum****
Thermostat setting	55 deg F	75 deg F	55 deg F	90 deg F
Location delta	0	+20	0	0
Instr error (5%)	-12	+12	-8	+8
Redline limit (deg F)	43	107	47	98

* V43T6230A, 6234A, 6235A, 6236A, 6237A, 6238A, and 6239A.
** V43T6218A, 6219A, 6242A, 6243A, and 6244A.
*** Redline limits based on control thermostat setting to detect a failed-OPEN control thermostat.
**** Maximum redline limits are based on overtemperature thermostat setting to detect a failed-CLOSED overtemperature thermostat.

CONSEQUENCES OF EXCEEDING REDLINE:

(15) Drain and bleed lines: Exceed component thermal limits, resulting in possible damage to system lines and QDs from overtemperature or propellant freezing.
(16) Propellant Lines: Propellant temperature out of spec limits for engine operation.

CAUSES OF EXCEEDING REDLINE:

(17) Maximum cause: A. Failed-CLOSED control and overtemperature thermostat.
B. Failed measurement.
(18) Minimum cause: A. Failed-OPEN control or overtemperature thermostat, fuse, or relay.
B. Failed heater element.
C. Failed measurement.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	deg.F								
V43T6238A	.9935	-73.91	174.5						
V43T6239A	.9935	-73.91	174.5						
V43T6236A	.6402	-.3684	159.7						
V43T6237A	.6402	-.3684	159.7						
V43T6218A	.6402	-.3684	159.7						
V43T6219A	.6402	-.3684	159.7						
V43T6242A	.6402	-.3684	159.7						
V43T6243A	.6402	-.3684	159.7						
V43T6244A	.6402	-.3684	159.7						
V43T6234A	.9935	-73.91	174.5						
V43T6235A	.9935	-73.91	174.5						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 11.9 SHEET 1 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-943099 SHEET 17 ZONE

ELEMENT: Orbiter SUBSYSTEM: OMS

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OMS Aft Gaging Probe Anomaly

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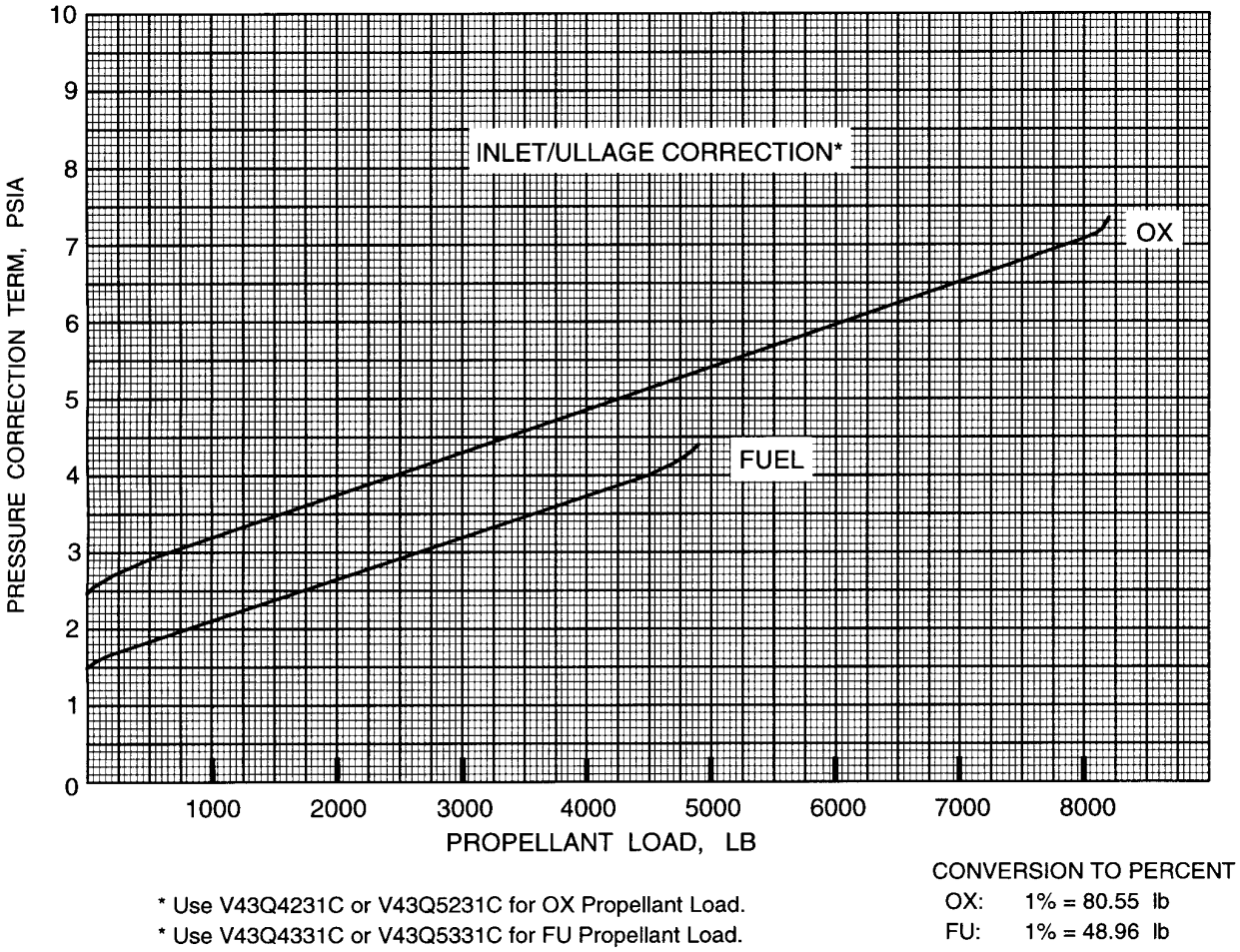

FIGURE 23-01 OMS PRESSURE CORRECTION VS PROPELLANT LOAD

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SECTION 24

POWER REACTANT SUPPLY AND DISTRIBUTION

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SECTION 24: POWER REACTANT SUPPLY AND DISTRIBUTION

SSID No.	Description/Violation Call	Page
PRSD-01	PRSD O2 Tank Control Pressure Anomaly	24-01.1
PRSD-02	PRSD Manifold Isolation Valve Anomaly	24-02.1
PRSD-03	PRSD FCP Reactant Valve Anomaly	24-03.1
PRSD-04	PRSD O2 Tank Heater Current Sensor Anomaly	24-04.1
PRSD-05	PRSD Gas Supply Valve Anomaly	24-05.1
PRSD-06	PRSD H2 Tank Heater Control Pressure Anomaly	24-06.1
PRSD-07	PRSD O2 Tank Quantity Anomaly	24-07.1
PRSD-08	PRSD H2 Tank Quantity Anomaly	24-08.1
PRSD-09	PRSD O2 ECS Supply Valve Anomaly	24-09.1

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LCC VIOLATION CALL: PRSD O2 Tank Control Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V45P1110A	PRSD O2 Tk 1 Htr Control Press	(3)	791	993	psia	CI
V45P1100A	PRSD O2 Tk 1 Pressure	(3)	779	981	psia	CI
V45P1210A	PRSD O2 Tk 2 Htr Control Press	(3)	791	993	psia	CI
V45P1200A	PRSD O2 Tk 2 Pressure	(3)	779	981	psia	CI
V45P1310A	PRSD O2 Tk 3 Htr Cont Press (Mid Body Kit)	(3)	820	993	psia	CI
V45P1300A	PRSD O2 Tk 3 Press (Mid Body Kit)	(3)	808	981	psia	CI
V45P1410A	PRSD O2 Tk 4(&5) Htr Cont Press	(3)	820	993	psia	CI
V45P1400A	PRSD O2 Tk 4 Press (Mid Body Kit)	(3)	808	981	psia	CI
V45P1510A	PRSD O2 Tk 5 Htr Cont Press	(3)	820	993	psia	CI
V45P1500A	PRSD O2 Tk 5 Press (Mid Body Kit)	(3)	808	981	psia	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 measurements per installed tank acceptable for confirmed instrumentation failure, provided automatic heater control function is maintained (individually or in a paired configuration). (4)

PREPLANNED CONTINGENCY PROCEDURE:

(3) If all Tank Pressures and Tank Heater Control Pressures are high or low, then reconfigure GSE to maintain pressures at desired range (ref. S0007.500).
- If pressures return to within LCC limits, then perform a data evaluation to determine if tank relief valves cracked (data evaluation not required for low excursions).
- If evaluation shows that the tank relief valves did not crack during the excursion above the high limit, or if the excursion was below the lower limit, then LCC violation cleared, continue countdown.

(4) For either pressure measurement in a tank high or low, a nominal pressure indication from the complementary measurement is required to confirm instrumentation failure. (Ref: S0007.500 "O2 Tank Press or Htr Cntrl Press Low or High").
- For Tank Heater Control Pressure failed High or Low, automatic heater control may have been lost. If automatic heater control function for no more than a single tank (O2 or H2) is lost, or cannot be confirmed, then LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

- If instrumentation failure is confirmed, then LCC violation cleared, continue countdown.

Switches will be reconfigured as necessary to insure two sources of pressure to the Fuel Cells (Ref: S0007.500).
Otherwise, LCC violation confirmed, No Go for launch.

NOTES:

(5) When GSE is on-line, target (desired) control range for heater control pressure is 918-962 psia and tank pressure is 906-974 psia. These target values are derived from the GSE T-0 regulated supply pressure setting of 930 to 950 psia and included a +/- 12 psi instrumentation error (heater control pressure) and +/- 24 psi instrumentation error (tank pressure).

REDLINE DERIVATION: CRITICALITY: 1R

(6) a. SSID Intent Summary - The Power Reactants Storage and Distribution (PRSD) tanks store reactants and supply them to the Fuel Cells for electrical power generation. In addition, oxygen is supplied to the Environmental Control and Life Support System (ECLSS) for crew cabin pressurization. The oxygen reactants are stored at a supercritical pressure above 731 psia. Pressures are maintained in the tank by the use of heaters. As the reactants are depleted, the heaters add heat energy to maintain tank pressure. There are two pressure sensors for each tank. The Tank Heater Control Pressure transducer transmits its data to the tank heater controllers while the Tank Pressure Sensor is used as instrumentation only. An automatic dual mode heater operation is used for tank pairs. Tanks 1 and 2 are a pair and Tanks 3 and 4 are a pair. Tank 5 does not have a paired tank. In the paired tanks the heater controllers of both tanks must sense a low pressure before the heaters will turn ON and a high pressure signal from either tank will turn the heaters in both tanks OFF. The system is single fault tolerant for loss of Cryo Controller power, Heater Control Pressure (HCP) failed high, or for Tank 5 HCP failed high or low. All other failures are two fault tolerant.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development -

1. Maximum: Protect against cracking of a tank relief valve. A cracked relief valve would require a functional check (ref OMRS V45DB0.020)

	Htr Cntl Press	Tank Press
Relief valve crack (min)	1020 psia	1020 psia
Prevent crack in orbit	-15	-15
Instr error by analysis	-12	-24
Maximum Pressure	993 psia	981 psia

REDLINE DERIVATION: (Continued)

2. Minimum: Used for detection of a significant leak.

	Tanks 1 & 2		Tanks 3 thru 5	
	Htr Cntl P	Tank P	Htr Cntl P	Tank P
Auto heater control (min)	803 psia	803 psia	832 psia	832 psia
Instrumentation error	-12	-24	-12	-24
Minimum Pressure	791 psia	779 psia	820 psia	808 psia

3. Backup information: Maximum working pressure 1050 psia.
   Proof (1.1 X 1050) 1155 psia (after first proof at 1.2).
   Burst (1.5 X 1050) 1575 psia.

4. Onboard meter is not accurate enough to be used as a backup. Meter reading error, plus instrumentation error, is 50-75 psi.

d. Time Period - Since the PRSD tanks are loaded with cryogenic fluid prior to the start of LCC effectivity, the time periods for this SSID begins at the start of ET cryo tanking, which marks the beginning of all LCC monitoring. Due to the criticality of the system, final verification of tank pressures occurs at T-31 seconds.

e. Requirements - Pressure visibility is required in each tank for leak isolation and consumables management. Instrumentation failure is acceptable since functionality of the system is not compromised and visibility of the system still exists with the other measurement.

f. Preplanned Contingency Procedures -

1. If all tank pressures are high or low the most likely cause is inadequate GSE supply pressures. The preplanned procedure will check for this and if possible reconfigure the GSE to bring tank pressures back within operating parameters. If successful, launch may proceed.

2. If both tank pressure sensors in a single tank are high and all other tanks are nominal a line blockage or leak has probably occurred. However, if one tank pressure sensor is nominal while the other sensor in the tank has failed, instrumentation failure or controller power loss has occurred. The preplanned procedure ensures that system functionality has been maintained if instrumentation failure occurs. A nominal Heater Control Sensor Checkout indication confirms Tank Heater Control Pressure instrument failure was not caused by sensor failure and has not affected automatic tank heater control. Automatic tank heater control maintains pressure in a pair of tanks by turning tank heaters on when both Tank Heater Control Pressure measurements reach the low pressure setpoint, and off when either Tank Heater Control Pressure measurement reaches the high pressure setpoint. One of the two measurements failed low does not preclude automatic tank pressure control, provided controller power has not been affected, but one measurement failed high prevents tank heaters from turning on automatically.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Loss of automatic heater control requires the crew to manually turn the heater switch ON and OFF at 10-minute intervals early in the mission and at 60-minute intervals late in the mission.
(8) Maximum: Tank relief valve operation. Leak check required if relief valve is cracked to ensure valve reseats. A leaky relief valve would potentially shorten the mission due to lost consumables.
(9) Minimum: Potential starvation of fuel cell (100 psia minimum) and ECLSS O2 (750 psia minimum).
(10) Reference Integrated Hazard Report ISPR-03 and Orbiter Hazard Reports ORBI-047, ORBI-089, ORBI-094, ORBI-172, ORBI-278, and ORBI-286.

CAUSES OF EXCEEDING REDLINE:

(11) Maximum: A. Heater failed ON.
B. Loss of annulus vacuum.
C. Restricted supply line.
D. GSE pressure control malfunction.
(12) Minimum: A. High leak rate.
B. Loss of O2 controller power (output goes to lower limit).
(13) Failed measurement(s).

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
UNITS-->	psia								
n = 1 THROUGH 5 FOR PRSD O2 TANKS 1 THROUGH 5 RESPECTIVELY									
x = 1,2,3,5 FOR PRSD O2 TANKS 1,2,3,5 RESPECTIVELY									
V45P1n00A	4.8	0	1200						
V45P1n10A	2.0	515	1015	540	985	540	985		
V45P1x15A	4.8	0	1200						
V45P1465A	4.8	0	1200						

METER/DISPLAY RANGE - MSID: V45P1n00A LOW: 0 HIGH: 1200

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 3.2 SHEET 1/2 ZONE P/T3&6
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-945099 SHEET 8-16 ZONE 20-B

ELEMENT: Orbiter SUBSYSTEM: PRSD

LCC VIOLATION CALL: PRSD Manifold Isolation Valve Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V45X1141E	PRSD O2 Manf 1 Isln Vlv-Open	(2)	ON	NA	Event	CI
V45X1146E	PRSD O2 Manf 2 Isln Vlv-Open	(2)	ON	NA	Event	CI
V45X2141E	PRSD H2 Manf 1 Isln Vlv-Open	(2)	ON	NA	Event	CI
V45X2146E	PRSD H2 Manf 2 Isln Vlv-Open	(2)	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE:

(3) For OPEN indicator OFF: Contingency procedure S0007, Volume 5, "O2 or H2 Manif Iso Vlv Indicates Closed", exists to open/verify valve position. If valve is opened, LCC violation cleared, continue countdown.

NOTES:

(4) An OFF indication will cause an SM alert.

REDLINE DERIVATION: CRITICALITY:

(5) Redline required to ensure redundant fuel cell reactant supply and to prevent trapping cryogen.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) If one isolation valve is CLOSED, a relatively minor leak or loss of one tank would result in loss of one fuel cell. If both valves are closed, one additional failure (reactant valve closed or fuel cell open circuited) will result in trapped cryogen, and rupture of component.

CAUSES OF EXCEEDING REDLINE:

(7) Inadvertent closing of valve.
(8) Valve fails CLOSED.
(9) Valve position indicator failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 3.2	SHEET 1	ZONE G3&6
	DWG NO 3.3	SHEET 1	ZONE G4&6
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-945099	SHEET 12	ZONE 6&13-F
	DWG NO VS70-945099	SHEET 22	ZONE 10&16-F

ELEMENT: Orbiter SUBSYSTEM: PRSD

LCC VIOLATION CALL: PRSD FCP Reactant Valve Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V45X1150E	PRSD FCP 1 O2 Reac Vlv-Open	(2)	ON	NA	Event	CI
V45X2150E	PRSD FCP 1 H2 Reac Vlv-Open	(2)	ON	NA	Event	CI
V45X1155E	PRSD FCP 2 O2 Reac Vlv-Open	(2)	ON	NA	Event	CI
V45X2155E	PRSD FCP 2 H2 Reac Vlv-Open	(2)	ON	NA	Event	CI
V45X1160E	PRSD FCP 3 O2 Reac Vlv-Open	(2)	ON	NA	Event	CI
V45X2160E	PRSD FCP 3 H2 Reac Vlv-Open	(2)	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE:

(3) If either H2 or O2 reactant valve open discrete indicates OFF, monitor coolant pressure and reactant flowrates. If coolant pressure drops below 55 psia, verify/remove affected fuel cell from the main and essential busses and expeditiously perform shutdown (Prior to Orbiter GSE Power removal, LPS will set the purge valve open commands OFF, disconnect the fuel cell from the main bus and set the reactant valve open commands to ON).

A. Prior to T-2 minutes 35 seconds (on external reactant gas): If the coolant pressure and reactant flowrates are normal, LCC violation cleared, continue countdown. Coolant pressure and reactant flowrates will start to decrease within 3 seconds for H2 and 30 seconds for O2 if the valve is actually closed.

B. After T-2 minutes 35 seconds (on internal reactants): If active, maintain reactive control logic and GSE ground power until problem is confirmed as instrumentation failure. Establish GSE ground power immediately upon failure indication. Monitor coolant pressure and reactant flowrates for 3 minutes for H2 and 6 minutes for O2 from the time of the valve closed indication. If the coolant pressure and reactant flowrates remain stable, the problem is instrumentation failure only, LCC violation cleared, continue countdown.

NOTES:

(4) The GLS inhibits reactive control logic (coolant pressure) immediately prior to initiating Orbiter GSE Power removal. (T-50 seconds)

NOTES: (Continued)

(5) A PRSD FCP Reac Vlv-Open indication OFF will cause a caution and warning alarm.

REDLINE DERIVATION: CRITICALITY:

(6) Ensures that reactant valves are open and remain open.
(7) Fuel cell reactant valves are monitored to T-10 seconds to protect against launching with a potential fuel cell reactant supply problem, which could result in the rapid loss of a fuel cell prior to SRB separation. A risk trade analysis indicates that the potential, yet improbable risk and associated consequences of launching with a reactant valve failure, outweighs the remote risk and associated consequences of a cutoff due to instrumentation failure.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Fuel cell failure if valve fails closed.

CAUSES OF EXCEEDING REDLINE:

(9) Inadvertent closure of valve.
(10) Valve fails CLOSED.
(11) Valve position indicator failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	Event								
V45X1150E				ON		ON			
V45X2150E				ON		ON			
V45X1155E				ON		ON			
V45X2155E				ON		ON			
V45X1160E				ON		ON			
V45X2160E				ON		ON			

METER/DISPLAY RANGE - MSID: LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: PRSD

LCC VIOLATION CALL: PRSD O2 Tank Heater Current Sensor Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V45X1185E	PRSD O2 Tk 1 Htr Cur Snsr 1A-Trip		OFF	NA	Event	CI
V45X1187E	PRSD O2 Tk 1 Htr Cur Snsr 1B-Trip		OFF	NA	Event	CI
V45X1186E	PRSD O2 Tk 1 Htr Cur Snsr 2A-Trip		OFF	NA	Event	CI
V45X1188E	PRSD O2 Tk 1 Htr Cur Snsr 2B-Trip		OFF	NA	Event	CI
V45X1285E	PRSD O2 Tk 2 Htr Cur Snsr 1A-Trip		OFF	NA	Event	CI
V45X1287E	PRSD O2 Tk 2 Htr Cur Snsr 1B-Trip		OFF	NA	Event	CI
V45X1286E	PRSD O2 Tk 2 Htr Cur Snsr 2A-Trip		OFF	NA	Event	CI
V45X1288E	PRSD O2 Tk 2 Htr Cur Snsr 2B-Trip		OFF	NA	Event	CI
V45X1385E	PRSD O2 Tk 3 Htr Cur Snsr 1A-Trip	(4)	OFF	NA	Event	CI
V45X1387E	PRSD O2 Tk 3 Htr Cur Snsr 1B-Trip	(4)	OFF	NA	Event	CI
V45X1386E	PRSD O2 Tk 3 Htr Cur Snsr 2A-Trip	(4)	OFF	NA	Event	CI
V45X1388E	PRSD O2 Tk 3 Htr Cur Snsr 2B-Trip	(4)	OFF	NA	Event	CI
V45X1485E	PRSD O2 Tk 4 Htr Cur Snsr 1A-Trip	(4)	OFF	NA	Event	CI
V45X1487E	PRSD O2 Tk 4/5 Htr Cur Snsr 1B/1A	(4)	OFF	NA	Event	CI
V45X1486E	PRSD O2 Tk 4 Htr Cur Snsr 2A-Trip	(4)	OFF	NA	Event	CI
V45X1488E	PRSD O2 Tk 4/5 Htr Cur Snsr 2B/2A	(4)	OFF	NA	Event	CI
V45X1585E	PRSD O2 Tk 5 Htr Cur Snsr 1A-Trip	(4)	OFF	NA	Event	CI
V45X1587E	PRSD O2 Tk 5 Htr Cur Snsr 1B-Trip	(4)	OFF	NA	Event	CI
V45X1586E	PRSD O2 Tk 5 Htr Cur Snsr 2A-Trip	(4)	OFF	NA	Event	CI
V45X1588E	PRSD O2 Tk 5 Htr Cur Snsr 2B-Trip	(4)	OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) One set (1A & 1B or 2A & 2B) of Heater Current Sensors per tank is required.

(3) The following hardware, as a minimum, is required for launch: two tanks with no Heater Current Sensors tripped; one Heater Current Sensor set disabled (circuit breaker open) in one of these two tanks is acceptable.

(4) Applicable when installed. For OV-102 only, when tank 5 is installed, measurements V45X1485E and V45X1486E pertain to tank 4 (Heater Current Sensors 1A and 2A) and measurements V45X1487E and V45X1488E pertain to tank 5 (Heater Current Sensors 1A and 2A).

PREPLANNED CONTINGENCY PROCEDURE:

(5) For any Heater Current Sensor trip indication prior to T-31 seconds, verify Heater Current Sensor function by attempting to reset the Heater Current Sensor. Reset will not be attempted after T-31 seconds. (Ref: S0007 Vol. 5 - "One O2 Htr Current Trip Sensor ON".)

NOTES:

(6) Heater Current Sensors are also referred to as Current Level Detectors (CLDs) in some released engineering and documents such as the Space Shuttle Systems Handbook and the Shuttle Operational Data Book.
(7) A Heater Current Sensor trip with the heater OFF indicates an inadvertent trip indication. A trip with the heater ON is indicative of a short circuit of a tank heater, but may be an inadvertent trip indication.
(8) A set of measurements is defined as one Heater Current Sensor in each circuit; i.e., V45X1185E and V45X1187E constitute one set for tank 1.
(9) The EDO pallet PRSD Tank Heater circuits are powered only on orbit. There is no need to monitor an unpowered circuit.
(10) Loss of the measurement is not necessarily loss of the function.

REDLINE DERIVATION: CRITICALITY:

(11) This redline will maintain system redundancy in case of avionics/electrical failures.

CONSEQUENCES OF EXCEEDING REDLINE:

(12) Heaters will be turned OFF automatically.
(13) Next failure (loss of redundant Heater Current Sensor) requires heater shutdown, and loss of oxygen in that tank.

CAUSES OF EXCEEDING REDLINE:

(14) Short circuit in heater.
(15) Failure of differential current sensor.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 3.2	SHEET 1	ZONE N-P/
	DWG NO 3.2	SHEET 1	ZONE H-J7
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-945099	SHEET 8-17	ZONE 4,5,
	DWG NO VS70-945099	SHEET 8-17	ZONE 12&13F

ELEMENT: Orbiter SUBSYSTEM: PRSD

LCC VIOLATION CALL: PRSD Gas Supply Valve Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V45X1195E	PRSD O2 Gas Sply Vlv-Closed	(2)	ON	NA	Event	CI
V45X2195E	PRSD H2 Gas Sply Vlv-Closed	(2)	ON	NA	Event	CI

TIME PERIOD:

(1) From Termination of GSE Supply (T-2 minutes, 30 seconds) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE:

(3) If indicator goes to OFF, implement contingency procedure S0007 Volume 5 "T-0 Vlv Indicates Open" to close/verify valve position. For successful valve closure, LCC violation cleared, continue countdown.

NOTES:

REDLINE DERIVATION: CRITICALITY:

(4) This redline ensures that gas supply valves are closed and remain closed after termination of GSE supply.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) If the supply is open, O2 or H2 reactant will have a direct path to an overboard leak for the next failure (the airborne half coupling is a secondary seal on H2 gas supply/O2 gas supply).
(6) The next failure is a leaking poppet in the airborne half coupling. Loss of Tank 1 and FCP 1 can result from an O2 poppet leak. Loss of Tank 2 and FCP 2 can result from an H2 poppet leak.

CAUSES OF EXCEEDING REDLINE:

(7) Inadvertent opening of the supply valve.
(8) The supply valve fails open.
(9) Failure of the supply valve position indicator.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 3.2	SHEET 1	ZONE H8
	DWG NO 3.3	SHEET 1	ZONE H2
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-945099	SHEET 12	ZONE 20-F
	DWG NO VS70-945099	SHEET 22	ZONE 6-F

ELEMENT: Orbiter SUBSYSTEM: PRSD

LCC VIOLATION CALL: PRSD H2 Tank Heater Control Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V45P2110A	PRSD H2 Tk 1 Htr Control Press	(3)	196	298	psia	CI
V45P2100A	PRSD H2 Tk 1 Pressure	(3)	192	294	psia	CI
V45P2210A	PRSD H2 Tk 2 Htr Control Press	(3)	196	298	psia	CI
V45P2200A	PRSD H2 Tk 2 Pressure	(3)	192	294	psia	CI
V45P2310A	PRSD H2 Tk 3 Htr Cont Press (Mid Body Kit)	(3)	213	298	psia	CI
V45P2300A	PRSD H2 Tk 3 Press (Mid Body Kit)	(3)	209	294	psia	CI
V45P2410A	PRSD H2 Tk4(&5) Htr Cont Press	(3)	213	298	psia	CI
V45P2400A	PRSD H2 Tk 4 Press (Mid Body Kit)	(3)	209	294	psia	CI
V45P2510A	PRSD H2 Tk 5 Htr Cont Press	(3)	213	298	psia	CI
V45P2500A	PRSD H2 Tk 5 Press (Mid Body Kit)	(3)	209	294	psia	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 measurements per installed tank acceptable for confirmed instrumentation failure, provided automatic tank heater control function is maintained (individually or in a paired configuration). (4)

PREPLANNED CONTINGENCY PROCEDURE:

(3) If all Tank Pressures and Tank Heater Control Pressures are high or low, then reconfigure GSE to maintain pressures at desired range (ref. S0007.500).
- If pressures return to within LCC limits, then perform a data evaluation to determine if tank relief valves cracked (data evaluation not required for low excursions).
- If evaluation shows that the tank relief valves did not crack during the excursion above the high limit, or if the excursion was below the lower limit, then LCC violation cleared, continue countdown.

(4) For either pressure measurement in a tank high or low, a nominal pressure indication from the complementary measurement is required to confirm instrumentation failure. (Ref: S0007.500 "H2 Tank Press or Htr Cntrl Press Low or High").
- For Tank Heater Control Pressure failed High or Low, automatic heater control may have been lost. If automatic heater control function for no more than a single tank (O2 or H2) is lost, or cannot be confirmed, then LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

- If instrumentation failure is confirmed, then LCC violation cleared, continue countdown.

Switches will be reconfigured as necessary to insure two sources of pressure to the Fuel Cells (Ref: S0007.500).
Otherwise, LCC violation confirmed, No Go for launch.

NOTES:

(5) When GSE is on-line, target (desired) control range for heater control pressure is 251-279 psia and tank pressure is 247-283 psia. These target values are derived from the GSE T-0 regulated supply pressure setting of 255 to 275 psia and included a +/- 4 psi instrumentation error (heater control pressure) and +/- 8 psi instrumentation error (tank pressure).

REDLINE DERIVATION: CRITICALITY: 1R

(6) a. SSID Intent Summary - The Power Reactants Storage and Distribution (PRSD) tanks store reactants and supply them to the Fuel Cells for electrical power generation. The hydrogen reactants are stored at a supercritical pressure above 188 psia. Pressures are maintained in the tank by the use of heaters. As the reactants are depleted, the heaters add heat energy to maintain tank pressure. There are two pressure sensors for each tank. The Tank Heater Control Pressure transducer transmits its data to the tank heater controllers while the Tank Pressure Sensor is used as instrumentation only. An automatic dual mode heater operation is used for tank pairs. Tanks 1 and 2 are a pair and Tanks 3 and 4 are a pair. Tank 5 does not have a paired tank. In the paired tanks the heater controllers of both tanks must sense a low pressure before the heaters will turn ON and a high pressure signal from either tank will turn the heaters in both tanks OFF. The system is single fault tolerant for loss of Cryo Controller power, Heater Control Pressure (HCP) failed high, or for Tank 5 HCP failed high or low. All other failures are two fault tolerant.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development -

1. Maximum: Protect against cracking of tank relief valve. A cracked relief valve would require a functional check (ref OMRS V45DB0.020)

	Htr Cntl Press	Tank Press
Relief valve crack (min)	317 psia	317 psia
Prevent crack in orbit	-15	-15
Instr error by analysis	-4	-8
Maximum Pressure	298 psia	294 psia

2. Minimum: Used for detection of a significant leak.

REDLINE DERIVATION: (Continued)

	Tanks 1 & 2		Tanks 3 thru 5	
	Htr Cntl P	Tank P	Htr Cntl P	Tank P
Auto heater control (min)	200 psia	200 psia	217 psia	217 psia
Instrumentation error	-4	-8	-4	-8
Minimum Pressure	196 psia	192 psia	213 psia	209 psia

3. Backup information: Maximum working pressure 335.0 psia.
   Proof (1.1 x 335) 368.5 psia.
   Burst (1.5 x 335) 502.5 psia.

4. Onboard meter is not accurate enough to be used as backup. Meter reading error, plus instrumentation error, is 20 to 40 psia.

d. Time Period - Since the PRSD tanks are loaded with cryogenic fluid prior to the start of LCC effectivity, the time periods for this SSID begins at the start of ET cryo tanking, which marks the beginning of all LCC monitoring. Due to the criticality of the system, final verification of tank pressures occurs at T-31 seconds.

e. Requirements - Pressure visibility is required in each tank for leak isolation and consumables management. Instrumentation failure is acceptable since functionality of the system is not compromised and visibility of the system still exists with the other measurement.

f. Preplanned Contingency Procedures -

1. If all tank pressures are high or low the most likely cause is inadequate GSE supply pressures. The preplanned procedure will check for this and if possible reconfigure the GSE to bring tank pressures back within operating parameters. If successful, launch may proceed.

2. If both tank pressure sensors in a single tank are high and all other tanks are nominal a line blockage or leak has probably occurred. However, if one tank pressure sensor is nominal while the other sensor in the tank has failed, instrumentation failure or controller power loss has occurred. The preplanned procedure ensures that system functionality has been maintained if instrumentation failure occurs. A nominal Heater Control Sensor Checkout indication confirms Tank Heater Control Pressure instrument failure was not caused by sensor failure and has not affected automatic tank heater control. Automatic tank heater control maintains pressure in a pair of tanks by turning tank heaters on when both Tank Heater Control Pressure measurements reach the low pressure setpoint, and off when either Tank Heater Control Pressure measurement reaches the high pressure setpoint. One of the two measurements failed low does not preclude automatic tank pressure control, provided controller power has not been affected, but one measurement failed high prevents tank heaters from turning on automatically.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Loss of automatic heater control requires the crew to manually turn the heater switch ON and OFF at 30-minute intervals early in the mission and at 90-minute intervals late in the mission.
(8) Maximum: Tank relief valve operation. Leak check required if relief valve is cracked to ensure valve reseats. A leaky relief valve would potentially shorten the mission due to lost consumables.
(9) Minimum: A. Potential starvation of fuel cells (100 psia minimum).
B. Hydrogen leakage into midbody causes fire hazard.
(10) Reference Orbiter Hazard Reports ORBI-047, ORBI-089, ORBI-094, ORBI-172 and ORBI-278.

CAUSES OF EXCEEDING REDLINE:

(11) Maximum: A. Heaters failed ON.
B. Loss of annulus vacuum.
C. Restricted supply line.
(12) Minimum: A. High leak rate.
B. Loss of hydrogen controller power (output goes to lower limit).
(13) Measurement(s) failed.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
UNITS-->	psia								
n = 1 THROUGH 5 FOR PRSD H2 TANKS 1 THROUGH 5 RESPECTIVELY									
x = 1,2,3,5 FOR PRSD H2 TANKS 1,2,3,5 RESPECTIVELY									
V45P2n00A	1.6	0	400						
V45P2n10A	0.64	145	305	153	293.8	153	293.8		
V45P2x15A	1.6	0	400						
V45P2465A	1.6	0	400						

METER/DISPLAY RANGE - MSID: V45P2n10A LOW: 0 HIGH: 400

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 3.3 SHEET 1 ZONE N3&5
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-945099 SHEET 19-25 ZONE 19-B

ELEMENT: Orbiter SUBSYSTEM: PRSD

LCC VIOLATION CALL: PRSD O2 Tank Quantity Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V45Q1105A	PRSD O2 Tk 1 Quantity		30(4,5)	NA	%	CI
V45Q1205A	PRSD O2 Tk 2 Quantity		30(4,5)	NA	%	CI
V45Q1305A	PRSD O2 Tk 3 Quantity (MBK)	(3)	30(4,5)	NA	%	CI
V45Q1405A	PRSD O2 Tk 4 Quantity (MBK)	(3)	30(4,5)	NA	%	CI
V45Q1505A	PRSD O2 Tk 5 Quantity (MBK)	(3)	30(4,5)	NA	%	CI
V45Q3105A	PRSD O2 Tk 6 Quantity	(3)	30(4,5)	NA	%	CI
V45Q3205A	PRSD O2 Tk 7 Quantity	(3)	30(4,5)	NA	%	CI
V45Q3305A	PRSD O2 Tk 8 Quantity	(3)	30(4,5)	NA	%	CI
V45Q3405A	PRSD O2 Tk 9 Quantity	(3)	30(4,5)	NA	%	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) A minimum of two quantity measurements are required, one of which must be tank 1 or tank 2.
(3) Applicable when installed.
(4) Total PRSD minimum lift-off quantity is defined by the web based E-consumables system (URL for web based E-consumables system home page: http://usa1.unitedspacealliance.com/usahou/projects/loads/index.cfm).
(5) For tanks which have been launched off-loaded (less than 90% full) 25 times, the minimum Tank Quantity is 90%.

PREPLANNED CONTINGENCY PROCEDURE:

(6) Use pressure and temperature to confirm instrumentation failure (ref. SSID: PRSD-01). Onboard meter (panel O2) provides backup for telemetry loss. Meter applies to tanks 1 thru 4 on OV-102 and to tanks 1 thru 5 on OV-103, OV-104 and OV-105.

NOTES:

REDLINE DERIVATION: CRITICALITY:

(7) The minimum redline is a hardware constraint due to qualification levels for launch vibrations.
(8) A tank quantity of less than 90% constitutes a tank off-load. The O2 tanks are qualified for 25 launches at less than 90%. After 25 launches at less than 90%, the hardware constraint changes from 30% to 90%. The number of times a tank has been launched off-loaded is tracked in accordance with OMRSD File II, Volume 3, Table C00AB0.030-000, Item 3.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Structural damage.

CAUSES OF EXCEEDING REDLINE:

(10) Launch loads not meeting redline quantities.
(11) Higher cryogenic usage than predicted.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	pcnt								
n = 1 THROUGH 5 FOR PRSD O2 TANKS 1 THROUGH 5 RESPECTIVELY									
V45Q1n05A	.4379	-5.474	104						
n = 1 THROUGH 4 FOR PRSD O2 TANKS 6 THROUGH 9 RESPECTIVELY									
V45Q3n05A	.4379	-5.474	104						

METER/DISPLAY RANGE - MSID: V45Q1n05A LOW: 0 HIGH: 100
V45Q3n05A LOW: 0 HIGH: 100

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: PRSD

LCC VIOLATION CALL: PRSD H2 Tank Quantity Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V45Q2105A	PRSD H2 Tk 1 Quantity		0 (4,5)	NA	%	CI
V45Q2205A	PRSD H2 Tk 2 Quantity		0 (4,5)	NA	%	CI
V45Q2305A	PRSD H2 Tk 3 Quantity (MBK)	(3)	0 (4,5)	NA	%	CI
V45Q2405A	PRSD H2 Tk 4 Quantity (MBK)	(3)	0 (4,5)	NA	%	CI
V45Q2505A	PRSD H2 Tk 5 Quantity (MBK)	(3)	0 (4,5)	NA	%	CI
V45Q4105A	PRSD H2 Tk 6 Quantity	(3)	0 (4,5)	NA	%	CI
V45Q4205A	PRSD H2 Tk 7 Quantity	(3)	0 (4,5)	NA	%	CI
V45Q4305A	PRSD H2 Tk 8 Quantity	(3)	0 (4,5)	NA	%	CI
V45Q4405A	PRSD H2 Tk 9 Quantity	(3)	0 (4,5)	NA	%	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) A minimum of two quantity measurements are required, one of which must be tank 1 or tank 2.
(3) Applicable when installed.
(4) Total PRSD minimum lift-off quantity is defined by the web based E-consumables system (URL for web based E-consumables system home page: http://usa1.unitedspacealliance.com/usahou/projects/loads/index.cfm).
(5) For tanks which have been launched off-loaded (less than 90% full) 25 times, the minimum Tank Quantity is 90%.

PREPLANNED CONTINGENCY PROCEDURE:

(6) Use pressure and temperature to confirm instrumentation failure (ref. SSID: PRSD-06). Onboard meter (panel O2) provides backup for telemetry loss. Meter applies to tanks 1 thru 4 on OV-102 and to tanks 1 thru 5 on OV-103, OV-104 and OV-105.

NOTES:

REDLINE DERIVATION: CRITICALITY:

(7) The minimum redline is a hardware constraint due to qualification levels for launch vibrations. The tank may be empty, but must be pressurized.
(8) A tank quantity of less than 90% constitutes a tank off-load. The H2 tanks are qualified for 25 launches at less than 90%. After 25 launches at less than 90%, the hardware constraint changes from 0% to 90%. The number of times a tank has been launched off-loaded is tracked in accordance with OMRSD File II, Volume 3, Table C00AB0.030-000, Item 3.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Structural damage.

CAUSES OF EXCEEDING REDLINE:

(10) Launch loads not meeting redline quantities.
(11) Higher cryogenic usage than predicted.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	pcnt								
n = 1 THROUGH 5 FOR PRSD H2 TANKS 1 THROUGH 5 RESPECTIVELY									
V45Q2n05A	.4421	-5.526	105						
n = 1 THROUGH 4 FOR PRSD H2 TANKS 6 THROUGH 9 RESPECTIVELY									
V45Q4n05A	.4421	-5.526	105						

METER/DISPLAY RANGE - MSID: V45Q2n05A LOW: 0 HIGH: 100
V45Q4n05A LOW: 0 HIGH: 100

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: PRSD

LCC VIOLATION CALL: PRSD O2 ECS Supply Valve Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V45X1080E	PRSD O2 ECS Prim Sup Vlv-Open		ON	NA	Event	CI
V45X1083E	PRSD O2 ECS Sec Sup Vlv-Open		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) If indicator goes to OFF, implement contingency procedure OMI S0007.500, "O2 ECS Vlv Indicates Closed". Contingency procedure to be coordinated with Environmental Control and Life Support System (ECLSS) console. For confirmed instrumentation failure, LCC violation cleared, continue countdown.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1

(4) a. SSID Intent Summary - The intent of this SSID is to ensure an adequate oxygen supply for crew breathing. There are two Environmental Control System (ECS) valves, primary and secondary, that supply oxygen from the Power Reactant Storage and Distribution (PRSD) System to the Atmosphere Revitalization and Pressure Control System (ARPCS). The ECS valve state is verified by a position indicator.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - The minimum redline limit of "ON" means that the ECS valve is open. There is not a maximum redline limit.

d. Time Period - The ECS valves are opened prior to Fuel Cell Start. Direct flow of O2 to all crew members is initiated at T-2:00 minutes. Final verification of valve position should occur as late as practical.

REDLINE DERIVATION: (Continued)

e. Requirements - To guarantee an adequate O2 supply for a crew configuration of five or more, both ECS valves must be open. The ECS valves each feed one of two ARPCS breathing oxygen systems, and each O2 system is capable of supplying O2 at a rate of approximately 24 lbm/hr. The maximum demand on the O2 systems occurs when either the Launch and Entry Helmets (LEH) or Quick Don Mask Assemblies (QDMA) are in use. In either case, crew O2 usage is a maximum of 5.5 lbm/hr per crew member. So a crew of five requires a maximum of 27.5 lbm/hr, which cannot be supplied by a single O2 system. Instrumentation failure is allowable.

f. Preplanned Contingency Requirements - An operational talk back on panel L2 confirms that the valve in question is open, this indicates the failure is either confined to Multiplexer/Demultiplexer (MDM) OF4 or the circuitry downstream of the panel talk back. In either case, the LCC violation is cleared. Otherwise, valve flow test troubleshooting (with ECLSS) must be performed to determine the actual position of the valve. If the valve is open, the LCC violation is cleared.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Crew sizes of five or more require both O2 systems to be on line to ensure adequate flow of breathing air. An insufficient O2 supply may cause starvation of the LEH/QDMA. This could lead to crew inhalation of harmful gases or combustion products in the event of a fire or toxic spill. For smaller crew sizes failure means a loss of redundancy; the next failure after that is loss of the breathing O2 supply.

CAUSES OF EXCEEDING REDLINE:

(6) Inadvertent closure of valve.
(7) Valve fails CLOSED.
(8) Valve position indicator failure, orbiter circuitry or MDM OF4 failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 3.2	SHEET 1	ZONE H6, H2
	DWG NO 6.1	SHEET 2	ZONE S1-2
	DWG NO 6.1	SHEET 2	ZONE S7-8
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-945099	SHEET 45DA	ZONE ALL

ELEMENT: Orbiter SUBSYSTEM: PRSD

SECTION 25

FUEL CELL POWERPLANT

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SECTION 25: FUEL CELL POWERPLANT

SSID No.	Description/Violation Call	Page
FCP-01	Fuel Cell Performance Anomaly	25-01.1
FCP-02	Fuel Cell Thermal Performance Anomaly	25-02.1
FCP-03	Fuel Cell Substack Delta Anomaly	25-03.1
FCP-04	Fuel Cell Coolant Pump Anomaly	25-04.1
FCP-05	Fuel Cell Water Condition Anomaly	25-05.1
FCP-06	Fuel Cell Water Relief System Temperature Anomaly	25-06.1
FCP-FG01	Figure 25-01 Fuel Cell PopwerPlant Minimum Launch Performance Limits (measured voltage)	25-FG01.1
FCP-FG02	Figure 25-02 Fuel Cell Powerplant Stack Coolant Outlet Pressure	25-FG02.1
FCP-FG03	Figure 25-03 FCP Electrolyte Concentration Nomograph	25-FG03.1

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LCC VIOLATION CALL: Fuel Cell Performance Anomaly | EMERG COND: Yellow (16)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V45V0100A	Fuel Cell No 1 Voltage	(2)	(5,6)	NA	Volts	CI
V76V0100A	Main Bus A Voltage	(2)	(5,6)	NA	Volts	CI
V45C0101A	Fuel Cell No 1 Current	(3)	NA	(7)	Amps	CI
V45V0200A	Fuel Cell No 2 Voltage	(2)	(5,6)	NA	Volts	CI
V76V0200A	Main Bus B Voltage	(2)	(5,6)	NA	Volts	CI
V45C0201A	Fuel Cell No 2 Current	(3)	NA	(7)	Amps	CI
V45V0300A	Fuel Cell No 3 Voltage	(2)	(5,6)	NA	Volts	CI
V76V0300A	Main Bus C Voltage	(2)	(5,6)	NA	Volts	CI
V45C0301A	Fuel Cell No 3 Current	(3)	NA	(7)	Amps	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) To Prior To APU Start (T-5 minutes)

REQUIREMENTS: FIGURES/TABLES: 25-01

(2) One of two voltage measurements per Fuel Cell acceptable for confirmed instrumentation failure. (8)
(3) Two of three current measurements are acceptable for confirmed instrumentation failure. (4,10)
(4) The onboard meter on panel F9 must be functional for the Fuel Cell current instrumentation that has been lost, and the performance for that fuel cell must be equal to or better than the Minimum Required Voltage for Loss of Current OI curve (reference Figure 25-01). (10)
(5) Reference Figure 25-01 "Fuel Cell Powerplant Minimum Launch Performance Limits" for acceptable values. Temporary voltage drops below the Minimum Required Voltage Curve lasting 5 minutes or less are acceptable if they are the result of a sudden shift in electrical load.
(6) Steady state deviations of 0.5 volts below the flight specific predicted performance must be investigated. (9)
(7) Fuel Cell power (voltage x current) must not exceed 10 kw steady state.

PREPLANNED CONTINGENCY PROCEDURE:

(8) Perform OMI S0007.500 "FCP Volts Low" to compare failed measurement with the redundant measurement and the Panel F9 Volt Meter. If instrumentation failure confirmed, LCC violation cleared, continue countdown.
(9) Perform OMI S0007.500 "FCP Volts Low" to perform reactant purge of affected Fuel Cell to recover degraded performance. If performance is restored and the cause of the degradation can be attributed to inert gas in the reactant supply, then LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

(10) Perform OMI S0007.500 "FCP Current Low" to compare failed measurement with the Panel F9 Current Meter. The panel meter can be used to periodically verify Fuel Cell performance, but the Minimum Required Voltage for Loss of Current OI curve (reference figure 25-01) will become the minimum acceptable voltage to compensate for reduced fidelity inherent in reading the meter. Current must be verified (using the panel meter) and Fuel Cell Powerplant (FCP) performance committed to launch following prelaunch thermal conditioning. If instrumentation failure confirmed, LCC violation cleared, continue countdown.

NOTES:

(11) Fuel Cell reactant purging is performed to remove inert build up which inhibits performance (voltage). Reactant purging is verified late in the countdown to assure maximum performance through the launch sequence.
(12) For real-time comparison, the FCP-to-Main Bus voltage drop can be neglected.
(13) Main Bus Voltage redline is a backup for Fuel Cell performance only. Finite minimum/maximum values for electrical power distribution are contained in SSID EPDC-01 (Main Bus Voltage 28.3/32.0 Vdc).
(14) Predicted fuel cell performance curves are generated for each mission by the Boeing JSC Propulsion and Power Systems Division and submitted to the Mission Operations Directorate (MOD) to satisfy Shuttle Operational Data Request R1-0949.

REDLINE DERIVATION: CRITICALITY: 1R

(15) a. SSID Intent Summary - The redlines ensure nominal Fuel Cell performance. Minor degradation in Fuel Cell performance, caused by inert gas build up, will be recovered with additional reactant purging, but if a Fuel Cell is unable to maintain a voltage of 27.5 VDC it is considered lost. Flight rules dictate a Minimum Duration Flight (MDF) for one Fuel Cell down, and a Next Primary Landing Site (PLS) Entry for two Fuel Cells down.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - The minimum voltage redline protects the minimum Solid Rocket Booster (SRB) interface voltage. The minimum Fuel Cell voltage required to do this is 28.3 VDC (ref: EPDC-01).

The curve produced when Fuel Cell voltage is plotted as a function of current (V-I curve) is a defining characteristic of a given Fuel Cell. As the Fuel Cell ages (run time increases) the curve will shift generally downward. The minimum allowed Fuel Cell voltage specified in this SSID is derived by imposing line losses and transient voltage requirements to the minimum allowed SRB interface voltage under launch load conditions with only 2 Fuel Cells active (28.3 volts at 9 kW)(reference EPDC-01 for derivation). The minimum Fuel Cell V-I curve is constructed passing through this defined minimum voltage point.

REDLINE DERIVATION: (Continued)

The maximum redline for current is the value that yields 10 kW when multiplied by the Fuel Cell voltage. Higher than nominal loads on the Fuel Cell have the result of accelerating the nominal performance degradation a Fuel Cell experiences with accumulated run-time. Although certified to 12 kW, the 10 kW maximum will minimize irreversible losses in performance which may shorten the operational life of the Fuel Cell. In addition, elevated loads above 10 kW are far greater than expected during countdown and may be an indicator of anomalies occurring in other systems.

d. Time Period - Since the Fuel Cells are activated prior to the start of LCC effectivity, the time period for this SSID begins at the start of ET cryo tanking, which marks the beginning of all LCC monitoring. Final LCC commitment to launch occurs prior to APU start. After Go For APU Start, load transients prohibit steady state performance evaluation.

e. Requirements - Fuel Cell Voltage and Main Bus Voltage will track each other whenever the Fuel Cell/Main Bus motor switch is on. For this reason, either measurement for each of the three Fuel Cells is acceptable. Two of three current measurements are required based on an acceptable reduction in remote monitor and system evaluation capability using the panel meter. On orbit procedures may include periodic bus ties and Fuel Cell Monitoring System (FCMS) snapshots to obtain more insight into Fuel Cell health.

The voltage limits are structured around Fuel Cell performance requirements since the purpose of this SSID is to verify the health of the Fuel Cell and not duplicate the minimum and maximum Electrical Power and Distribution (EPD) voltage requirements. The low-voltage curve displayed in Figure 25-01 is for steady state operation. Shifts in internal Fuel Cell operating temperature brought about by an electrical load change may lag the load change by up to 5 minutes. The cause of this is relative inefficiencies within the Fuel Cell which are exhibited temporarily as a lower voltage.

The flight specific predicted performance curve (not to be confused with the LCC minimum voltage curve) is generated by the design center for each Fuel Cell prior to countdown using mission and ground testing data. A variance below this curve of 0.5 volts could indicate the loss of an individual cell. Other indicators such as fuel cell substack delta voltage via the Cell Performance Monitor (CPM) or single cell voltage via the Fuel Cell Monitoring System (FCMS) provide higher fidelity for detection of the loss of a single cell.

The predicted performance of a Fuel Cell can be classified using a family of V-I curves numbered 1 through 20: number 1 representing the maximum theoretical performance for a new, 0-hour, Fuel Cell, and number 20 representing the LCC minimum required voltage. The inaccuracies associated with reading the meter on panel F9 dictate the use of a Fuel Cell performing equal to or better than that of a curve 17, when the OI

REDLINE DERIVATION: (Continued)

measurement is unavailable. This is based on the assertion that the fidelity of reading the meter is half the value of the graduations (each graduation = 25 amps). Application of an error of 12.5 amps to the polynomial approximating the LCC minimum voltage curve results in a voltage equal to that of at least a curve 17 Fuel Cell. Therefore, the Minimum Required Voltage for Loss of Current OI curve is equivalent to a curve 17.

f. Preplanned Contingency Requirements - Degraded Fuel Cell voltage performance violating the LCC that cannot be remedied with reactant purging will always result in a no go condition and Fuel Cell deactivation. While degraded fuel cell performance is observed before a powerplant has reached optimum operating temperatures, a significant voltage below the Fuel Cell performance curve may be due to reactant crossover and/or cell flooding, either of which may be a hazardous condition. Instrumentation failures, specifically Multiplexer/Demultiplexer (MDMs), signal conditioners and electrical circuitry, will not constrain launch as long as the required redundant measurement is available (Main Bus or Fuel Cell Voltage) and the meter on panel F9 is operational. A lower voltage limit reading on panel F9 in addition to the voltage function designator (FD) measurement requires an assessment by EPDC to verify the Fuel Cell-to-Essential Bus feed is intact (i.e. 20 amp fuse not blown).

If a Fuel Cell current measurement is lost, using the panel F9 meter will result in a loss of accuracy due to the inherent inaccuracies in reading the analog meter. If the power plant is performing above the Minimum Required Voltage for Loss of Current OI, then any error in reading the meter will not mask a violation of the actual requirement (Minimum Required Voltage curve).

CONSEQUENCES OF EXCEEDING REDLINE:

(16) Individual cell crossover leading to potential fire in Fuel Cell due to cross leak.
(17) Low Fuel Cell voltage - Insufficient bus voltage to operate critical equipment. The EPDC requirement at the SRB interface is 26.15 VDC (Main A and B) or 25.6 VDC (Main C) for three Fuel Cells active, 25.7 VDC (Main A and B) or 25.2 (Main C) for two Fuel Cells active.
(18) High Fuel Cell current - Violation of thermal limits within the powerplant or degradation of voltage performance.

CAUSES OF EXCEEDING REDLINE:

(19) Fuel Cell components malfunction, valves, regulators, pumps, etc.
(20) Fuel Cell contamination
(21) Instrumentation failure.
(22) Individual cell crossover.
(23) Fuel Cell flooding.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR FUEL CELLS 1, 2, AND 3 RESPECTIVELY									
UNITS-->	Vdc								
V76V0n00A	0.16	0	40			26.4		27	32
V45V0n00A	0.16	0	40					27.5	32.5
UNITS-->	Adc								
V45C0n01A	2	0	500					54	410

METER/DISPLAY RANGE - MSID: V76V0n00A LOW: 20 HIGH: 45
V45C0n01A LOW: 0 HIGH: 500
V45V0n00A LOW: 20 HIGH: 45

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 3.4	SHEET 1	ZONE L-K,1
	DWG NO 2.2	SHEET 1	ZONE P 2-7
	DWG NO 2.2	SHEET 1	ZONE W 1-8
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-976099	SHEET 7/14/21	ZONE E 6,9
	DWG NO VS70-976099	SHEET 7/14/21	ZONE E 11

ELEMENT: Orbiter SUBSYSTEM: FCP

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LCC VIOLATION CALL: Fuel Cell Thermal Performance Anomaly | EMERG COND: Yellow (20)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V45T0113A	Fuel Cell No 1 Stack Inlet Temp	(1)	176 (5)	191 (5)	deg F	CI
V45T0120A	Fuel Cell No 1 Stack Cool Out Temp	(1)	(5,6)	(5,6)	deg F	CI
V45T0130A	Fuel Cell No 1 Condenser Exit Temp	(1,4	140(5)	160(5)	deg F	CI
V45P0147A	Fuel Cell 1 Coolant Pressure		55(2)	75(1)	psia	CI
V45T0213A	Fuel Cell No 2 Stack Inlet Temp	(1)	176 (5)	191 (5)	deg F	CI
V45T0220A	Fuel Cell No 2 Stack Cool Out Temp	(1)	(5,6)	(5,6)	deg F	CI
V45T0230A	Fuel Cell No 2 Condenser Exit Temp	(1,4	140(5)	160(5)	deg F	CI
V45P0247A	Fuel Cell 2 Coolant Pressure		55(2)	75(1)	psia	CI
V45T0313A	Fuel Cell No 3 Stack Inlet Temp	(1)	176 (5)	191 (5)	deg F	CI
V45T0320A	Fuel Cell No 3 Stack Cool Out Temp	(1)	(5,6)	(5,6)	deg F	CI
V45T0330A	Fuel Cell No 3 Condenser Exit Temp	(1,4	140(5)	160(5)	deg F	CI
V45P0347A	Fuel Cell 3 Coolant Pressure		55(2)	75(1)	psia	CI

TIME PERIOD:

(1) From FCP Performance Calibration Start to Go For RSLS Start (T-31 seconds)
(2) From FCP Performance Calibration Start to Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES: Figures 25-02,-03

(3) 3 of 4 measurements on each Fuel Cell acceptable for confirmed instrumentation failure only. (9)
(4) 2 of 3 condenser exit temperature (Tce) measurements are acceptable.
(5) Specified temperature limits guarantee FCP inlet and outlet electrolyte concentrations remain within 24-48 percent limits. Steady state operation outside specified temperature limits is acceptable provided FCP inlet and outlet electrolyte concentrations remain within 24-48 percent. Temporary temperature excursions that violate electrolyte concentration limits are acceptable if associated with a load change, provided acceptable electrolyte concentrations of 24-48 percent return when steady state Fuel Cell temperatures are reached. FCP electrolyte concentration may be derived using FIGURE 25-03, FCP ELECTROLYTE CONCENTRATION NOMOGRAPH.
(6) Reference Figure 25-02, Fuel Cell Powerplant Stack Coolant Outlet Temperatures, for acceptable values. (8)

PREPLANNED CONTINGENCY PROCEDURE:

(7) For loss of coolant pressure, maintain or reestablish GSE ground power until problem is confirmed as instrumentation failure.
(8) Flight Deck meter (Panel O2) is an acceptable backup for Stack Cool Out Temperature with Caution and Warning.
(9) Reference S0007, Volume 5, "FCP Temps (stack inlet, stack cool out, condenser exit) High or Low" or "FCP Coolant Press Low/High".

NOTES:

(10) Orbiter GSE ground power is removed at T-50 seconds.
(11) Caution and Warning (C&W) limits for stack coolant outlet Temperatures are based on possible fuel cell damage.
(12) Systems Management (SM) limits for stack coolant outlet temperatures are:

	Minimum	Maximum
For loads </= 3.5 kW	172.5 deg F	212 deg F
For loads > 3.5 kW but < 7.5 kW	172.5 deg F	222 deg F
For loads >/= 7.5 kW	172.5 deg F	238 deg F

REDLINE DERIVATION: CRITICALITY:

(13) Redlines for fuel cell stack inlet temperatures, stack coolant outlet temperatures, and condenser exit temperatures ensure proper fuel cell function, i.e., proper thermal control functions, H2 recirculation function, and H2 water separation.
(14) Stack inlet temperature and condenser exit temperature limits are derived from the FCP vendor Acceptance Test Procedure (ATP).
(15) Fuel cell coolant pressure is a direct indication of oxygen pressure, since it is referenced to the oxygen pressure via the accumulator bladder; and it is an indirect indication of H2 pressure, which is referenced to the O2 pressure via the dual coupled regulator. The regulator maintains O2 pressure 4-6 psi above the H2 pressure.
(16) The normal operating band for fuel cell coolant pressure includes normal regulator dead band and regulator shift due to changing supply pressure and instrumentation error.
(17) Fuel cell coolant pressure is monitored to T-10 seconds to protect against launching with a potential fuel cell reactant supply problem, which could result in the rapid loss of a fuel cell prior to SRB separation. A risk trade analysis indicates that the potential, yet remote risk and associated consequences of launching with a reactant supply problem, outweighs the remote risk and associated consequences of a cutoff due to instrumentation failure.

CONSEQUENCES OF EXCEEDING REDLINE:

(18) Fuel cell stack inlet temperature, stack coolant outlet temperature, and condenser exit temperature:
A. Maximum: 1. Stack inlet: KOH concentration high, reactant cross leak.
2. Stack coolant outlet: seal damage, reactant leakage.
3. Condenser exit: KOH concentration low, cell flooding.
B. Minimum: 1. Stack inlet: KOH concentration low, cell flooding, low voltage performance.
2. Stack coolant outlet: KOH concentration low, cell flooding, low voltage performance.
3. Condenser exit: KOH concentration high, reactant cross leak.
C. Loss of fuel cell

CONSEQUENCES OF EXCEEDING REDLINE: (Continued)

(19) Fuel cell coolant pressure:
A. Minimum: 1. Loss of power plant due to loss of reactant from the fuel cell regulator.
2. Reduction of powerplant performance; may lose fuel cell due to inability to discharge water.
3. Loss of power plant due to loss of cooling and subsequent exceedence of temperature limits.
B. Maximum: Eventual loss of powerplant.
(20) Potential fire in fuel cell due to reactant cross leak. Potential hydrogen in midbody due to seal leak.

CAUSES OF EXCEEDING REDLINE:

(21) Fuel cell stack inlet temperature, stack coolant outlet temperature, and condenser exit temperature:
A. Thermal control valve(s) malfunction (high or low).
B. High - coolant leakage, coolant pump failure.
C. High/low - Electrical failure within stack, heater failed ON.
(22) Fuel cell coolant pressure:
A. Minimum: 1. Leak from the coolant loop to surroundings (evident only after accumulator is devoid of coolant).
2. Regulator malfunction.
3. Reactant valve closure.
B. Maximum: 1. Freon leak in FCP coolant HX, interloop coolant leak, or reactant leak in FCP preheater.
2. Regulator malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	deg.F								
n = 1, 2, AND 3 FOR FUEL CELLS 1, 2, AND 3 RESPECTIVELY									
FOR LOADS <= 3.5 kW									
V45T0n20A	1.499	-76.65	298.1	172.5	243.7	172.5	243.7		212
FOR LOADS > 3.5 kW AND < 7.5 kW									
V45T0n20A	1.499	-76.65	298.1	172.5	243.7	172.5	243.7		222
FOR LOADS >= 7.5 kW									
V45T0n20A	1.499	-76.65	298.1	172.5	243.7	172.5	243.7		238
V45T0n30A	.9997	-.7958	249.1					131	164
V45T0n13A	.9997	-.7958	249.1						
UNITS-->	psia								
V45P0n47A	0.4	0	100					50	75

METER/DISPLAY RANGE - MSID: V45T0n20A LOW: -75 HIGH: 300

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 3.4	SHEET 1	ZONE WV-4&5
	DWG NO 3.4	SHEET 1	ZONE N-7,M-
	DWG NO 3.4	SHEET 1	ZONE 2&3
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-945099	SHEET 29/32	ZONE 9-C,13-
	DWG NO VS70-945099	SHEET 35	ZONE -B,10-C

ELEMENT: Orbiter SUBSYSTEM: FCP

LCC VIOLATION CALL: Fuel Cell Substack Delta Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V45V0102A	FCP No 1 Substack 1 Delta Voltage	(2)	NA	150 (1)	mV	CI
V45V0103A	FCP No 1 Substack 2 Delta Voltage	(2)	NA	150 (1)	mV	CI
V45V0104A	FCP No 1 Substack 3 Delta Voltage	(2)	NA	150 (1)	mV	CI
V45V0202A	FCP No 2 Substack 1 Delta Voltage	(2)	NA	150 (1)	mV	CI
V45V0203A	FCP No 2 Substack 2 Delta Voltage	(2)	NA	150 (1)	mV	CI
V45V0204A	FCP No 2 Substack 3 Delta Voltage	(2)	NA	150 (1)	mV	CI
V45V0302A	FCP No 3 Substack 1 Delta Voltage	(2)	NA	150 (1)	mV	CI
V45V0303A	FCP No 3 Substack 2 Delta Voltage	(2)	NA	150 (1)	mV	CI
V45V0304A	FCP No 3 Substack 3 Delta Voltage	(2)	NA	150 (1)	mV	CI

TIME PERIOD:

(1) From start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds) (3)
(2) From start of ET Cryo Tanking (T-6 hours) to Go for GLS Start (T-9 minutes) (4,5,6)

REQUIREMENTS: FIGURES/TABLES:

(3) For confirmed instrumentation failure, LCC violation confirmed, No Go for launch.
(4) For a fixed reading at the self test value (approx. 50 mV) or a reading of 0 mV which does not vary with load changes, LCC violation confirmed, No Go for launch. (7)
(5) For an FCP Substack Delta Voltage absolute change greater than 18 mV at steady state load, LCC violation confirmed, No Go for launch. (8)
(6) For an FCP Substack Delta Voltage absolute change greater than 28 mV during a load change, LCC violation confirmed, No Go for launch. (8)

PREPLANNED CONTINGENCY PROCEDURE:

(7) For a fixed reading of 0 mV (excluding self-test) or 50 mV spanning from fuel cell start complete to end of prelaunch conditioning (T-9 minutes), perform additional load changes to evaluate potential instrumentation failure. If instrumentation failure is not indicated, LCC violation cleared, continue countdown. (Reference S0007 Vol. 5)
(8) For a Substack Delta Voltage change greater than 18 mV at steady state loads or greater than 28 mV during step load changes, perform a fuel cell 10 minute purge to remove potential inert contamination. Perform additional load changes to evaluate fuel cell stability/sensitivity. If degradation ceases, LCC violation cleared, continue countdown.

NOTES:

(9) A FCP Substack Delta Voltage fixed reading of 0 mV, 50 mV, or 500 mV confirms instrumentation failure.

NOTES: (Continued)

(10) The Fuel Cell Monitoring System (FCMS), when installed, may be useful in providing additional fuel cell health data. It is not a substitute for the CPM.

REDLINE DERIVATION: CRITICALITY:

(11) Redline ensures proper function of individual cells by comparison of the voltage difference between two halves of each substack.
(12) The allowable FCP substack delta voltage absolute change limits were determined by reviewing the data from STS-26R to STS-83 to determine the maximum observed changes. The stabilization limit (18 mV), from the time period of performance cal end plus 1 hour to start of prelaunch conditioning, accepts all data points including a maximum absolute change of 14 mV while rejecting the STS-83 data point of 88 mV. The sensitivity limit (28 mV), from the prelaunch conditioning data, accepts all data points including a maximum absolute change of 20 mV, while rejecting the STS-83 data point of 46 mV.
(13) The following are out-of-family conditions and could indicate a problem within a single cell or cells in a substack:
   a) A FCP Substack Delta Voltage absolute change of greater than 28 mV during a load change.
   b) A FCP Substack Delta Voltage absolute change of greater than 18 mV during steady state loads.

CONSEQUENCES OF EXCEEDING REDLINE:

(14) Redline violation indicates potential single-cell failure which may lead to reactant mixing, loss of the powerplant, and local hazard to the Orbiter.

CAUSES OF EXCEEDING REDLINE:

(15) Voltage difference between the two halves of a substack greater than 150 mV may indicate failure of a cell or cells within the substack.
(16) Self test check failure will cause full-scale readout.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR FUEL CELLS 1, 2, AND 3 RESPECTIVELY									
UNITS-->	mV								
V45V0n02A	2	0	500						150
V45V0n03A	2	0	500						150
V45V0n04A	2	0	500						150

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: FCP

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LCC VIOLATION CALL: Fuel Cell Coolant Pump Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V45X0143E	Fuel Cell No 1 Coolant Pump Status	(2)	ON (5)	NA	Event	CI
V45X0243E	Fuel Cell No 2 Coolant Pump Status	(2)	ON (5)	NA	Event	CI
V45X0343E	Fuel Cell No 3 Coolant Pump Status	(2)	ON (5)	NA	Event	CI
V45V0114A	FCP No 1 H2 Pump Mtr Condition	(2)	0.28	1.00 (3,4)	Volts	CI
V45V0214A	FCP No 2 H2 Pump Mtr Condition	(2)	0.28	1.00 (3,4)	Volts	CI
V45V0314A	FCP No 3 H2 Pump Mtr Condition	(2)	0.28	1.00 (3,4)	Volts	CI

TIME PERIOD:

(1) From FCP Performance Calibration Start To Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown.
(3) Values in excess of maximum redline are acceptable if caused by AC phase imbalances. (Such as are caused by crew compartment lighting load.) (8)
(4) From FCP Performance Calibration Start to Go For GLS Start (T-9 minutes), for any H2 Pump Mtr Condition reading above 0.75 volts, LCC violation confirmed, No Go for launch. (10)

PREPLANNED CONTINGENCY PROCEDURE:

(5) For Fuel Cell Coolant Pump Status instrumentation failure, immediately request crew (if available) to check for caution and warning (C&W) and talkback indication. If C&W and talkback are OK, the failure is telemetry. Condenser Exit Temperature (V45T0130A, 0230A, and 0330A) (reference LCC FCP-02) is an acceptable backup measurement if the H2 Pump Motor Condition measurement and its FDA software are functional.
(6) For failure of FCP H2 pump motor condition instrumentation, use the following inverter phase currents as backup for pump stall or loss of power indication:
V76C1540A AC Bus 1 Phase A Current.
V76C1541A AC Bus 1 Phase B Current.
V76C1542A AC Bus 1 Phase C Current.
V76C1640A AC Bus 2 Phase A Current.
V76C1641A AC Bus 2 Phase B Current.
V76C1642A AC Bus 2 Phase C Current.
V76C1740A AC Bus 3 Phase A Current.
V76C1741A AC Bus 3 Phase B Current.
V76C1742A AC Bus 3 Phase C Current.
For unexplained change greater than plus or minus 2 PCM counts (0.16 amps), LCC violation confirmed, No Go for launch. (Reference LCC EPDC-04.)

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

(7) For a fuel cell pump power failure, FCP shutdown is required within 9 minutes (for a 7kW per fuel cell load).
(8) Request crew report on overhead lights configuration changes. If recent changes have been made, request crew to return to prior configuration. If H2 Pump Motor Condition falls below maximum redline, LCC violation cleared, continue countdown. Otherwise LCC violation confirmed, No Go for launch.

NOTES:

(9) The coolant pump delta P talkback on Panel R1 is a discrete measurement and used in-flight as the only rapid indication of power loss to the coolant pump. FCP shutdown is required for a pump power failure because of a possible hazardous FCP failure.
(10) A gradual rise and or cycling in Fuel Cell Pump Motor Condition volts may indicate developing flooding of H2 pump.

REDLINE DERIVATION: CRITICALITY:

(11) Both the coolant pump and the hydrogen pump must be functioning during fuel cell operation to prevent FCP damage.
(12) Fuel cell H2 Pump Motor Condition value is sensitive to AC phase voltage imbalance. Minimum redline of 0.28 volts protects against a loss of pump power indication being masked by an AC phase voltage imbalance. Maximum redline of 1.00 volts protects against an impending pump stall condition (2.0 to 2.5 volts) or loss of a single AC phase (3.0 to 4.5 volts). The redline value of 1.00 was selected high enough to protect against possible violation due to AC phase voltage imbalance but low enough that fuel cell damage due to flooding has not occurred.
(13) Backup: Loss of coolant pump may be accompanied by loss of hydrogen pump/ separator; both are on the same electrical circuit. Development fuel cell testing at 7-kW power level showed Condenser Exit Temperature (V45T0130A, 0230A, and 0330A) rise of 36 deg F in 30 seconds and Stack Coolant Outlet Temperature decrease of 10 deg F in 2 minutes when coolant pump was turned OFF. If both coolant and hydrogen pump are failed, Condenser Exit Temperature change will be slower, Stack Coolant Outlet Temperature rate of change will be the same or slightly greater.

CONSEQUENCES OF EXCEEDING REDLINE:

(14) Violation of the Coolant Pump Status minimum redline will cause overheating and loss of the affected fuel cell because of inability to remove heat (9). Reactant leakage may result from exceeding material temperature limits.
(15) Violation of the H2 Pump Mtr Condition minimum redline (loss of power) or maximum redline (approaching pump stall) will result in water accumulation with resultant flooding of the affected fuel cell.

CAUSES OF EXCEEDING REDLINE:

(16) Coolant pump/hydrogen pump failure.
(17) Loss of power to pump motors or delta P transducer.
(18) Loss of coolant.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR FUEL CELLS 1, 2, AND 3 RESPECTIVELY									
UNITS-->	Volts								
V45V0n14A	0.02	0	5.00						
UNITS-->	Event								
V45X0n43E				ON		ON			

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 3.4	SHEET 1	ZONE P,6;
	DWG NO 3.4	SHEET 1	ZONE WV2-3
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-945099	SHEET 27/30/	ZONE 15C
	DWG NO VS70-945099	SHEET 33	ZONE

ELEMENT: Orbiter SUBSYSTEM: FCP

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LCC VIOLATION CALL: Fuel Cell Water Condition Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V45X0410E	Fuel Cell No 1 H2O Condition	(2)	OFF (3)	NA	Event	CI
V45X0420E	Fuel Cell No 2 H2O Condition	(2)	OFF (3)	NA	Event	CI
V45X0430E	Fuel Cell No 3 H2O Condition	(2)	OFF (3)	NA	Event	CI
V45X0462E	Fuel Cell H2O Conductivity	(2)	OFF (3)	NA	Event	CI

TIME PERIOD:

(1) From FCP Performance Calibration Start To Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Three of four measurements acceptable for confirmed instrumentation failure only. (5)
(3) For redline violations of 5 minutes or less, LCC violation cleared, continue countdown. Fuel Cell H2O Condition/H2O Conductivity indications must be OFF to continue. For redline violations longer than 5 minutes, LCC violation confirmed, No Go for launch (4).

PREPLANNED CONTINGENCY PROCEDURE:

(4) If engineering evaluation confirms nominal fuel cell operation and Fuel Cell H2O Condition/H2O Conductivity indications are OFF, LCC violation cleared, continue countdown. FCP shutdown and safing shall be initiated after one hour of continuous HIGH pH indications from both the individual (Fuel Cell No x H2O Condition) and common (Fuel Cell H2O Conductivity) water conductivity sensors unless a check of the potable water pH does not confirm the continuous presence of HIGH pH (pH>9). The common water conductivity sensor indication may be delayed up to eight minutes after a fuel cell indication due to transport time between sensors. Transport time between the fuel cell and the galley may require 20 minutes. FCP shutdown and safing shall be initiated at any time if fuel cell flooding is confirmed. Confirming cues for FCP flooding are coolant pressure, FCP temperatures, Cell Performance Monitor (CPM), or H2 pump currents out of limits.
(5) Reference S0007 Volume 5 "pH Sensor test at galley". A check of the potable water is required to verify a water conductivity sensor failed ON. A check of the potable water that does not indicate high pH while a conductivity sensor is indicating HIGH pH is confirmation of instrumentation failure.

NOTES:

(6) An ON condition will cause an SM alert.
(7) Fuel cell loads may be reduced to decrease water production rate to manage potable water quantity.
(8) Newly installed fuel cells increase the probability of temporary high pH indications due to metallic ions or residual KOH.

REDLINE DERIVATION: CRITICALITY:

(9) Redline ensures that KOH is not present in product water.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Indicates presence of KOH in product water.
(11) Potable water unusable and FCP lost.

CAUSES OF EXCEEDING REDLINE:

(12) Oxygen overpressure.
(13) Hydrogen underpressure.
(14) Excessive water in the cell resulting in electrolyte (KOH) expulsion into the product water.
(15) Metallic ions temporarily increasing the conductivity of the fuel cell water.
(16) Residual KOH.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR FUEL CELLS 1, 2, AND 3 RESPECTIVELY									
UNITS-->	Event								
V45X04n0E								OFF	

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 3.4	SHEET 1	ZONE K4
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-945099	SHEET 29/32/	ZONE 12-A
	DWG NO VS70-945099	SHEET 3S	ZONE

ELEMENT: Orbiter SUBSYSTEM: FC

LCC VIOLATION CALL: Fuel Cell Water Relief System Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V45T0455A	FCP H2O Relief Nozzle Temp A	(5,6,7	157	235	deg F	CI
V45T0456A	FCP H2O Relief Nozzle Temp B	(5,6,7	157	235	deg F	CI
V45T0412A	FC No 1 H2O Relief Valve Temp	(3,4)	60	NA	deg F	CI
V45T0422A	FC No 2 H2O Relief Valve Temp	(3,4)	60	NA	deg F	CI
V45T0432A	FC No 3 H2O Relief Valve Temp	(3,4)	60	NA	deg F	CI
V45T0450A	H2O Relief Line Temp	(2,4)	60	NA	deg F	CI
V45T0182A	FCP No 1 Alt Product H2O Line Temp	(8)	60	NA	deg F	CI
V45T0282A	FCP No 2 Alt Product H2O Line Temp	(4,5)	60	NA	deg F	CI
V45T0382A	FCP No 3 Alt Product H2O Line Temp	(4,5)	60	NA	deg F	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) Measurement loss is acceptable for confirmed instrumentation failure. (9)
(3) 2 of 3 measurements acceptable for confirmed instrumentation failure. (9)
(4) 1 of 2 heaters (A or B) acceptable for launch. (11)
(5) 1 of 2 measurements acceptable for confirmed instrumentation failure. (9)
(6) Nozzle temperature sensor (A or B) control function loss (inside or outside the controller) is acceptable provided the nozzle heater is functioning within a control band of 157 - 317 deg F. (10)
(7) Temporary FCP H2O Relief Nozzle Temperature excursions high or low are acceptable during periods of rain.
(8) Instrumentation required for launch. Both A and B heaters required for launch. (11)

PREPLANNED CONTINGENCY PROCEDURE:

(9) Instrumentation failure is confirmed for measurements indicating off scale (high or low) and/or exhibiting a step function change. For confirmed instrumentation failure, LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

(10) If the B temperature sensor (or B controller input signal) fails low, the B controller attempts to maintain the heater ON, but the A controller over-temp cutoff will cycle the nozzle heater, the redline maximum limit will be raised from 235 degrees F to 317 degrees F, LCC violation cleared, continue countdown. If either temperature sensor fails high, determine if the "high" failure is acceptable for launch by either:
(A) Verify other nozzle temperature is cycling (ON/OFF) within normal limits; or
(B) Deactivate the relief nozzle heaters by placing the FC H2O Relief Heater switch (Panel R12) to OFF until the nozzle temperature is less than 157 degrees F, then reactivate the heater. If the nozzle heater cycles ON, the high failure does not affect the operation of the nozzle heater.
If either A or B is satisfied, LCC violation cleared, continue countdown. Otherwise, the nozzle heater will be disabled; LCC violation confirmed, No Go for launch.
(11) Heater cycling when temperature indications are below thermostat set point confirms heater function. Heater verification is only required if heater failure is suspected (Reference S0007 Vol 5). For confirmed heater function, LCC violation cleared, continue countdown.

NOTES:

(12) For FCP H20 relief nozzle temp, if the A temperature sensor fails low, the "A" controller over-temp nozzle heater cutoff is lost, but the heater will continue cycling within limits.

REDLINE DERIVATION: CRITICALITY:

(13) Subsystem limit. Redline limits are to detect a heater system failure.
(14) V45T0455A and V45T0456A:
A. Max redline: To detect a failed-ON heater system.
B. Min redline: To detect a failed-OFF heater system.
C. Redline development:

	Min	Max
Controller set point	168 deg F	206 deg F
Instr error (2.5%)	-11	+29 (Includes thermal overshoot)
	---	---
	157 deg F	235 deg F

D. FCP H2O Relief Nozzle Temperature 317 degrees F redline derivation:
1. With "B" controller input failed low (V45T0456A = 0 deg F)
a. "B" controller will try to keep nozzle heater B ON.
b. Htr-B high temp cutoff will then be controlled by "A" controller overtemp output (V45X0460E).
2. Redline development:

	Maximum
"A" controller overtemp output (htr off)	288 deg F
Instrumentation error and thermal overshoot	+29 deg F

Secondary redline maximum temperature	317 deg F

REDLINE DERIVATION: (Continued)

(15) V45T0412A, V45T0422A, V45T0432A, V45T0450A, V45T0182A, V45T0282A, and V45T0382A:
A. Minimum redline: Detect a heater-OFF failure.
B. Redline development:

Thermostat set point	70 deg F
Location delta	-5
Instrumentation error (2.1%)	-5
	--
Redline limit	60 deg F

(16) V45T0182A:
Fuel cell 1 alternate water line heaters protect a section of alternate water line common to all three fuel cells. If line freezes, alternate water path is lost for all three fuel cells. Next failure (loss of Water Relief Panel) is loss of vehicle (1R2). Measurement (V45T0182A) is the only visibility of alternate line heater operation during flight.

CONSEQUENCES OF EXCEEDING REDLINE:

(17) Maximum: Temperature above 700 degrees F may cause damage to the structure between the nozzle and structure in the area of the seal.
(18) Minimum: Possible freezing/blockage and loss of water flow capability.

CAUSES OF EXCEEDING REDLINE:

(19) Heater, driver, or controller failure.
(20) Rain impingement.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR FUEL CELLS 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.F								
V45T0n82A	.9997	-.7958	249.1						
V45T04n2A	.9997	-.7958	249.1						
V45T0455A	1.77	.8964	443.4						
V45T0456A	1.77	.8964	443.4						
V45T0450A	.9997	-.7958	249.1						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 3.4	SHEET	ZONE F3
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-945102	SHEET 21/24	ZONE 3-B
	DWG NO VS70-945102	SHEET 27	ZONE 3-B
	DWG NO VS70-945102	SHEET 29	ZONE 13-A&B/
	DWG NO VS70-945102	SHEET	ZONE 23-B

ELEMENT: Orbiter SUBSYSTEM: FCP

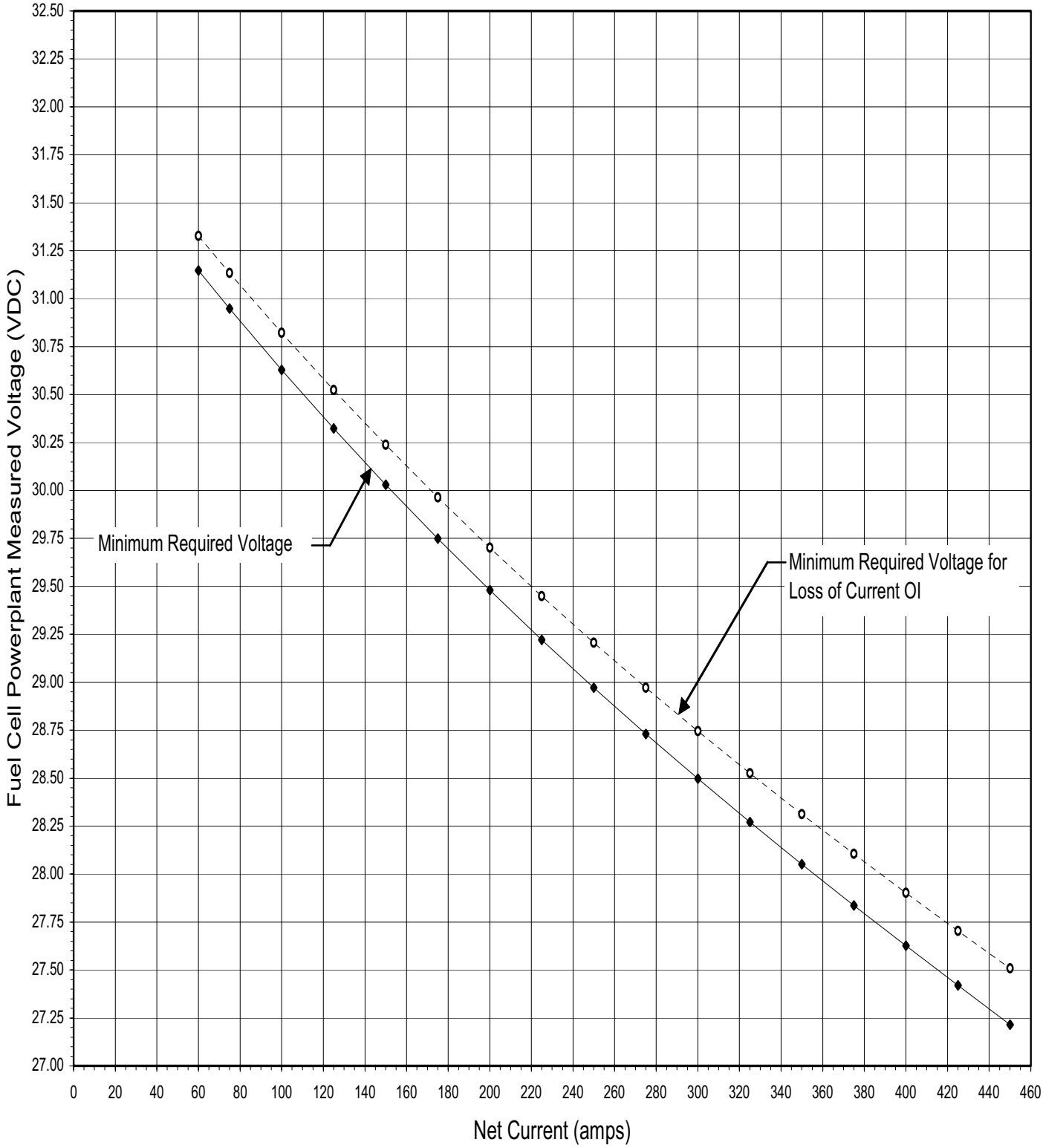

Figure 25-01
FUEL CELL POWERPLANT MINIMUM LAUNCH PERFORMANCE LIMITS
(MEASURED VOLTAGE)

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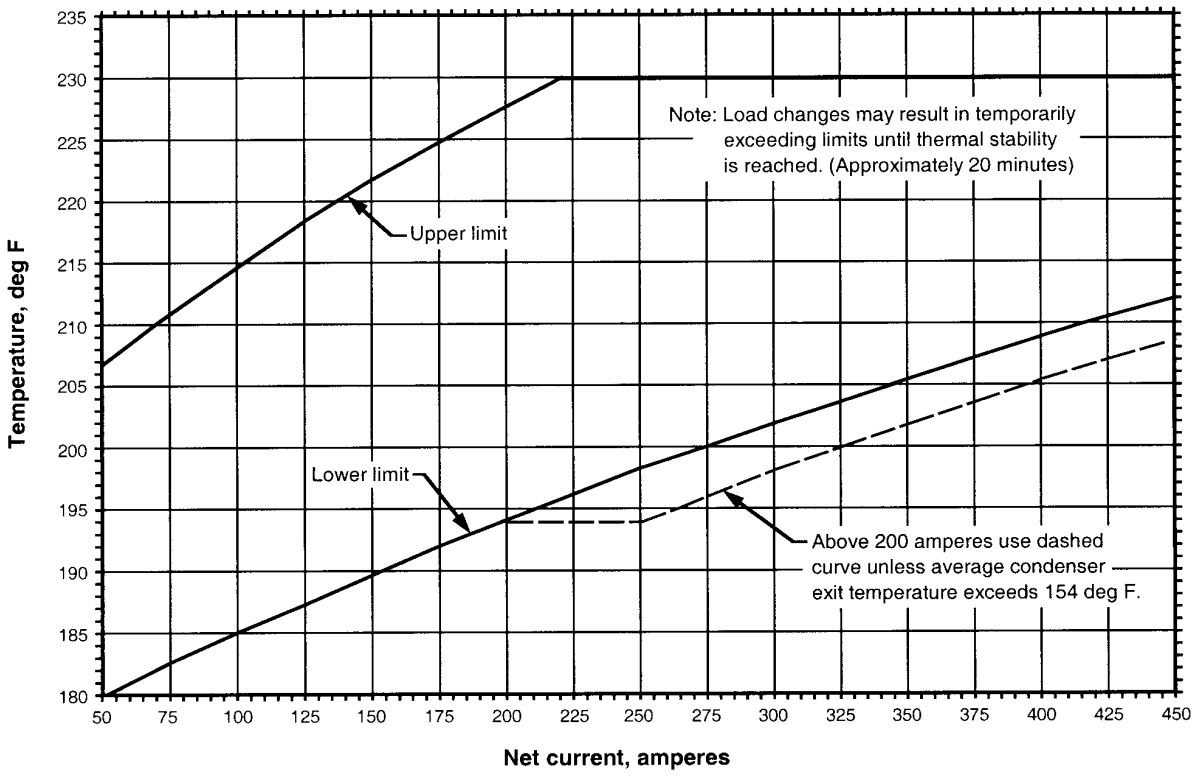

FIGURE 25-02 FUEL CELL POWERPLANT STACK COOLANT OUTLET TEMPERATURES

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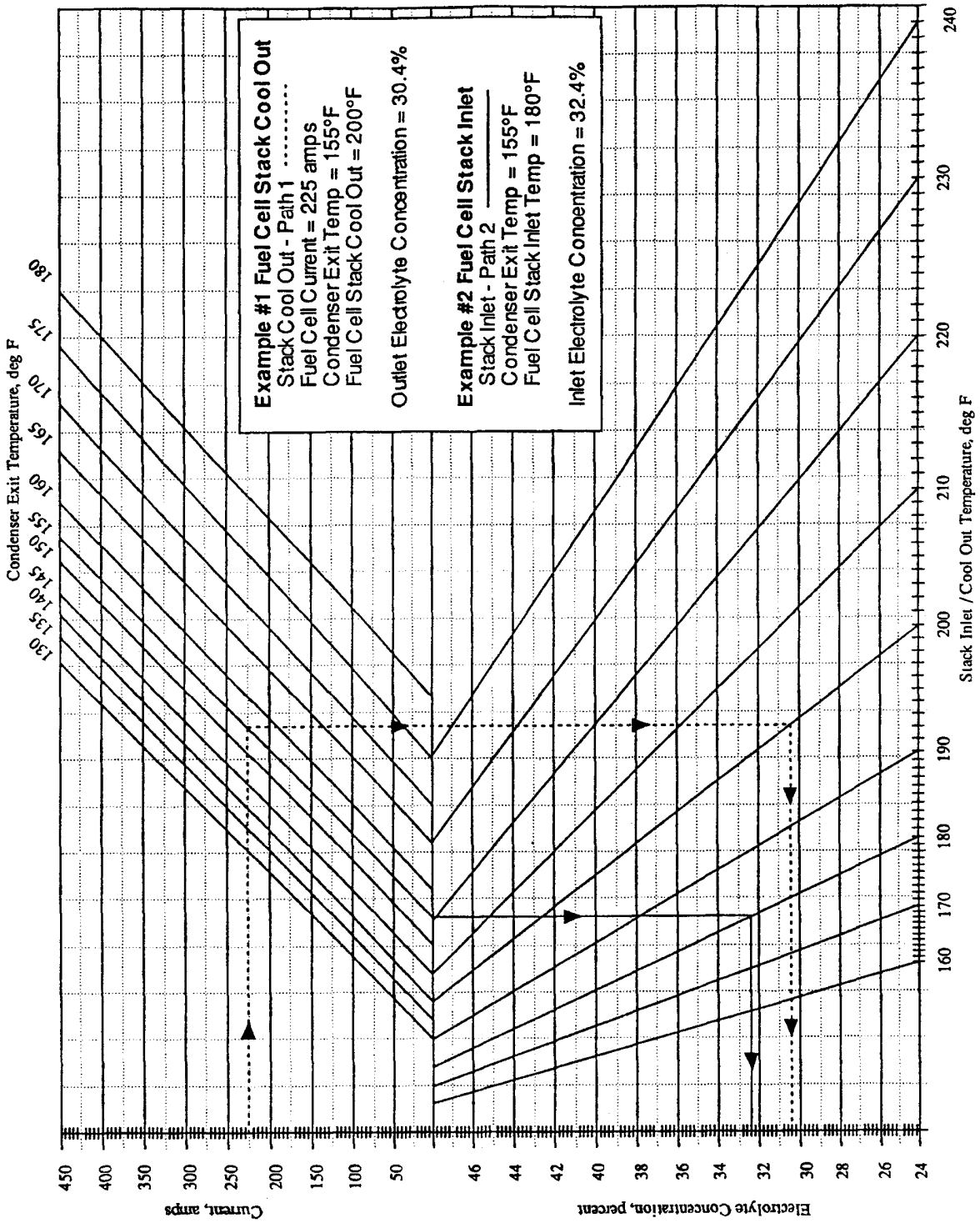

FIGURE 25-03 FCP ELECTROLYTE CONCENTRATION NOMOGRAPH

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SECTION 26

ELECTRICAL POWER DISTRIBUTION AND CONTROL

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SECTION 26: ELECTRICAL POWER DISTRIBUTION AND CONTROL

SSID No.	Description/Violation Call	Page
EPDC-01	Orbiter Main Bus Voltage Anomaly	26-01.1
EPDC-02	Orbiter Control Bus RPC Anomaly	26-02.1
EPDC-03	Orbiter AC Bus Voltage Anomaly	26-03.1
EPDC-04	Orbiter AC Bus Phase Current Anomaly	26-04.1
EPDC-05	SRB Bus Power Anomaly	26-05.1
EPDC-06	Essential Bus Source Anomaly	26-06.1
EPDC-07	Essential Bus Source Anomaly	26-07.1
EPDC-08	Orbiter Master Events Controller (MEC) Power Anomaly	26-08.1
EPDC-09	Orbiter Master Events Controller Preflight BITE Anomaly	26-09.1
EPDC-10	GSE Main Bus Motor Switch Anomaly	26-10.1
EPDC-11	Orbiter Fire Extinguisher Pyro Voltage Anomaly	26-11.1
EPDC-12	Orbiter Landing Gear Pyro Voltage Anomaly	26-12.1
EPDC-13	ET/ORB SEPARATION Anomaly	26-13.1
EPDC-14	Orbiter Drag Chute Pyro Voltage Anomaly	26-14.1

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LCC VIOLATION CALL: Orbiter Main Bus Voltage Anomaly | EMERG COND: Yellow

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76V0100A	Main Bus A Voltage	(2)	28.3	32.0	Vdc	CI
V45V0100A	Fuel Cell No 1 Voltage	(2)	28.3	32.0	Vdc	CI
V76V0200A	Main Bus B Voltage	(2)	28.3	32.0	Vdc	CI
V45V0200A	Fuel Cell No 2 Voltage	(2)	28.3	32.0	Vdc	CI
V76V0300A	Main Bus C Voltage	(2)	28.3	32.0	Vdc	CI
V45V0300A	Fuel Cell No 3 Voltage	(2)	28.3	32.0	Vdc	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) One of two measurements acceptable for confirmed instrumentation failure. (4)
(3) Actual bus voltage is determined by the fuel cell performance curve. (Reference SSID FCP-01.)

PREPLANNED CONTINGENCY PROCEDURE:

(4) To confirm instrumentation failure verify associated fuel cell and main bus voltages and currents (PCM and hardline), and forward and aft PCA bus voltages. If no corresponding changes to the following measurements, instrumentation failure. LCC violation cleared, continue countdown.
V45C0101A, 0201A, 0301A Fuel Cell Currents 1, 2, 3.
V76C3085A, 3086A, 3087A Mid Main Bus Currents A, B, C.
V76V3071A, 3072A, 3073A Fwd PCA Bus Voltages 1, 2, 3.
V76V3091A, 3092A, 3093A Aft PCA Bus Voltages 4, 5, 6.

NOTES:

(5) Panel F9 meter available for fuel cell and main bus voltages if crew on board.
(6) Hardline measurements V76V0100H, V76V0200H, and V76V0300H are available prelaunch. (Main Bus A, B, and C voltage respectively.)
(7) Main bus undervoltage and backup C&W alarm will occur when bus voltage is less than or equal to 26.4 Vdc. Backup C&W alarm will occur 2 to 3 seconds after the main bus undervoltage C&W. Because the Orbiter is required to provide 24.0 volts at its loads, it must provide a minimum of 26.4 volts at the bus, taking into consideration the IR drop to the load.

REDLINE DERIVATION: CRITICALITY: 1R

(8) To launch with less than three functional main busses is less than FAIL SAFE.
(9) Instrumentation error: PCM - 0.5% full scale; Meter - 0.5% full scale.
(10) Basis for redline:

A. Main bus undervoltage C&W alarm minimum limit of 26.4 Vdc indicates that the load interface voltage is approaching the specified value of 24 Vdc (5). The most sensitive load on the distribution system is the SRBs (Solid Rocket Boosters). The SRBs are powered from the aft main busses and require a minimum of 26.15 volts for busses A and B and 25.6 volts for bus C at the SRB interface.

B. The derivation of these redlines is based on supporting the case of a fuel cell failure during ascent. For this case, the SRB interface voltage minimum for busses A and B is reduced to 25.7 Vdc and bus C is reduced to 25.2 Vdc. Results from delta-OIT have shown that with an MDA (main distribution assembly) main bus voltage of *27.4 Vdc, the SRB interface voltage for busses A and B will be *25.77 Vdc. Also, Rockwell math model analyses (**assuming approximately 9 kW/fuel cell prelaunch load) indicate that there will be approximately an 0.8 Vdc drop on the remaining fuel cells if a fuel cell is lost during ascent (**assuming a resultant load of approximately 11 kW/fuel cell on remaining fuel cells).

C. Using the Rockwell math model resistance values for the distribution system for analyzing the fuel cell failure case during ascent, there is a 1.6 Vdc drop from the MDA main bus to the SRB interface. Therefore, utilizing the test and analytical data, a minimum main bus redline can be established as follows:

Maximum Redline: 32.0 = 32.0 - 0.
Redline = fuel cell voltage - negligible IR drop (main bus loaded to 2 kW).

Minimum Redline = Minimum SRB interface voltage with + IR drop between SRB interface with fuel cell failed during ascent and MDA main bus + delta voltage drop on remaining fuel cells + instrumentation error.

D. *28.3 = 25.7 + 1.6 + 0.8 + 0.2

* Instrumentation error included.
** Rockwell math model analysis load considers all cyclic loads on at the same time.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Maximum: A. Open circuit protective device.
B. Possible damage to critical loads because of overvoltage stress.
(12) Minimum: A. Activate C&W alarm.
B. Possible loss of critical loads because of insufficient operating voltage.

CAUSES OF EXCEEDING REDLINE:

(13) Maximum: A. Very low preflight load condition allowing main bus voltage to exceed the maximum value (fuel cell output voltage increases with decreasing load conditions).
B. Improper GSE power supply regulation caused by:
1. Loss of sense line.
2. Internal fault.
3. LPS malfunction.

(14) Minimum: A. Very heavy preflight load conditions.
B. Sustained bus-to-ground fault causing bus voltage to drop below minimum value.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	Vdc								
n = 1, 2, AND 3 FOR MAIN BUS A, B, AND C RESPECTIVELY									
V76V0n00A	0.16	0.0	40.0			26.4		27	32
n = 1, 2, AND 3 FOR FUEL CELL 1, 2, AND 3 RESPECTIVELY									
V45V0n00A	0.16	0.0	40.0					27.5	32.5

METER/DISPLAY RANGE - MSID: V76V0n00A LOW: 20.0 HIGH: 45.0
MSID: V45V0n00A LOW: 20.0 HIGH: 45.0

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 2.2 SHEET 1 ZONE P-7
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-976099 SHEET 76B ZONE E-10

ELEMENT: Orbiter SUBSYSTEM: EPDC

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LCC VIOLATION CALL: Orbiter Control Bus RPC Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76X0124E	Main Bus A Cont Bus AB1/CA1 RPC On	(2)	ON	NA	Event	CI
V76X0125E	Main Bus A Cont Bus AB2/CA2 RPC On	(2)	ON	NA	Event	CI
V76X0126E	Main Bus A Cont Bus AB3/CA3 RPC On	(2)	ON	NA	Event	CI
V76X0224E	Main Bus B Cont Bus AB1/BC1 RPC On	(2)	ON	NA	Event	CI
V76X0225E	Main Bus B Cont Bus AB2/BC2 RPC On	(2)	ON	NA	Event	CI
V76X0226E	Main Bus B Cont Bus AB3/BC3 RPC On	(2)	ON	NA	Event	CI
V76X0324E	Main Bus C Cont Bus BC1/CA1 RPC On	(2)	ON	NA	Event	CI
V76X0325E	Main Bus C Cont Bus BC2/CA2 RPC On	(2)	ON	NA	Event	CI
V76X0326E	Main Bus C Cont Bus BC3/CA3 RPC On	(2)	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 8 of 9 measurements acceptable if 2 of 3 sources on affected control bus are verified ON. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Each RPC feeds power to two control busses, if an RPC indicates OFF, both control busses must be checked for redundancy. Notify test director that a control bus could drop off if this redundancy check is not successful. (Ref. S0007 Vol. 5)
   A. On panel R14/R15, verify control bus circuit breaker (CB) related to failed RPC/MSID is not tripped or open. If CB is tripped or open, LCC violation confirmed, No Go for launch.
   B. Turn off good RPC on affected control bus.
   C. If control bus remains up, this verifies another source to the bus.
   D. Turn on good RPC.
   E. Repeat steps A through D for the other affected control bus.
   If RPC redundancy is confirmed for both affected Control Busses, LCC violation cleared, continue countdown.

NOTES:

(4) Each control bus is powered by all three main busses (A, B, and C). Each control bus is connected to two main busses through RPCs and one main bus through a circuit breaker.
(5) Control bus with electrical short to ground may not trip both RPCs and may only be indicated by loss of function or one RPC tripped.
(6) Two power sources are required for redundancy.

REDLINE DERIVATION: CRITICALITY: 1R

(7) These redlines ensure redundant power to each Control Bus.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Loss of two of three power sources to a control bus.

CAUSES OF EXCEEDING REDLINE:

(9) Malfunction or tripped RPC for two main bus sources of power.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2 OR 3 FOR MAIN BUS A, B OR C RESPECTIVELY									
V76X0n24E								ON	
V76X0n25E								ON	
V76X0n26E								ON	

METER/DISPLAY RANGE - MSID: LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 2.2	SHEET 1	ZONE H-8,5,3
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-976099	SHEET 76 AU	ZONE G18-22
	DWG NO	SHEET	ZONE 10-15,
	DWG NO	SHEET	ZONE 3-81

ELEMENT: Orbiter SUBSYSTEM: EPDC

LCC VIOLATION CALL: Orbiter AC Bus Voltage Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76V1500A	AC Bus 1 Phase A Volt	(2)	115	120	V AC	CI
V76V1501A	AC Bus 1 Phase B Volt	(2)	115	120	V AC	CI
V76V1502A	AC Bus 1 Phase C Volt	(2)	115	120	V AC	CI
V76V1600A	AC Bus 2 Phase A Volt	(2)	115	120	V AC	CI
V76V1601A	AC Bus 2 Phase B Volt	(2)	115	120	V AC	CI
V76V1602A	AC Bus 2 Phase C Volt	(2)	115	120	V AC	CI
V76V1700A	AC Bus 3 Phase A Volt	(2)	115	120	V AC	CI
V76V1701A	AC Bus 3 Phase B Volt	(2)	115	120	V AC	CI
V76V1702A	AC Bus 3 Phase C Volt	(2)	115	120	V AC	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Zero of three measurements per AC bus are acceptable for confirmed OI system measurement failure(s). (4)
(3) For the loss of a voltage measurement, the current measurement for that phase must be available (reference SSID EPDC-04).

PREPLANNED CONTINGENCY PROCEDURE:

(4) Verify bus phase voltages are nominal on D&C Panel F9 - meter M 1. If failed AC bus voltage OI measurement(s) can be verified on panel F9, and primary C&W does not detect a corresponding AC bus failure, LCC violation cleared, continue countdown.

NOTES:

(5) Hardwire measurements V76V1500H, 1501H, 1502H, 1600H, 1601H, 1602H, 1700H, 1701H, 1702H can be used as a reference pre-launch.

NOTES: (Continued)

(6) C&W limits are set to alert the crew in case of undervoltage, overvoltage or overload. Backup C&W monitors the same PCM OI voltage measurements used in this SSID. HW C&W monitors performance of AC bus phase voltages through a sensor unit inside the Inverter Distribution and Control Assembly (IDCA) using a separate instrumentation circuit. The IDCA outputs a discrete flag to HW C&W when a limit is exceeded.
 A. HW C&W activates when any AC bus phase voltage is:
  - Less than 102 +6/-0 V AC for 8.5 +0/-2 sec, or
  - Greater than 127 +0/-4 V AC for 90 +0/-40 msec.
 B. Backup C&W alarm light comes on when any AC bus phase voltage OI measurement is:
  - Less than 108 V AC, or
  - Greater than 123 V AC.

(7) An actual AC bus failure (any phase loss) will be detected by the Main Engine Controllers and result in an RSLS abort after T-31 seconds.

(8) Although the measurements for each of the three busses are routed to three different DSC's, then to three different MDM's, single point failures still exist. The voltage measurements for each of the three phases of any given bus are all processed by the same DSC card, and two of the three phase voltage measurements on a given bus are processed by the same MDM card.

REDLINE DERIVATION: CRITICALITY: 1R

(9) Instrumentation error:
PCM - 1.0% full scale; Meter - 105-125 volts: +/- 1.5 V AC

(10) Basis for Redline:
Maximum Redline: 120 V AC measured at the inverter ensures a maximum of 120 V AC at the load interface after line loss.
Minimum Redline: 115 V AC was chosen because of Orbiter Integrated Test (OIT) data and experience with the AC system. The test data shows that the inverter output will not drop below 115 V AC with loads up to 220% of rated load.

(11) AC bus phase voltages must be maintained within redline limits to provide 110 to 120 V AC at the load interface, with allowances for voltage drop from wiring and relay contacts.

(12) All AC loads are rated to operate at a minimum of 110 V AC and up to a maximum of 120 V AC.

CONSEQUENCES OF EXCEEDING REDLINE:

(13) Maximum: A. Possible damage to critical loads because of overvoltage stress.
B. Activate C&W alarm and automatic disconnect.

(14) Minimum: Possible loss of critical loads because of insufficient operating voltage.

CAUSES OF EXCEEDING REDLINE:

(15) Maximum: Failure of the internal regulator of the inverter.

(16) Minimum: A. Failed inverter.
B. Excessive load on the inverter.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 5, 6, AND 7 FOR AC BUS 1, 2, AND 3 RESPECTIVELY									
UNITS-->	V AC								
V76V1n00A	0.56	0	140	(6)A	(6)A	108	123		
V76V1n01A	0.56	0	140	(6)A	(6)A	108	123		
V76V1n02A	0.56	0	140	(6)A	(6)A	108	123		

METER/DISPLAY RANGE - MSID: V76V1n00A LOW: 90 HIGH: 130
V76V1n01A LOW: 90 HIGH: 130
V76V1n02A LOW: 90 HIGH: 130

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 2.3 SHEET 1 OF 1 ZONE F-7
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-976099 SHEET 76BG ZONE 7E
DWG NO VS70-976099 SHEET 76BN ZONE 7E
DWG NO VS70-976099 SHEET 76BV ZONE 7E

ELEMENT: Orbiter SUBSYSTEM: EPDC

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LCC VIOLATION CALL: Orbiter AC Bus Phase Current Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76C1540A	AC Bus 1 Phase A Current	(3)	0.16	9.6 (2)	Amps	CI
V76C1541A	AC Bus 1 Phase B Current	(3)	0.16	9.6 (2)	Amps	CI
V76C1542A	AC Bus 1 Phase C Current	(3)	0.16	9.6 (2)	Amps	CI
V76C1640A	AC Bus 2 Phase A Current	(3)	0.16	9.6 (2)	Amps	CI
V76C1641A	AC Bus 2 Phase B Current	(3)	0.16	9.6 (2)	Amps	CI
V76C1642A	AC Bus 2 Phase C Current	(3)	0.16	9.6 (2)	Amps	CI
V76C1740A	AC Bus 3 Phase A Current	(3)	0.16	9.6 (2)	Amps	CI
V76C1741A	AC Bus 3 Phase B Current	(3)	0.16	9.6 (2)	Amps	CI
V76C1742A	AC Bus 3 Phase C Current	(3)	0.16	9.6 (2)	Amps	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) After stabilization (cabin fan activation may result in exceeding the redline limit).
(3) Two of three measurements acceptable for confirmed instrumentation failure. (6)
(4) For the loss of a current measurement, the voltage measurement for that phase must be available (reference SSID EPDC-03).
(5) Minimum redline is for confirming instrumentation failure only.

PREPLANNED CONTINGENCY PROCEDURE:

(6) To confirm instrumentation failure, check hardwire measurements and remaining PCM measurements for affected bus. If loads are normal, and associated voltage measurement is nominal, instrumentation failure, LCC violation cleared, continue countdown.

NOTES:

(7) Backup hardwire current measurements may be used to verify function. V76C1540H, 1541H, 1542H, 1640H, 1641H, 1642H, 1740H, 1741H, 1742H.
(8) AC OVERLOAD light comes on when:
225% overload for 10 to 20 sec (14.45 amps).
300% overload for 4 to 6 sec (19.23 amps).

REDLINE DERIVATION: CRITICALITY: 1R

(9) Instrumentation error: PCM - 1.8% full scale
(10) Basis for Redline:
A. The normal operating range of these measurements during a countdown is from 4.2 to 7.3 amps.
B. Maximum redline value is based on 150% of rated load, which should not be exceeded during the countdown.
C. Minimum redline is not necessary since each AC unit has its own redline.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) AC bus voltage may drop below minimum redline value.
(12) Launch AC load conditions may be excessive because of unnecessary loads on the AC bus.
(13) May exceed temperature limits of inverters.

CAUSES OF EXCEEDING REDLINE:

(14) Too many AC loads are ON.
(15) Sustained bus-to-ground fault.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 5, 6, AND 7 FOR AC BUS 1, 2, AND 3 RESPECTIVELY									
UNITS-->	Aac								
V76C1n40A	0.08	0	20						
V76C1n41A	0.08	0	20						
V76C1n42A	0.08	0	20						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 2.3 SHEET 1 of 1 ZONE L-7
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-976099 SHEET 76BG,BN ZONE C-F-14
DWG NO VS70-976099 SHEET BV ZONE

ELEMENT: Orbiter SUBSYSTEM: EPDC

LCC VIOLATION CALL: SRB Bus Power Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76X6775E	L SRB Bus A BU Pwr On		OFF	NA	Event	CI
V76X6776E	R SRB Bus A BU Pwr On		OFF	NA	Event	CI
V76X6777E	L SRB Bus B BU Pwr On		OFF	NA	Event	CI
V76X6778E	R SRB Bus B BU Pwr On		OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) The Orbiter aft main busses A and B are switched to both SRBs for operational power through an RPC and relay. Also, the Orbiter aft main bus C is automatically switched through the relay as a backup to bus A or B should either bus fail.

REDLINE DERIVATION: CRITICALITY: 1R

(3) These discretes are necessary to verify that the SRB Bus A & B redundancy exists. If either of the SRB busses (A or B) has switched over to its backup bus C prior to launch, the SRB will not be two-fault tolerant.

CONSEQUENCES OF EXCEEDING REDLINE:

(4) Loss of SRB bus redundancy.

CAUSES OF EXCEEDING REDLINE:

(5) Low voltage condition ON or complete loss of Orbiter bus A or B causing the backup power to be switched in.
(6) Failure of an RPC, relay or hybrid driver in the backup or the primary circuit.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 2.2	SHEET 2 of 2	ZONE F-I
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS72-948099	SHEET 48A,B,	ZONE C-16
	DWG NO VS72-948099	SHEET BN, BP	ZONE

ELEMENT: Orbiter SUBSYSTEM: EPDC

LCC VIOLATION CALL: Essential Bus Source Anomaly | EMERG COND:

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76X0236E	MNB to ESS1BC RPC On	(2)	ON	None	Event	CI
V76X0335E	MNC to ESS1BC RPC On	(2)	ON	None	Event	CI
V76X0336E	MNC to ESS2CA RPC On	(2)	ON	None	Event	CI
V76X0136E	MNA to ESS2CA RPC On	(2)	ON	None	Event	CI
V76X0135E	MNA to ESS3AB RPC On	(2)	ON	None	Event	CI
V76X0235E	MNB to ESS3AB RPC On	(2)	ON	None	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) To Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Five of six RPC sources mandatory.

A. Prior to APU Start:

For any main bus source (RPC) that indicates OFF, perform Preplanned Contingency Procedure (3) to verify fuel cell and alternate RPC sources are operative and to determine if RPC OFF indication is instrumentation failure or RPC failure. Repeat procedure for any subsequent RPC OFF indications. Only one actual RPC loss is allowed for all essential busses. For proven instrumentation failures, LCC violation cleared, continue countdown.

B. After APU Start:

If no prior essential bus RPC failure, accept 1 failure indication, LCC violation cleared, continue countdown.

If prior RPC failure and second RPC OFF indication occurs on a different essential bus, perform Preplanned Contingency Procedure (3) to determine if OFF indication is an instrumentation failure or an RPC failure. For an RPC failure, LCC violation confirmed, No Go for launch. For instrumentation failure, LCC violation cleared, continue countdown.

If prior RPC failure and a second RPC OFF indication occurs on the same essential bus, verify 1 of 2 main bus sources per Preplanned Contingency Procedure (4). If a good source is verified, LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE:

(3) If a source indication for an essential bus indicates OFF prior to APU start:
   A. Verify preflight bus ITCU voltage is 28-28.5 Vdc.
   B. On Panel R1 have Pilot verify/perform fuel cell source switch for affected bus ON.
   C. On Panel R1 have Pilot place main bus source switch for affected essential bus OFF.
   D. If essential bus voltage remains above 27 Vdc, via PCM and Panel F9 meter, this verifies a good fuel cell source.
   E. Command suspect RPC ON via LPS and verify increase in essential bus voltage. (Adjust main bus power supply if necessary.) This will confirm an instrumentation only failure if successful.
   F. Command suspect RPC OFF via LPS.
   G. On Panel R1 have Pilot place main bus source switch back to ON.
   H. On Panel R1 have Pilot place fuel cell source switch for affected essential bus back to OFF (if prior to T-8 minutes).
(4) For a second RPC source violation on the same essential bus:
   A. Verify preflight bus ITCU voltage is 28-28.5 Vdc.
   B. On Panel R1 have Pilot place fuel cell source switch for affected essential bus OFF.
   C. Verify affected essential bus voltage remains above 27 Vdc via PCM and Panel F9 meter. This verifies one of two main bus sources.
   D. On Panel R1 have Pilot place fuel cell source switch for affected essential bus back ON (if after T-8 minutes).

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(5) Each ESS bus has three power sources, one from a fuel cell and two from main busses. Two power sources are required for redundancy.
(6) Loss of an essential bus results in loss of a fuel cell and loss of the ability to shut off that fuel cell's reactants. Loss of ESS3AB causes the loss of BFS engage capability.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Loss of two power sources to an ESS bus.
(8) Loss of loads if third ESS bus power source is lost during flight.

CAUSES OF EXCEEDING REDLINE:

(9) Malfunctioning or tripped RPC, or inoperative switch contacts for two main bus sources of power.
(10) Loss of one main bus source of power as above and a blown fuse, inoperative switch for fuel cell source of power.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 2.2	SHEET 1 of 2	ZONE S-1-7
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO V70-976099	SHEET 76 AK	ZONE 18,20,
	DWG NO	SHEET	ZONE 22

ELEMENT: Orbiter SUBSYSTEM: EPDC

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LCC VIOLATION CALL: Essential Bus Source Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76S0163E	Fuel Cell 1 To Ess Bus 1BC-On	(3)	(2)	NA	Event	CI
V76S0263E	Fuel Cell 2 To Ess Bus 2CA-On	(3)	(2)	NA	Event	CI
V76S0363E	Fuel Cell 3 To Ess Bus 3AB-On	(3)	(2)	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) To Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Measurement should indicate OFF prior to crew positioning of switches at T-8 minutes (except when closeout crew checks switch function at approximately T-2.5 hours). Measurement should indicate ON after flight crew positions switches at T-8 minutes.
(3) Mandatory unless verified as instrumentation failure. See Item (4) for verification procedure.

PREPLANNED CONTINGENCY PROCEDURE:

(4) If a fuel cell to essential source indicates a violation:
A. Verify preflight bus source ITCU voltage is 28-28.5 Vdc.
B. Execute GSE command to affected fuel cell coolant pump relays.
C. On Panel R1 have Pilot verify/perform fuel cell source for affected essential bus ON.
D. On Panel R1 have Pilot place main bus source switch for affected essential bus OFF.
E. Verify essential bus PCM and Panel F9 meter above 27 Vdc. This verifies a good fuel cell source to the essential bus and a good path to the flight deck busses via FC to ESS BUS switch. (Failure is attributed to instrumentation.)
F. On Panel R1 have Pilot place main bus source switch back ON.
G. Remove GSE command to fuel cell coolant pump.
H. If prior to T-8 minutes, on Panel R1 have Pilot place fuel cell source switch back OFF.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(5) Each ESS bus has three power sources, one from a fuel cell and two from main busses. Two power sources are required for redundancy. Flight deck loop has two sources, one from each essential bus source switch, and both are required.
(6) Loss of an essential bus results in loss of a fuel cell. Loss of ESS3AB causes the loss of BFS engage capability.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Loss of two power sources to an ESS bus.
(8) Loss of loads if third ESS bus power source is lost during flight.
(9) Loss of essential bus power to flight deck panels.

CAUSES OF EXCEEDING REDLINE:

(10) Inoperative fuel cell to essential bus switch contacts or blown fuse.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 2.2	SHEET 1 of 2	ZONE S-1-7
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO V70-976099	SHEET 76 AK	ZONE 18,20,
	DWG NO	SHEET	ZONE 22

ELEMENT: Orbiter SUBSYSTEM: EPDC

LCC VIOLATION CALL: Orbiter Master Events Controller (MEC) Power Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76S4601E	MEC 1 Bus A Pwr On	(2,4)	ON	NA	Event	CI
V76S4605E	MEC 2 Bus B Pwr On	(2,4)	ON	NA	Event	CI
V76X4395E	MEC 1 Core B RPC B On	(3,5)	ON	NA	Event	CI
V76X4396E	MEC 1 Core B RPC C On	(3,5)	ON	NA	Event	CI
V76X4397E	MEC 2 Core B RPC A On	(3,5)	ON	NA	Event	CI
V76X4398E	MEC 2 Core B RPC C On	(3,5)	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Loss of Core A Bus Pwr ON indication is acceptable if instrumentation failure is confirmed. (4)
(3) Loss of RPC ON indication is acceptable if instrumentation failure is confirmed. (5)

PREPLANNED CONTINGENCY PROCEDURE:

(4) To confirm instrumentation failure, perform launch preflight BITE read. Read response must confirm that required Core A drivers are ON (ref S0007.500). For confirmed instrumentation failure, LCC violation cleared, continue countdown.
(5) To confirm instrumentation failure, drop specified control bus (ref OMRS S00GEN.780) and perform launch preflight BITE to confirm the required Core B drivers are ON with the redundant RPC unpowered (ref S0007.500).
For MEC 1 Core B RPC B On indicating OFF, drop AB2,
For MEC 1 Core B RPC C On indicating OFF, drop CA1,
For MEC 2 Core B RPC A On indicating OFF, drop BC2,
For MEC 2 Core B RPC C On indicating OFF, drop CA2.
For confirmed instrumentation failure, LCC violation cleared, continue countdown.

NOTES:

(6) Switch scan related measurements represent configuration of bus power specifically supporting only Core A for both MEC 1 and MEC 2.

REDLINE DERIVATION: CRITICALITY: 1R

(7) a) SSID Intent Summary - The intent of this SSID is to ensure that all power inputs to the MECs are present from T-6 hours until T-31 seconds, to verify full MEC functional and output driver redundancy.

REDLINE DERIVATION: (Continued)

The primary means of determining power status of the MECs is through monitoring the Core A switchscan indicators and Core B RPC indicators. Power to each MEC is activated by a single cockpit switch. One pole of the switch controls a single main bus power feed to Core A. The other two poles control redundant power feeds to Core B from the other two main buses. Loss of input power to a Core results in loss of Core redundancy to the output drivers of a given MEC. Power loss in or to both Cores would cause the MEC to be inoperable. The input power is single fault tolerant provided that instrumentation failure can be verified by confirming downstream Core functionality.

b) Voting Logic - N/A

c) Minimum and/or Maximum Redline Development - The minimum redline limit of ON indicates that both Cores of both MECs have power feeding them. The requirement that all MEC input power indications (two switchscan and four RPC) are ON ensures that Program required fault tolerance level with respect to the critical MEC functions is maintained. No maximum redline is required for these discrete measurements.

d) Time Period - The time period effectivity from T-6 hours to commitment for launch at T-31 seconds ensures continuous health monitoring. The ending effectivity is acceptable based on probability of failure and system redundancy after T-31 seconds.

e) Requirements - This requirement ensures that the Program required power redundancy for mission critical MEC functions is monitored and verified down to T-31 seconds.

f) Preplanned Contingency Procedures - Preflight BITE reads provide internal core functionality status by verifying individual core driver outputs.

The preflight BITE read should occur during low LDB traffic periods to mitigate timing and/or priority conflicts. The Preflight BITE read does not have any affect on other LDB traffic due to its low priority.

For Core A, a single preflight BITE read is sufficient to determine instrumentation failure of the switchscan indicator.

Due to redundant RPC power feeds to Core B, Control Bus drops are necessary to isolate the affected Core B source prior to preflight BITE read and determination of instrumentation failure.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Loss of redundancy for SRB/ET power, separation, and launch release systems.
(9) Ref. hazard reports ORBI-289 and ORBI-332.

CAUSES OF EXCEEDING REDLINE:

(10) Switch failure.
(11) Loss of control bus AB2, CA1 (MEC 1) or BC2, CA2 (MEC 2).
(12) Open circuit.
(13) MDM failure: OA1 - V76S4601E, V76X4397E;
OA2 - V76X4395E, V76S4605E;
OA3 - V76X4396E, V76X4398E.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.1	SHEET 2	ZONE S-7
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET 76 DA	ZONE 14-24

ELEMENT: Orbiter SUBSYSTEM: EPDC

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LCC VIOLATION CALL: Orbiter Master Events Controller Preflight BITE Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	Preflight BITE, MEC		(2)	NA	Binar	DI
NA	Preflight BITE, EMEC/AMEC		(3)	NA	Binar	DI

TIME PERIOD:

(1) Verify each time Preflight BITE is read prior to OPS 101 Transition (T-20 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) See Table 26-01, "MEC PREFLIGHT BITE" for bit status requirements and preplanned contingency procedures. For bit values not contained in Table 26-01, LCC violation cleared, continue countdown.
   a) For intermittent erroneous BITE circuit indications, LCC violation confirmed, No Go for launch.
   b) If word 4 bits 13 and 17 are set to a "1" state, then there is no requirement for word 2 bits 09, 11-18,23,24 and word 4 bit 13, LCC violation cleared, continue countdown.
   c) If word 5 bits 13 and 17 are set to a "1" state, then there is no requirement for word 3 bits 09, 11-18,23,24 and word 5 bit 13, LCC violation cleared, continue countdown.
   d) For confirmed BITE circuit hard failure, LCC violation cleared, continue countdown. (5)

(3) See Table 26-02 "EMEC/AMEC PREFLIGHT BITE" for bit status requirements and preplanned contingency procedures. For bit values not contained in Table 26-02, LCC violation cleared, continue countdown.
   a) For intermittent erroneous BITE circuit indications, LCC violation confirmed, No Go for launch.
   b) For confirmed BITE circuit hard failure, LCC violation cleared, continue countdown. (5)

(4) For multiple bit error indications, whether LCC or non-LCC bits, LCC violation confirmed, No Go for launch.

PREPLANNED CONTINGENCY PROCEDURE:

(5) BITE circuit hard failure can be confirmed by utilizing Table 26-01 and 26-02 with the following conditions:
   a) All LCC power supply bits, PTO logic (MEC only), and output driver LCC Preflight BITE (PFB) bits, except for the bits in question, shall be verified to comply with Tables 26-01 and 26-02 during all phases of the preplanned contingency procedure, otherwise LCC violation confirmed, No Go for launch.
   b) At the completion of the preplanned contingency procedure, a Master Reset command shall be transmitted to all four channels. Subsequently, a PFB command shall be transmitted on channel 1 or channel 3. All LCC PFB bits, except for the bits in question and words 4 and 5 bit 13 (only when MEC critical commands were transmitted as required by the

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

contingency procedure), shall be verified to comply with Tables 26-01 and 26-02, otherwise LCC violation confirmed, No Go for launch.

NOTES:

(6) MEC preflight BITE commands, when issued in OPS 1, can result in "E" bit errors. "E" bit error responses are acceptable with MECs, but are not acceptable with EMECs/AMECs.
(7) Reference documents SSD92D0694 and SSD96D0625 for detailed descriptions and impact assessment of MEC Preflight BITE bits. Reference RSS00HB261 for EMEC/AMEC PFB bits.

REDLINE DERIVATION: CRITICALITY: 1R

(8) Full core redundancy at the LRU level and system redundancy are required. For EMEC/AMEC, single channel failure is not a constraint to launch.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Loss of two-fault tolerance for SRB power, separation (SRB & ET), and launch release.

CAUSES OF EXCEEDING REDLINE:

(10) Loss of core power.
(11) Loss of voting logic.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 10.1	SHEET 1	ZONE 2L,2G
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET 76W1	ZONE 1-6

ELEMENT: Orbiter SUBSYSTEM: EPDC

SUPPORTING DATA:

Table 26-01 MEC Preflight BITE

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
WD02 B09	CORE A VALID INTERCHANNEL MESSAGE Required State: '0' Preplanned Contingency Procedure (generic for WD02,03 B09,11): If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit Master Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 02,03 Bit 09,11 = '0' (except suspect Bit = '1'), WD 04,05 Bit 13,18-24 = '0'. Transmit SRB RSS SAFE 1 command on all four channels. Transmit PFB read on channel 1. Verify WD 04,05 Bit 13,18-24 = '1', WD 10,11 Bit 16 = '1'. (previous commanded outputs also 'on' in both cores) Transmit PFB read on channel 1. Verify WD 02,03 Bit 09,11 = '0' (except suspect Bit = '1'), WD 04,05 Bit 13 = '1', WD 04,05 Bit 18-24 = '0', WD 10,11 Bit 16 = '1'. (previous commanded outputs also 'on' in both cores) Transmit SRB RSS SAFE 2 command on all four channels. Transmit PFB read on channel 1. Verify WD 04,05 Bit 13,18-24 = '1', WD 10,11 Bit 16,17 = '1'. (previous commanded outputs also 'on' in both cores) Transmit PFB read on channel 1. Verify WD 02,03 Bit 09,11 = '0' (except suspect Bit = '1'), WD 04,05 Bit 13 = '1', WD 04,05 Bit 18-24 = '0', WD 10,11 Bit 16,17 = '1'. (previous commanded outputs also 'on' in both cores)

SUPPORTING DATA:

Table 26-01 MEC Preflight BITE (Continued)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
WD02 B10	CORE A 12 VDC POWER OUT-OF-TOLERANCE Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit Master Reset command on all four channels. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit ET DFI Set command on all four channels. Transmit PFB read on channel 1. Verify WD 02 Bit 10 = '1', WD 10,11 Bit 18 = '1'. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit ET DFI Set command on all four channels. Transmit PFB read on channel 1. Verify WD 02 Bit 10 = '1', WD 10,11 Bit 18 = '1'. Transmit SRB RSS SAFE 1 then SAFE 2 command on all four channels. Transmit PFB read on channel 1. Verify WD 02 Bit 10 = '1', WD 04 Bit 09,11 = '0', WD 10,11 Bit 16,17 = '1'. (previous commanded outputs also 'on' in both cores)
WD02 B11	CORE A VALID NUMBER OF CDW Required State: '0' Preplanned Contingency Procedure: Refer to WD02 B09

SUPPORTING DATA:

Table 26-01 MEC Preflight BITE (Continued)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
WD02 B12	CORE A VALID CR CDW NO. 1 Required State: '0' Preplanned Contingency Procedure (generic for WD02,03 B12-18,23,24): If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit Master Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 02,03 Bit 09-18,23,24 = '0' (except suspect Bit = '1'), WD 04,05 Bit 13,18-24 = '0'. Transmit CR command on all four channels with following CDW's: CDW 1: SRB RSS SAFE 1, CDW 2: SRB RSS SAFE 2, CDW 3: ET TUMBLE FIRE, CDW 4: ET TUMBLE FIRE. Transmit PFB read on channel 1. Verify WD 02,03 Bit 12-18,23,24 = '0' (except suspect Bit = '1'), WD 10,11 Bit 16,17 = '1'. (previous commanded outputs also 'on' in both cores) Transmit Master Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 02,03 Bit 12-18,23,24 = '0' (except suspect Bit = '1'), WD 10,11 Bit 16,17 = '0'. (previous commanded outputs also 'on' in both cores) Transmit CR command on all four channels with following CDW's: CDW 1: ET TUMBLE FIRE, CDW 2: ET TUMBLE FIRE, CDW 3: SRB RSS SAFE 1, CDW 4: SRB RSS SAFE 2. Transmit PFB read on channel 1. Verify WD 02,03 Bit 12-18,23,24 = '0' (except suspect Bit = '1'), WD 10,11 Bit 16,17 = '1'. (previous commanded outputs also 'on' in both cores)
The following 8 BITS are Required State ‘0’, Preplanned Contingency Procedure: Refer to WD02 B12	
WD02 B13	CORE A VALID CR CDW NO.2
WD02 B14	CORE A VALID CR CDW NO.3
WD02 B15	CORE A VALID CR CDW NO.4
WD02 B16	CORE A 2&2 SPLIT LOGIC (1*4)(2*3)
WD02 B17	CORE A 2&2 SPLIT LOGIC (1*3)(2*4)
WD02 B18	CORE A 2&2 SPLIT LOGIC (1*2)(3*4)
WD02 B23	CORE A CR PAIR VOTING (1&3)
WD02 B24	CORE A CR PAIR VOTING (1&2)
WD03 B09	CORE B VALID INTERCHANNEL MESSAGE Required State: '0' Preplanned Contingency Procedure: Refer to WD02 B09

SUPPORTING DATA:

Table 26-01 MEC Preflight BITE (Continued)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
WD03 B10	CORE B 12 VDC POWER OUT-OF-TOLERANCE Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit Master Reset command on all four channels. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit ET DFI Set command on all four channels. Transmit PFB read on channel 3. Verify WD 03 Bit 10 = '1', WD 10,11 Bit 18 = '1'. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 3. Verify WD 10,11 Bit 18 = '0'. Transmit ET DFI Set command on all four channels. Transmit PFB read on channel 3. Verify WD 03 Bit 10 = '1', WD 10,11 Bit 18 = '1'. Transmit SRB RSS SAFE 1 then SAFE 2 command on all four channels. Transmit PFB read on channel 3 Verify WD 03 Bit 10 = '1', WD 05 Bit 09,11 = '0', WD 10,11 Bit 16,17 = '1'. (previous commanded outputs also 'on' in both cores)
WD03 B11	CORE B VALID NUMBER OF CDW Required State: '0' Preplanned Contingency Procedure: Refer to WD02 B09
The following 9 BITS are Required State ‘0’, Preplanned Contingency Procedure: Refer to WD02 B12	
WD03 B12	CORE B VALID CR CDW NO. 1
WD03 B13	CORE B VALID CR CDW NO.2
WD03 B14	CORE B VALID CR CDW NO.3
WD03 B15	CORE B VALID CR CDW NO.4
WD03 B16	CORE B 2&2 SPLIT LOGIC (1*4)(2*3)
WD03 B17	CORE B 2&2 SPLIT LOGIC (1*3)(2*4)
WD03 B18	CORE B 2&2 SPLIT LOGIC (1*2)(3*4)
WD03 B23	CORE B CR PAIR VOTING (1&3)
WD03 B24	CORE B CR PAIR VOTING (3&4)

SUPPORTING DATA:

Table 26-01 MEC Preflight BITE (Continued)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
WD04 B09	CORE A PTO ENABLE Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit PFB read on channel 1 then channel 3. Verify WD 02 Bit 10 = '0', WD 04 Bit 09 = '1', WD 04 Bit 11,12,14-16 = '0'. Transmit SRB RSS SAFE 1 then SAFE 2 command on all four channels. Transmit PFB read on channel 1 then channel 3. Verify WD 10,11 Bit 16,17 = '1'. (previous commanded outputs also 'on' in both cores)
WD04 B10	CORE A PTO RESET Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit Master Reset command on all four channels. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit ET DFI Set command on all four channels. Transmit SRB RSS SAFE 1 then SAFE 2 command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 16-18 = '1'. (previous commanded outputs also 'on' in both cores)
WD04 B11	CORE A PTO GO #1 Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit PFB read on channel 3 then channel 1. Verify WD 02 Bit 10 = '0', WD 04 Bit 11 = '1', WD 04 Bit 09,15,16 = '0'. Transmit SRB RSS SAFE 1 then SAFE 2 command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 16,17 = '1'. (previous commanded outputs also 'on' in both cores)

SUPPORTING DATA:

Table 26-01 MEC Preflight BITE (Continued)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
WD04 B12	CORE A PTO GO #2 Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit PFB read on channel 3 then channel 1. Verify WD 02 Bit 10 = '0', WD 04 Bit 12 = '1', WD 04 Bit 09,15,16 = '0'. Transmit SRB RSS SAFE 1 then SAFE 2 command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 16,17 = '1'. (previous commanded outputs also 'on' in both cores)
WD04 B13	CORE A CR PROCESSING RESET LOGIC Required State: '0' Preplanned Contingency Procedure (generic for WD04 B13,18-22): If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit Master Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 02,03 Bit 09,11 = '0', WD 04,05 Bit 13,18-24 = '0' (except suspect Bit = '1'). Transmit SRB RSS SAFE 1 command on all four channels. Transmit PFB read on channel 1. Verify WD 02,03 Bit 09,11 = '0', WD 04,05 Bit 13,18-24 = '1', WD 10,11 Bit 16 = '1'. (previous commanded outputs also 'on' in both cores) Transmit PFB read on channel 1. Verify WD 02,03 Bit 09,11 = '0', WD 04,05 Bit 13 = '1', WD 04,05 Bit 18-24 = '0' (except suspect Bit = '1'), WD 10,11 Bit 16 = '1'. (previous commanded outputs also 'on' in both cores) Transmit SRB RSS SAFE 2 command on all four channels. Transmit PFB read on channel 1. Verify WD 02,03 Bit 09,11 = '0', WD 04,05 Bit 13,18-24 = '1', WD 10,11 Bit 16,17 = '1'. (previous commanded outputs also 'on' in both cores) Transmit PFB read on channel 1. Verify WD 02,03 Bit 09,11 = '0', WD 04,05 Bit 13 = '1', WD 04,05 Bit 18-24 = '0' (except suspect Bit = '1'), WD 10,11 Bit 16,17 = '1'. (previous commanded outputs also 'on' in both cores)

SUPPORTING DATA:

Table 26-01 MEC Preflight BITE (Continued)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
WD04 B14	CORE A 12 VDC POWER OUT-OF-TOLERANCE Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit ET DFI Set command on channels 1 and 2. Transmit PFB read on channel 1 then channel 3. Verify WD 04 Bit 14 = '1', WD 10 Bit 18 = '1', WD 11 Bit 18 = '0'. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit ET DFI Set command on all four channels. Transmit PFB read on channel 1. Verify WD 04 Bit 14 = '1', WD 10,11 Bit 18 = '1'. Transmit SRB RSS SAFE 1 then SAFE 2 command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 16-18 = '1'. (previous commanded outputs also 'on' in both cores)
WD04 B15	CORE A 5 VDC #1 POWER OUT-OF-TOLERANCE Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit Master Reset command on all four channels. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit PFB read on channel 1. Verify WD 04 Bit 15 = '1', WD 04 Bit 11,14,16 = '0'. Transmit ET DFI Set command on all four channels. Transmit PFB read on channel 1 then channel 3. Verify WD 04 Bit 15 = '1', WD 10,11 Bit 18 = '1'. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit ET DFI Set command on all four channels. Transmit PFB read on channel 1. Verify WD 04 Bit 09 = '0', WD 04 Bit 15 = '1', WD 10,11 Bit 18 = '1'. Transmit SRB RSS SAFE 1 then SAFE 2 command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 16-18 = '1'. (previous commanded outputs also 'on' in both cores)

SUPPORTING DATA:

Table 26-01 MEC Preflight BITE (Continued)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
WD04 B16	CORE A 5 VDC #2 POWER OUT-OF-TOLERANCE Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit Master Reset command on all four channels. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit PFB read on channel 1. Verify WD 02 Bit 10 = '0', Verify WD 04 Bit 16 = '1', WD 04 Bit 12,14 = '0'. Transmit ET DFI Set command on all four channels. Transmit PFB read on channel 1 then channel 3. Verify WD 04 Bit 16 = '1', WD 10,11 Bit 18 = '1'. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit ET DFI Set command on all four channels. Transmit PFB read on channel 1. Verify WD 04 Bit 09 = '0', WD 04 Bit 16 = '1', WD 10,11 Bit 18 = '1'. Transmit SRB RSS SAFE 1 then SAFE 2 command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 16-18 = '1'. (previous commanded outputs also 'on' in both cores)
The following 5 BITS are Required State ‘0’, Preplanned Contingency Procedure: Refer to WD04 B13	
WD04 B18	CORE A WORD COMPARISON MODE ENABLE
WD04 B19	CORE A WORD COMPARISON GO/NOGO GENERATED
WD04 B20	CORE A CR DECODING MODE ENABLE
WD04 B21	CORE A CR END OF DATA PROCESSING
WD04 B22	CORE A INITIATE CR PROCESSING RESET SEQUENCE
WD05 B09	CORE B PTO ENABLE Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit PFB read on channel 3 then channel 1. Verify WD 03 Bit 10 = '0', WD 05 Bit 09 = '1', WD 05 Bit 11,12,14-16 = '0'. Transmit SRB RSS SAFE 1 then SAFE 2 command on all four channels. Transmit PFB read on channel 3 then channel 1. Verify WD 10,11 Bit 16,17 = '1'. (previous commanded outputs also 'on' in both cores)

SUPPORTING DATA:

Table 26-01 MEC Preflight BITE (Continued)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
WD05 B10	CORE B PTO RESET Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit Master Reset command on all four channels. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit ET DFI Set command on all four channels. Transmit SRB RSS SAFE 1 then SAFE 2 command on all four channels. Transmit PFB read on channel 3. Verify WD 10,11 Bit 16-18 = '1'. (previous commanded outputs also 'on' in both cores)
WD05 B11	CORE B PTO GO #1 Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit PFB read on channel 1 then channel 3. Verify WD 03 Bit 10 = '0', WD 05 Bit 11 = '1', WD 05 Bit 09,15,16 = '0'. Transmit SRB RSS SAFE 1 then SAFE 2 command on all four channels. Transmit PFB read on channel 3. Verify WD 10,11 Bit 16,17 = '1'. (previous commanded outputs also 'on' in both cores)
WD05 B12	CORE B PTO GO #2 Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit PFB read on channel 1 then channel 3. Verify WD 03 Bit 10 = '0', WD 05 Bit 12 = '1', WD 05 Bit 09,15,16 = '0'. Transmit SRB RSS SAFE 1 then SAFE 2 command on all four channels. Transmit PFB read on channel 3. Verify WD 10,11 Bit 16,17 = '1'. (previous commanded outputs also 'on' in both cores)

SUPPORTING DATA:

Table 26-01 MEC Preflight BITE (Continued)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
WD05 B13	CORE B CR PROCESSING RESET LOGIC Required State: '0' Preplanned Contingency Procedure (generic for WD05 B13,18-22): If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit Master Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 02,03 Bit 09,11 = '0', WD 04,05 Bit 13,18-24 = '0' (except suspect Bit = '1'). Transmit SRB RSS SAFE 1 command on all four channels. Transmit PFB read on channel 1. Verify WD 02,03 Bit 09,11 = '0', WD 04,05 Bit 13,18-24 = '1', WD 10,11 Bit 16 = '1'. (previous commanded outputs also 'on' in both cores) Transmit PFB read on channel 1. Verify WD 02,03 Bit 09,11 = '0', WD 04,05 Bit 13 = '1', WD 04,05 Bit 18-24 = '0' (except suspect Bit = '1'), WD 10,11 Bit 16 = '1'. (previous commanded outputs also 'on' in both cores) Transmit SRB RSS SAFE 2 command on all four channels. Transmit PFB read on channel 1. Verify WD 02,03 Bit 09,11 = '0', WD 04,05 Bit 13,18-24 = '1', WD 10,11 Bit 16,17 = '1'. (previous commanded outputs also 'on' in both cores) Transmit PFB read on channel 1. Verify WD 02,03 Bit 09,11 = '0', WD 04,05 Bit 13 = '1', WD 04,05 Bit 18-24 = '0' (except suspect Bit = '1'), WD 10,11 Bit 16,17 = '1'. (previous commanded outputs also 'on' in both cores)

SUPPORTING DATA:

Table 26-01 MEC Preflight BITE (Continued)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
WD05 B14	CORE B 12 VDC POWER OUT-OF-TOLERANCE Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit ET DFI Set command on channels 3 and 4. Transmit PFB read on channel 3 then channel 1. Verify WD 05 Bit 14 = '1', WD 10 Bit 18 = '0', WD 11 Bit 18 = '1'. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 3. Verify WD 10,11 Bit 18 = '0'. Transmit ET DFI Set command on all four channels. Transmit PFB read on channel 3. Verify WD 05 Bit 14 = '1', WD 10,11 Bit 18 = '1'. Transmit SRB RSS SAFE 1 then SAFE 2 command on all four channels. Transmit PFB read on channel 3. Verify WD 10,11 Bit 16-18 = '1'. (previous commanded outputs also 'on' in both cores)
WD05 B15	CORE B 5 VDC #1 POWER OUT-OF-TOLERANCE Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit Master Reset command on all four channels. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit PFB read on channel 3. Verify WD 05 Bit 15 = '1', WD 05 Bit 09,11,14,16 = '0'. Transmit ET DFI Set command on all four channels. Transmit PFB read on channel 1 then channel 3. Verify WD 05 Bit 15 = '1', WD 10,11 Bit 18 = '1'. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit ET DFI Set command on all four channels. Transmit PFB read on channel 3. Verify WD 05 Bit 09 = '0', WD 05 Bit 15 = '1', WD 10,11 Bit 18 = '1'. Transmit SRB RSS SAFE 1 then SAFE 2 command on all four channels. Transmit PFB read on channel 3. Verify WD 10,11 Bit 16-18 = '1'. (previous commanded outputs also 'on' in both cores)

SUPPORTING DATA:

Table 26-01 MEC Preflight BITE (Continued)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
WD05 B16	CORE B 5 VDC #2 POWER OUT-OF-TOLERANCE Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit Master Reset command on all four channels. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit PFB read on channel 3. Verify WD 03 Bit 10 = '0', Verify WD 05 Bit 16 = '1', WD 05 Bit 12,14 = '0'. Transmit ET DFI Set command on all four channels. Transmit PFB read on channel 3 then channel 1. Verify WD 05 Bit 16 = '1', WD 10,11 Bit 18 = '1'. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit ET DFI Set command on all four channels. Transmit PFB read on channel 3. Verify WD 05 Bit 09 = '0', WD 05 Bit 16 = '1', WD 10,11 Bit 18 = '0'. Transmit SRB RSS SAFE 1 then SAFE 2 command on all four channels. Transmit PFB read on channel 3. Verify WD 10,11 Bit 16-18 = '1'. (previous commanded outputs also 'on' in both cores)
The following 5 BITS are Required State ‘0’, Preplanned Contingency Procedure: Refer to WD05 B13	
WD05 B18	CORE B WORD COMPARISON MODE ENABLE
WD05 B19	CORE B WORD COMPARISON GO/NOGO GENERATED
WD05 B20	CORE B CR DECODING MODE ENABLE
WD05 B21	CORE B CR END OF DATA PROCESSING
WD05 B22	CORE B INITIATE CR PROCESSING RESET SEQUENCE
WD06 B09	CH1 +12 VDC POWER OUT-OF-TOLERANCE Required State: '0' Preplanned Contingency Procedure: LCC violation confirmed, No Go for launch.

SUPPORTING DATA:

Table 26-01 MEC Preflight BITE (Continued)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
WD06 B11	CH2 +12 VDC POWER OUT-OF-TOLERANCE Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit Master Reset command on all four channels. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit PFB read on channel 1 then channel 2. Verify WD 06 Bit 11 = '1'. Transmit ET DFI Set command on all four channels. Transmit PFB read on channel 2. Verify WD 06 Bit 11 = '1'. WD 10,11 Bit 18 = '1'. (previous commanded outputs also 'on' in both cores) Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit ET DFI Set command on all four channels. Transmit PFB read on channel 1. Verify WD 06 Bit 11 = '1'. WD 10,11 Bit 18 = '1'. (previous commanded outputs also 'on' in both cores)
WD06 B13	CH1 -12 VDC POWER OUT-OF-TOLERANCE Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit Master Reset command on all four channels. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit PFB read on channel 1. Verify WD 06 Bit 13 = '1'. Transmit PFB read on channel 2. Verify WD 06 Bit 13 = '1'. Transmit ET DFI Set command on channels 1 and 2. Transmit PFB read on channel 2. Verify WD 06 Bit 13 = '1', WD 10 Bit 18 = '1', WD 11 Bit 18 = '0'. (previous commanded outputs also 'on' in both cores) Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit ET DFI Set command on channels 1 and 2. Transmit PFB read on channel 1. Verify WD 06 Bit 13 = '1', WD 10 Bit 18 = '1', WD 11 Bit 18 = '0'. (previous commanded outputs also 'on' in both cores)

SUPPORTING DATA:

Table 26-01 MEC Preflight BITE (Continued)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
WD06 B15	CH2 -12 VDC POWER OUT-OF-TOLERANCE Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit Master Reset command on all four channels. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit PFB read on channel 2. Verify WD 06 Bit 15 = '1'. Transmit PFB read on channel 1. Verify WD 06 Bit 15 = '1'. Transmit ET DFI Set command on channels 1 and 2. Transmit PFB read on channel 2. Verify WD 06 Bit 15 = '1', WD 10 Bit 18 = '1', WD 11 Bit 18 = '0'. (previous commanded outputs also 'on' in both cores) Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit ET DFI Set command on channels 2 and 3. Transmit PFB read on channel 1. Verify WD 06 Bit 15 = '1', WD 10 Bit 18 = '1', WD 11 Bit 18 = '0'. (previous commanded outputs also 'on' in both cores)

SUPPORTING DATA:

Table 26-01 MEC Preflight BITE (Continued)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
WD06 B17	CH1 +5 VDC POWER OUT-OF-TOLERANCE Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit Master Reset command on all four channels. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit PFB read on channel 2. Verify WD 06 Bit 17 = '1'. Transmit PFB read on channel 1. Verify WD 06 Bit 17 = '1'. Transmit ET DFI Set command on channels 1 and 2. Transmit PFB read on channel 2. Verify WD 06 Bit 17 = '1', WD 10 Bit 18 = '1', WD 11 Bit 18 = '0'. (previous commanded outputs also 'on' in both cores) Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit ET DFI Set command on channels 2 and 3. Transmit PFB read on channel 2. Verify WD 06 Bit 17 = '1', WD 10 Bit 18 = '1', WD 11 Bit 18 = '0'. (previous commanded outputs also 'on' in both cores) Transmit SRB RSS SAFE 1 then SAFE 2 command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 16,17 = '1'. (previous commanded outputs also 'on' in both cores)

SUPPORTING DATA:

Table 26-01 MEC Preflight BITE (Continued)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
WD06 B19	CH2 +5 VDC POWER OUT-OF-TOLERANCE Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit Master Reset command on all four channels. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit PFB read on channel 1. Verify WD 06 Bit 19 = '1'. Transmit PFB read on channel 2. Verify WD 06 Bit 19 = '1'. Transmit ET DFI Set command on all four channels. Transmit PFB read on channel 1. Verify WD 06 Bit 19 = '1', WD 10 Bit 18 = '1', WD 11 Bit 18 = '1'. (previous commanded outputs also 'on' in both cores) Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit ET DFI Set command on all four channels. Transmit PFB read on channel 1. Verify WD 06 Bit 19 = '1', WD 10,11 Bit 18 = '1'. (previous commanded outputs also 'on' in both cores) Transmit SRB RSS SAFE 1 then SAFE 2 command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 16-18 = '1'. (previous commanded outputs also 'on' in both cores)
WD07 B09	CH3 +12 VDC POWER OUT-OF-TOLERANCE Required State: '0' Preplanned Contingency Procedure: LCC violation confirmed, No Go for launch.

SUPPORTING DATA:

Table 26-01 MEC Preflight BITE (Continued)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
WD07 B11	CH4 +12 VDC POWER OUT-OF-TOLERANCE Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit Master Reset command on all four channels. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit PFB read on channel 3 then channel 4. Verify WD 07 Bit 11 = '1'. Transmit ET DFI Set command on channels 3 and 4. Transmit PFB read on channel 3. Verify WD 07 Bit 11 = '1', WD 10 Bit 18 = '0', WD 11 Bit 18 = '1'. (previous commanded outputs also 'on' in both cores) Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 3. Verify WD 10,11 Bit 18 = '0'. Transmit ET DFI Set command on channels 1 and 3. Transmit PFB read on channel 3. Verify WD 07 Bit 11 = '1', WD 10 Bit 18 = '0', WD 11 Bit 18 = '1'. (previous commanded outputs also 'on' in both cores)
WD07 B13	CH3 -12 VDC POWER OUT-OF-TOLERANCE Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit Master Reset command on all four channels. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit PFB read on channel 3. Verify WD 07 Bit 13 = '1'. Transmit PFB read on channel 4. Verify WD 07 Bit 13 = '1'. Transmit ET DFI Set command on channels 3 and 4. Transmit PFB read on channel 3. Verify WD 07 Bit 13 = '1', WD 10 Bit 18 = '0', WD 11 Bit 18 = '1'. (previous commanded outputs also 'on' in both cores) Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 3. Verify WD 10,11 Bit 18 = '0'. Transmit ET DFI Set command on channels 1 and 3. Transmit PFB read on channel 3. Verify WD 07 Bit 13 = '1', WD 10 Bit 18 = '0', WD 11 Bit 18 = '1'. (previous commanded outputs also 'on' in both cores)

SUPPORTING DATA:

Table 26-01 MEC Preflight BITE (Continued)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
WD07 B15	CH4 -12 VDC POWER OUT-OF-TOLERANCE Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit Master Reset command on all four channels. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit PFB read on channel 4. Verify WD 07 Bit 15 = '1'. Transmit PFB read on channel 3. Verify WD 07 Bit 15 = '1'. Transmit ET DFI Set command on channels 3 and 4. Transmit PFB read on channel 4. Verify WD 07 Bit 15 = '1', WD 10 Bit 18 = '0', WD 11 Bit 18 = '1'. (previous commanded outputs also 'on' in both cores) Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit ET DFI Set command on channels 1 and 3. Transmit PFB read on channel 3. Verify WD 07 Bit 15 = '1', WD 10 Bit 18 = '0', WD 11 Bit 18 = '1'. (previous commanded outputs also 'on' in both cores)

SUPPORTING DATA:

Table 26-01 MEC Preflight BITE (Continued)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
WD07 B17	CH3 +5 VDC POWER OUT-OF-TOLERANCE Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit Master Reset command on all four channels. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit PFB read on channel 3. Verify WD 07 Bit 17 = '1'. Transmit PFB read on channel 4. Verify WD 07 Bit 17 = '1'. Transmit ET DFI Set command on all four channels. Transmit PFB read on channel 4. Verify WD 07 Bit 17 = '1', WD 10 Bit 18 = '1', WD 11 Bit 18 = '1'. (previous commanded outputs also 'on' in both cores) Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 4. Verify WD 10,11 Bit 18 = '0'. Transmit ET DFI Set command on all four channels. Transmit PFB read on channel 4. Verify WD 07 Bit 17 = '1', WD 10 Bit 18 = '1', WD 11 Bit 18 = '1'. (previous commanded outputs also 'on' in both cores) Transmit SRB RSS SAFE 1 then SAFE 2 command on all four channels. Transmit PFB read on channel 4. Verify WD 10,11 Bit 16,17 = '1'. (previous commanded outputs also 'on' in both cores)

SUPPORTING DATA:

Table 26-01 MEC Preflight BITE (Continued)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
WD07 B19	CH4 +5 VDC POWER OUT-OF-TOLERANCE Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit Master Reset command on all four channels. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit PFB read on channel 3. Verify WD 07 Bit 19 = '1'. Transmit PFB read on channel 4. Verify WD 07 Bit 19 = '1'. Transmit ET DFI Set command on channels 3 and 4. Transmit PFB read on channel 4. Verify WD 07 Bit 19 = '1', WD 10 Bit 18 = '0', WD 11 Bit 18 = '1'. (previous commanded outputs also 'on' in both cores) Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit ET DFI Set command on channels 1 and 3. Transmit PFB read on channel 4. Verify WD 07 Bit 19 = '1', WD 10 Bit 18 = '0', WD 11 Bit 18 = '1'. (previous commanded outputs also 'on' in both cores) Transmit SRB RSS SAFE 1 then SAFE 2 command on channels 3 and 4. Transmit PFB read on channel 3. Verify WD 07 Bit 19 = '1', WD 10 Bit 16,17 = '0', WD 11 Bit 16,17 = '1'. (previous commanded outputs also 'on' in both cores)

SUPPORTING DATA:

Table 26-01 MEC Preflight BITE (Continued)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
WD09 B18	CORE A 12 VDC POWER OUT-OF-TOLERANCE Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit Master Reset command on all four channels. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit PFB read on channel 3. Verify WD 09 Bit 18 = '1'. Transmit PFB read on channel 1. Verify WD 09 Bit 18 = '1'. Transmit ET DFI Set command on all four channels. Transmit PFB read on channel 1. Verify WD 09 Bit 18 = '1', WD 10,11 Bit 18 = '1'. (previous commanded outputs also 'on' in both cores) Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit ET DFI Set command on all four channels. Transmit PFB read on channel 1. Verify WD 09 Bit 18 = '1', WD 10,11 Bit 18 = '1'. (previous commanded outputs also 'on' in both cores)
WD09 B19	CORE A 28 VDC POWER OUT-OF-TOLERANCE Required State: '0' Preplanned Contingency Procedure: LCC violation confirmed, No Go for launch.

SUPPORTING DATA:

Table 26-01 MEC Preflight BITE (Continued)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
WD09 B22	CORE B 12 VDC POWER OUT-OF-TOLERANCE Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit Master Reset command on all four channels. Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit PFB read on channel 1. Verify WD 09 Bit 22 = '1'. Transmit PFB read on channel 3. Verify WD 09 Bit 22 = '1'. Transmit ET DFI Set command on all four channels. Transmit PFB read on channel 3. Verify WD 09 Bit 22 = '1', WD 10,11 Bit 18 = '1'. (previous commanded outputs also 'on' in both cores) Transmit ET DFI Reset command on all four channels. Transmit PFB read on channel 1. Verify WD 10,11 Bit 18 = '0'. Transmit ET DFI Set command on all four channels. Transmit PFB read on channel 3. Verify WD 09 Bit 22 = '1', WD 10,11 Bit 18 = '1'. (previous commanded outputs also 'on' in both cores)

The following 7 BITS are Required State as noted,
Preplanned Contingency Procedure: LCC violation confirmed, No Go for launch.

WD10 B09	F2/F3 FAIL	Required State: '0'
WD10 B10	CORE A LEFT SRB PWR CMD	Required State: '1'
WD10 B11	CORE A RIGHT SRB PWR CMD	Required State: '1'
WD10 B14	CORE A LEFT SRB RSS PWR CMD	Required State: '0'
WD10 B15	CORE A RIGHT SRB RSS PWR CMD	Required State: '0'
WD10 B16	CORE A SRB RSS SAFE 1 CMD	Required State: '0'
WD10 B17	CORE A SRB RSS SAFE 2 CMD	Required State: '0'

WD10 B18 CORE A ET DFI PWR ON
Required State: '1'
Preplanned Contingency Procedure:
If the following steps can be completed and verified, LCC violation cleared, continue countdown:

Transmit LEFT SRB BUS C PWR Reset command on channels 1 and 2.
Transmit PFB read on channel 1.
Verify WD 10,11 Bit 10,11 = '1'.
WD 10 Bit 18,19 = '0'.
WD 11 Bit 18,19 = '1'.
WD 10,11 Bit 20-22 = '1'.
Transmit LEFT SRB BUS C PWR Set command on channels 1 and 2.
Transmit PFB read on channel 1.
Verify WD 10,11 Bit 10,11 = '1'.
WD 10 Bit 18 = '0'.
WD 11 Bit 18 = '1'.
WD 10,11 Bit 19-22 = '1'.

SUPPORTING DATA:

Table 26-01 MEC Preflight BITE (Continued)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
The following 6 BITS are Required State as noted, Preplanned Contingency Procedure: LCC violation confirmed, No Go for launch.	
WD10 B19	CORE A LEFT SRB BUS C PWR CMD Required State: '1'
WD10 B20	CORE A RIGHT SRB BUS C PWR CMD Required State: '1'
WD10 B21	CORE A ATVC 2/1 PWR CMD Required State: '1'
WD10 B22	CORE A ATVC 4/3 PWR CMD Required State: '1'
WD10 B23	CORE A ATVC 2/1 26 V DEADFACE CMD Required State: '0'
WD10 B24	CORE A ATVC 4/3 26 V DEADFACE CMD Required State: '0'
The following 7 BITS are Required State as noted, Preplanned Contingency Procedure: LCC violation confirmed, No Go for launch.	
WD11 B09	CORE B 28 VDC POWER OUT-OF-TOL Required State: '0'
WD11 B10	CORE B LEFT SRB PWR CMD Required State: '1'
WD11 B11	CORE B RIGHT SRB PWR CMD Required State: '1'
WD11 B14	CORE B LEFT SRB RSS PWR CMD Required State: '0'
WD11 B15	CORE B RIGHT SRB RSS PWR CMD Required State: '0'
WD11 B16	CORE B SRB RSS SAFE 1 CMD Required State: '0'
WD11 B17	CORE B SRB RSS SAFE 2 CMD Required State: '0'
WD11 B18	CORE B ET DFI PWR ON Required State: '1' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit LEFT SRB BUS C PWR Reset command on channels 3 and 4. Transmit PFB read on channel 1. Verify WD 10,11 Bit 10,11 = '1'. WD 10 Bit 18,19 = '1'. WD 11 Bit 18,19 = '0'. WD 10,11 Bit 20-22 = '1'. Transmit LEFT SRB BUS C PWR Set command on channels 3 and 4. Transmit PFB read on channel 1. Verify WD 10,11 Bit 10,11 = '1'. WD 10 Bit 18 = '1'. WD 11 Bit 18 = '0'. WD 10,11 Bit 19-22 = '1'.
The following 6 BITS are Required State as noted, Preplanned Contingency Procedure: LCC violation confirmed, No Go for launch.	
WD11 B19	CORE B LEFT SRB BUS C PWR CMD Required State: '1'
WD11 B20	CORE B RIGHT SRB BUS C PWR CMD Required State: '1'
WD11 B21	CORE B ATVC 2/1 PWR CMD Required State: '1'
WD11 B22	CORE B ATVC 4/3 PWR CMD Required State: '1'
WD11 B23	CORE B ATVC 2/1 26 V DEADFACE CMD Required State: '0'
WD11 B24	CORE B ATVC 4/3 26 V DEADFACE CMD Required State: '0'

SUPPORTING DATA:

Table 26-01 MEC Preflight BITE (Continued)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
	The following 36 BITS are Required State '0', Preplanned Contingency Procedure: LCC violation confirmed, No Go for launch.
WD12 B09	CORE A LT&RT UMB RET SOL #2 FIRE 2
WD12 B10	CORE A LT&RT UMB RET SOL #2 FIRE 1
WD12 B11	CORE A LEFT UMB UNLATCH ARM
WD12 B13	CORE A SRB IGNITION FIRE 1
WD12 B14	CORE A RIGHT SRB SEP ARM
WD12 B15	CORE A ORB/ET SEP FIRE 2 QUALIFIER
WD12 B16	CORE A SRB HOLD DOWN FIRE 1
WD12 B17	CORE A SRB SEP FIRE 1
WD12 B19	CORE A LEFT UMB UNL FIRE 1
WD12 B20	CORE A RIGHT UMB UNL FIRE 1
WD12 B21	CORE A ORB/ET SEP FIRE 1
WD12 B22	CORE A T-0 SEP FIRE 1
WD13 B09	CORE B LT&RT UMB RET SOL #2 FIRE 2
WD13 B10	CORE B LT&RT UMB RET SOL #2 FIRE 1
WD13 B11	CORE B LEFT UMB UNL ARM
WD13 B13	CORE B RIGHT SRB SEP ARM
WD13 B14	CORE B SRB IGNITION FIRE 1
WD13 B15	CORE B ORB/ET SEP FIRE 2 QUALIFIER
WD13 B16	CORE B SRB HOLD DOWN FIRE 1
WD13 B17	CORE B SRB SEP FIRE 1
WD13 B19	CORE B LEFT UMB UNL FIRE 1
WD13 B20	CORE B RIGHT UMB UNL FIRE 1
WD13 B21	CORE B ORB/ET SEP FIRE 1
WD13 B22	CORE B T-0 SEP FIRE 1
WD14 B09	CORE A LT&RT UMB RET SOL #3 FIRE 2
WD14 B10	CORE A LT&RT UMB RET SOL #3 FIRE 1
WD14 B13	CORE A SRB IGNITION FIRE 2
WD14 B14	CORE A T-0 SEP ARM
WD14 B15	CORE A LEFT UMB UNL FIRE 2 QUALIFIER
WD14 B16	CORE A SRB HOLD DOWN FIRE 2
WD14 B17	CORE A SRB SEP FIRE 2
WD14 B18	CORE A RIGHT UMB UNL FIRE 2 QUALIFIER
WD14 B19	CORE A LEFT UMB UNL FIRE 2
WD14 B20	CORE A RIGHT UMB UNL FIRE 2
WD14 B21	CORE A ORB/ET SEP FIRE 2
WD14 B22	CORE A T-0 SEP FIRE 2

SUPPORTING DATA:

Table 26-01 MEC Preflight BITE (Concluded)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
The following 28 BITS are Required State '0', Preplanned Contingency Procedure: LCC violation confirmed, No Go for launch.	
WD15 B09	CORE B LT&RT UMB RET SOL #3 FIRE 2
WD15 B10	CORE B LT&RT UMB RET SOL #3 FIRE 1
WD15 B13	CORE B T-0 SEP ARM
WD15 B14	CORE B SRB IGNITION FIRE 2
WD15 B15	CORE B LEFT UMB UNL FIRE 2 QUALIFIER
WD15 B16	CORE B SRB HOLD DOWN FIRE 2
WD15 B17	CORE B SRB SEP FIRE 2
WD15 B18	CORE B RIGHT UMB UNL FIRE 2 QUALIFIER
WD15 B19	CORE B LEFT UMB UNL FIRE 2
WD15 B20	CORE B RIGHT UMB UNL FIRE 2
WD15 B21	CORE B ORB/ET SEP FIRE 2
WD15 B22	CORE B T-0 SEP FIRE 2
WD16 B09	CORE A LT&RT UMB RET SOL #1 FIRE 2
WD16 B10	CORE A LT&RT UMB RET SOL #1 FIRE 1
WD16 B11	CORE A RIGHT UMB UNL ARM
WD16 B12	CORE A ORB/ET SEP ARM
WD16 B13	CORE A RIGHT SRB IGN ARM
WD16 B14	CORE A LEFT SRB IGN ARM
WD16 B15	CORE A SRB HOLD DOWN ARM
WD16 B16	CORE A LEFT SRB SEP ARM
WD17 B09	CORE B LT&RT UMB RET SOL #1 FIRE 2
WD17 B10	CORE B LT&RT UMB RET SOL #1 FIRE 1
WD17 B11	CORE B RIGHT UMB UNL ARM
WD17 B12	CORE B ORB/ET SEP ARM
WD17 B13	CORE B LEFT SRB IGN ARM
WD17 B14	CORE B RIGHT SRB IGN ARM
WD17 B15	CORE B SRB HOLD DOWN ARM
WD17 B16	CORE B LEFT SRB SEP ARM

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SUPPORTING DATA:

Table 26-02 EMEC/AMEC Preflight BITE

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
	The following 5 BITS are Required State '0', Preplanned Contingency Procedure: LCC violation confirmed, No Go for launch.
WD04 B10	CORE A PTO ENABLE (ARM/NCR)
WD04 B11	CORE A PTO GO (FIRE 1)
WD04 B12	CORE A PTO GO (FIRE 2)
WD04 B14	CORE A -12 VDC POWER OUT-OF-TOLERANCE
WD04 B16	CORE A 5 VDC F2 POWER OUT-OF-TOLERANCE
WD04 B22	CORE A SKEW TIMER START ARM Required State: '0' Preplanned Contingency Procedure: If the following steps can be completed and verified, LCC violation cleared, continue countdown: Transmit PFB read on channel 1 then channel 3. Verify WD 04 Bit 22 = '1'. Transmit ET DFI Reset command on all four channels. Transmit Master Reset command on all four channels. Transmit ET DFI Set command on channels 1 and 3. Transmit following critical commands on channels 1 and 3: ET TUMBLE FIRE 1, RSS SAFE 1, RSS SAFE 2 Transmit PFB read on channel 1 then channel 3. Verify WD 04 Bit 22 = '1', WD 10,11 Bit 13,16-18 = '1'. (previous commanded outputs also 'on' in both cores) Transmit Master Reset command on all four channels. Transmit ET DFI Reset command on channels 1 and 3. Transmit PFB read on channel 1 then channel 3. Verify WD 04 Bit 22 = '1', WD 10,11 Bit 13,16-18 = '0'. (previous commanded outputs also 'on' in both cores) Repeat the above steps for the following channel pairs: (1 and 2), (1 and 4), (2 and 3), (2 and 4), (3 and 4). Note: For a single channel failure, only three of the Six channel pairs will complete successfully. Transmit ET DFI Reset command on all four channels. Transmit Master Reset command on all four channels. Execute LCC Preflight BITE Read.
WD04 B23	CORE A SKEW TIMER START FIRE 1 Required State: '0' Preplanned Contingency Procedure: Use the WD04 B22 procedure replacing WD04 B22 with WD04 B23
WD04 B24	CORE A SKEW TIMER START FIRE 2 Required State: '0' Preplanned Contingency Procedure: Use the WD04 B22 procedure replacing WD04 B22 with WD04 B24
	The following 5 BITS are Required State '0', Preplanned Contingency Procedure: LCC violation confirmed, No Go for launch.
WD05 B10	CORE B PTO ENABLE (ARM/NCR)
WD05 B11	CORE B PTO GO (FIRE 1)
WD05 B12	CORE B PTO GO (FIRE 2)
WD05 B14	CORE B -12 VDC POWER OUT-OF-TOLERANCE
WD05 B16	CORE B 5 VDC F2 POWER OUT-OF-TOLERANCE

SUPPORTING DATA:

Table 26-02 EMEC/AMEC Preflight BITE (Continued)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
WD05 B22	CORE B SKEW TIMER START ARM Required State: '0' Preplanned Contingency Procedure: Use the WD04 B22 procedure replacing WD04 B22 with WD05 B22
WD05 B23	CORE B SKEW TIMER START FIRE 1 Required State: '0' Preplanned Contingency Procedure: Use the WD04 B22 procedure replacing WD04 B22 with WD05 B23
WD05 B24	CORE B SKEW TIMER START FIRE 2 Required State: '0' Preplanned Contingency Procedure: Use the WD04 B22 procedure replacing WD04 B22 with WD05 B24

The following 5 BITS are Required State '0',
Preplanned Contingency Procedure: LCC violation confirmed, No Go for launch.

WD06 B17	CH1 +5 VDC POWER OUT-OF-TOLERANCE	
WD06 B19	CH2 +5 VDC POWER OUT-OF-TOLERANCE	
WD07 B17	CH3 +5 VDC POWER OUT-OF-TOLERANCE	
WD07 B19	CH4 +5 VDC POWER OUT-OF-TOLERANCE	
WD09 B19	CORE A 28 VDC POWER OUT-OF-TOLERANCE	

The following 12 BITS are Required State as noted,
Preplanned Contingency Procedure: LCC violation confirmed, No Go for launch.

WD10 B10	CORE A LEFT SRB PWR CMD	Required State: '1'
WD10 B11	CORE A RIGHT SRB PWR CMD	Required State: '1'
WD10 B14	CORE A LEFT SRB RSS PWR CMD	Required State: '0'
WD10 B15	CORE A RIGHT SRB RSS PWR CMD	Required State: '0'
WD10 B16	CORE A SRB RSS SAFE 1 CMD	Required State: '0'
WD10 B17	CORE A SRB RSS SAFE 2 CMD	Required State: '0'
WD10 B19	CORE A LEFT SRB BUS C PWR CMD	Required State: '1'
WD10 B20	CORE A RIGHT SRB BUS C PWR CMD	Required State: '1'
WD10 B21	CORE A ATVC 2/1 PWR CMD	Required State: '1'
WD10 B22	CORE A ATVC 4/3 PWR CMD	Required State: '1'
WD10 B23	CORE A ATVC 2/1 26 V DEADFACE CMD	Required State: '0'
WD10 B24	CORE A ATVC 4/3 26 V DEADFACE CMD	Required State: '0'

The following 12 BITS are Required State as noted,
Preplanned Contingency Procedure: LCC violation confirmed, No Go for launch.

WD11 B09	CORE B 28 VDC POWER OUT-OF-TOL	Required State: '0'
WD11 B10	CORE B LEFT SRB PWR CMD	Required State: '1'
WD11 B11	CORE B RIGHT SRB PWR CMD	Required State: '1'
WD11 B14	CORE B LEFT SRB RSS PWR CMD	Required State: '0'
WD11 B15	CORE B RIGHT SRB RSS PWR CMD	Required State: '0'
WD11 B16	CORE B SRB RSS SAFE 1 CMD	Required State: '0'
WD11 B17	CORE B SRB RSS SAFE 2 CMD	Required State: '0'
WD11 B19	CORE B LEFT SRB BUS C PWR CMD	Required State: '1'
WD11 B20	CORE B RIGHT SRB BUS C PWR CMD	Required State: '1'
WD11 B21	CORE B ATVC 2/1 PWR CMD	Required State: '1'
WD11 B22	CORE B ATVC 4/3 PWR CMD	Required State: '1'
WD11 B23	CORE B ATVC 2/1 26 V DEADFACE CMD	Required State: '0'
WD11 B24	CORE B ATVC 4/3 26 V DEADFACE CMD	Required State: '0'

SUPPORTING DATA:

Table 26-02 EMEC/AMEC Preflight BITE (Continued)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
The following 24 BITS are Required State '0', Preplanned Contingency Procedure: LCC violation confirmed, No Go for launch.	
WD12 B09	CORE A LT&RT UMB RET SOL #2 FIRE 2
WD12 B10	CORE A LT&RT UMB RET SOL #2 FIRE 1
WD12 B11	CORE A LEFT UMB UNLATCH ARM
WD12 B13	CORE A SRB IGNITION FIRE 1
WD12 B14	CORE A RIGHT SRB SEP ARM
WD12 B15	CORE A ORB/ET SEP FIRE 2 QUALIFIER
WD12 B16	CORE A SRB HOLD DOWN FIRE 1
WD12 B17	CORE A SRB SEP FIRE 1
WD12 B19	CORE A LEFT UMB UNL FIRE 1
WD12 B20	CORE A RIGHT UMB UNL FIRE 1
WD12 B21	CORE A ORB/ET SEP FIRE 1
WD12 B22	CORE A T-0 SEP FIRE 1
WD13 B09	CORE B LT&RT UMB RET SOL #2 FIRE 2
WD13 B10	CORE B LT&RT UMB RET SOL #2 FIRE 1
WD13 B11	CORE B LEFT UMB UNL ARM
WD13 B13	CORE B RIGHT SRB SEP ARM
WD13 B14	CORE B SRB IGNITION FIRE 1
WD13 B15	CORE B ORB/ET SEP FIRE 2 QUALIFIER
WD13 B16	CORE B SRB HOLD DOWN FIRE 1
WD13 B17	CORE B SRB SEP FIRE 1
WD13 B19	CORE B LEFT UMB UNL FIRE 1
WD13 B20	CORE B RIGHT UMB UNL FIRE 1
WD13 B21	CORE B ORB/ET SEP FIRE 1
WD13 B22	CORE B T-0 SEP FIRE 1

SUPPORTING DATA:

Table 26-02 EMEC/AMEC Preflight BITE (Concluded)

PFB BIT	INDICATION / REQUIRED STATE / PREPLANNED CONTINGENCY PROCEDURE
The following 40 BITS are Required State '0', Preplanned Contingency Procedure: LCC violation confirmed, No Go for launch.	
WD14 B09	CORE A LT&RT UMB RET SOL #3 FIRE 2
WD14 B10	CORE A LT&RT UMB RET SOL #3 FIRE 1
WD14 B13	CORE A SRB IGNITION FIRE 2
WD14 B14	CORE A T-0 SEP ARM
WD14 B15	CORE A LEFT UMB UNL FIRE 2 QUALIFIER
WD14 B16	CORE A SRB HOLD DOWN FIRE 2
WD14 B17	CORE A SRB SEP FIRE 2
WD14 B18	CORE A RIGHT UMB UNL FIRE 2 QUALIFIER
WD14 B19	CORE A LEFT UMB UNL FIRE 2
WD14 B20	CORE A RIGHT UMB UNL FIRE 2
WD14 B21	CORE A ORB/ET SEP FIRE 2
WD14 B22	CORE A T-0 SEP FIRE 2
WD15 B09	CORE B LT&RT UMB RET SOL #3 FIRE 2
WD15 B10	CORE B LT&RT UMB RET SOL #3 FIRE 1
WD15 B13	CORE B T-0 SEP ARM
WD15 B14	CORE B SRB IGNITION FIRE 2
WD15 B15	CORE B LEFT UMB UNL FIRE 2 QUALIFIER
WD15 B16	CORE B SRB HOLD DOWN FIRE 2
WD15 B17	CORE B SRB SEP FIRE 2
WD15 B18	CORE B RIGHT UMB UNL FIRE 2 QUALIFIER
WD15 B19	CORE B LEFT UMB UNL FIRE 2
WD15 B20	CORE B RIGHT UMB UNL FIRE 2
WD15 B21	CORE B ORB/ET SEP FIRE 2
WD15 B22	CORE B T-0 SEP FIRE 2
WD16 B09	CORE A LT&RT UMB RET SOL #1 FIRE 2
WD16 B10	CORE A LT&RT UMB RET SOL #1 FIRE 1
WD16 B11	CORE A RIGHT UMB UNL ARM
WD16 B12	CORE A ORB/ET SEP ARM
WD16 B13	CORE A RIGHT SRB IGN ARM
WD16 B14	CORE A LEFT SRB IGN ARM
WD16 B15	CORE A SRB HOLD DOWN ARM
WD16 B16	CORE A LEFT SRB SEP ARM
WD17 B09	CORE B LT&RT UMB RET SOL #1 FIRE 2
WD17 B10	CORE B LT&RT UMB RET SOL #1 FIRE 1
WD17 B11	CORE B RIGHT UMB UNL ARM
WD17 B12	CORE B ORB/ET SEP ARM
WD17 B13	CORE B LEFT SRB IGN ARM
WD17 B14	CORE B RIGHT SRB IGN ARM
WD17 B15	CORE B SRB HOLD DOWN ARM
WD17 B16	CORE B LEFT SRB SEP ARM

LCC VIOLATION CALL: GSE Main Bus Motor Switch Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76X0190W	GSE Mn Bus A Pwr ON Ind		OFF	NA	Event	DI
V76X0195W	Main Bus A Red ON Ind		OFF	NA	Event	DI
V76X0290W	GSE Mn Bus B Pwr ON Ind		OFF	NA	Event	DI
V76X0295W	Main Bus B Red ON Ind		OFF	NA	Event	DI
V76X0390W	GSE Mn Bus C Pwr ON Ind		OFF	NA	Event	DI
V76X0395W	Main Bus C Red ON Ind		OFF	NA	Event	DI

TIME PERIOD:

(1) Verify Ground Power is Removed at approximately T-40 seconds

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Instrumentation failure can be confirmed by checking the ITCU contactor discrete. If a main bus GSE motor switch fails to indicate OFF after being commanded OFF, check the ITCU contactor indicator. If it is OFF, LCC violation cleared, continue countdown.

NOTES:

(4) Ground Power termination sequence starts at T-50 seconds.

REDLINE DERIVATION: CRITICALITY: 1R

(5) The motor switches must be opened before launch.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Possible main bus short circuit at T-0 umbilical.
(7) Complete loss of AFT main bus.
(8) Transients on forward and mid main bus and AC bus.
(9) Loss of main engine controller redundancy.
(10) Loss of SRB power redundancy.

CAUSES OF EXCEEDING REDLINE:

(11) LPS failure.
(12) Short circuit between motor switch and HIM.
(13) Motor switch failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-976099	SHEET 76 B,	ZONE 22-24
	DWG NO	SHEET 2,4	ZONE

ELEMENT: Orbiter SUBSYSTEM: EPDC

LCC VIOLATION CALL: Orbiter Fire Extinguisher Pyro Voltage Anomaly | EMERG COND: Yellow (8)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76V4736A	Avn FEXT Av Bay 1 Pyro Cap Volt	(2)	NA	1.5	Vdc	CI
V76V4716A	Avn FEXT Av Bay 2 Pyro Cap Volt	(2)	NA	1.5	Vdc	CI
V76V4700A	Avn FEXT Av Bay 3A Pyro Cap Volt	(2)	NA	1.5	Vdc	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) If one or more of the avionics bay fire extinguisher Pyrotechnic Initiator Controller (PIC) capacitor voltages are above 1.5 Vdc, then check position of affected switch (Panel L1A1). (Ref S0007 Volume 5)

A. If the affected switch is in the ARM position, then reposition switch to the SAFE position.

1. If the PIC capacitor voltage decreases to within redline requirements, then LCC violation cleared, continue countdown.

2. If the PIC capacitor voltage does not decrease to within redline limits, then immediately remove power from the applicable circuit by opening the appropriate circuit breaker, LCC violation confirmed, No Go for launch. (3)

B. If the affected switch is in the SAFE position, perform a BITE TEST 4 on the Multiplexer/Demultiplexer (MDM) Command Decoders to determine the state of the applicable Launch Processing System (LPS) command.

Av Bay 1 Fire Suppression Arm Command V62K0810NL---MDM LA1
Av Bay 2 Fire Suppression Arm Command V62K0811NL---MDM LF1
Av Bay 3A Fire Suppression Arm Command V62K0812NL---MDM LF1

1. If the applicable Command Decoder avionics bay Fire Suppression Arm Command is ON, then perform data retrievals to determine if firing room personnel inadvertently issued the ARM command.

a. If firing room personnel inadvertently issued the ARM command, then turn the applicable Command Decoder avionics bay Fire Suppression Arm Command OFF. Verify the PIC capacitor voltage decreases to within redline requirements. LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

b. If firing room personnel did not issue the applicable ARM command, then immediately remove power from the applicable circuit by opening the appropriate circuit breaker. LCC violation confirmed, No Go for launch. (3)

2. If the applicable Command Decoder avionics bay Fire Suppression Arm Command is OFF, remove power from the affected circuit by opening the appropriate circuit breaker. LCC violation confirmed, No Go for launch. (3)

(3) Contingency Safing - Remove power from the affected unit by opening the appropriate circuit breaker (CB) listed below (Ref. S0007 Volume 5).

CB Location	CB
Panel O14 Row C	MN A Fire Suppression Bay 3A CB
Panel O15 Row C	MN B Fire Suppression Bay 1 CB
Panel O16 Row C	MN C Fire Suppression Bay 2 CB

NOTES:

(4) The avionics bay Fire Extinguisher (FEXT) Pyro PIC circuit can be armed from LPS or crew module panel L1A1.
(5) Fire Suppression circuit breakers are criticality 1R hardware. Due to the electrical conductivity failure history of panel circuit breakers, opening and subsequently closing the circuit breaker would render it functionally questionable unless a retest was performed to ensure electrical conductivity.
(6) Instrumentation failure is not acceptable because the PIC capacitor voltage is a criticality 1R measurement and is the only means available to verify the integrity of the system.

REDLINE DERIVATION: CRITICALITY: 1R

(7) A. SSID Intent Summary - The purpose of this redline is to ensure that the PICs are not prematurely charged. If the PIC's are charged the FEXT system is one failure away from discharging Halon into the forward avionics bays. There are three avionics bays in the forward crew compartment. Each bay has one fire extinguisher bottle to be used in case of a fire. The Halon in the bottle is discharged by a NASA Standard Initiator (NSI) and a PIC. The PIC capacitor voltage is the only means available to verify that the PIC has been charged.

B. Voting Logic - N/A

C. Minimum and Maximum Redline Development - Based upon the PIC specification MC450-0018, allowing for a +/- 2 bit count instrumentation error, and induced voltage; 1.5 VDC has been determined to be the maximum voltage reading for a lower limit indication.

REDLINE DERIVATION: (Continued)

D. Time Period - T-31 seconds was chosen because the FEXT system is a criticality 1R function and should be monitored as close to T-0 as practical.

E. Requirements - N/A

F. Pre-Planned Contingency Procedures - The procedure will determine if the PIC capacitor was charged by an inadvertent LPS command or crew module switch action. If an inadvertent action did not occur, the applicable circuit breaker would be opened and an LCC violation confirmed. It is imperative that the system be safed by removing the arm command or by disabling the circuit by opening the FEXT circuit breaker(s).

CONSEQUENCES OF EXCEEDING REDLINE:

(8) If the fire extinguisher PIC capacitor voltage(s) have exceeded their maximum redline, the fire extinguisher system is one step away from discharging Halon into the forward avionics bays.

CAUSES OF EXCEEDING REDLINE:

(9) Instrumentation or MDM card failure.
(10) Premature LPS arm command.
(11) Inadvertent switch positioning to ARM.
(12) Firex control circuit electrical failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	Vdc								
V76V4736A	0.163	0.0	40.75						
V76V4716A	0.163	0.0	40.75						
V76V4700A	0.163	0.0	40.75						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 5.1 SHEET 5.1.1 ZONE J
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: EPDC

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LCC VIOLATION CALL: Orbiter Landing Gear Pyro Voltage Anomaly | EMERG COND: Yellow

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76V4830A	NLG Emer Ext Pyro A Cap Volt		NA	1.5	Vdc	CI
V76V4900A	LMG Emer Ext Pyro A Cap Volt		NA	1.5	Vdc	CI
V76V4950A	RMG Emer Ext Pyro A Cap Volt		NA	1.5	Vdc	CI
V76V4820A	NLG Pyro Extend Actr-Cap Volt-1		NA	1.5	Vdc	CI
V76V4832A	NLG Emer Ext Pyro B Cap Volt		NA	1.5	Vdc	CI
V76V4902A	LMG Emer Ext Pyro B Cap Volt		NA	1.5	Vdc	CI
V76V4952A	RMG Emer Ext Pyro B Cap Volt		NA	1.5	Vdc	CI
V76V4821A	NLG Pyro Extend Actr-Cap Volt-2		NA	1.5	Vdc	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) The following three steps should reset the arm and down relays for the landing gear.
Panel R15-Ldg Gear Arm/DN Reset Circuit Breaker - CLOSE.
Panel A12-Ldg Gear Arm/DN Reset Switch - RESET (Release).
Panel R15-Ldg Gear Arm/DN Reset Circuit Breaker - OPEN.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(3) The purpose of this redline is to ensure that PICs are not prematurely charged.

CONSEQUENCES OF EXCEEDING REDLINE:

(4) Possible extension of landing gear during ascent.

CAUSES OF EXCEEDING REDLINE:

(5) Instrumentation failure.
(6) Premature arm commands.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	Vdc								
V76V4830A	0.163	0.0	40.75						
V76V4900A	0.163	0.0	40.75						
V76V4950A	0.163	0.0	40.75						
V76V4820A	0.163	0.0	40.75						
V76V4832A	0.163	0.0	40.75						
V76V4902A	0.163	0.0	40.75						
V76V4952A	0.163	0.0	40.75						
V76V4821A	0.163	0.0	40.75						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 13.1 SHEET 13.1.2 ZONE F4
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: EPDC

LCC VIOLATION CALL: ET/ORB SEPARATION Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76X9111X	ET Separation A	1 of	OFF	NA	Event	CI
V76X9113X	ET Separation C	2	OFF	NA	Event	CI
	AND					
V76X9112X	ET Separation B	1 of	OFF	NA	Event	CI
V76X9114X	ET Separation D	2	OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY:

(2) An energized Fire 2 circuit will negate operation of the associated forward Sep PIC (i.e., LOSS OF REDUNDANCY IN THE FORWARD ET/ORBITER SEPARATION CIRCUIT).

CONSEQUENCES OF EXCEEDING REDLINE:

(3) A high SEP Fire 2 output (MEC output or LCA/harness anomaly) prior to issuance of separation sequence would disable the redundancy of that function.
Furthermore, if the BFS is engaged between MECO confirmed & ET Separation (18 second window) and both discretes ((A & C) OR (B & D)) are high, then the BFS ET SEP sequence is moded to the cleanup step.
ET SEP processing is no longer performed and the ET cannot be separated from the Orbiter either manually or automatically.

CAUSES OF EXCEEDING REDLINE:

(4) MEC failure.
(5) Wire harness anomaly.
(6) LCA failure.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 10.1 SHEET 3 of 3 ZONE J2
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-976099 SHEET DP,EN ZONE D10

ELEMENT: Orbiter SUBSYSTEM: EPDC

LCC VIOLATION CALL: Orbiter Drag Chute Pyro Voltage Anomaly | EMERG COND: Yellow

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76V0940A	Drag Chute Deploy 1 Cap Volts		NA	1.5 (2)	Vdc	CI
V76V0946A	Drag Chute Deploy 2 Cap Volts		NA	1.5 (3)	Vdc	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) If V76V0940A exceeds 1.5V, open cb Pnl O16 Row E Mn C Drag Chute Sys 1, which removes power from drag chute controller assy, and verify voltage returns to less than 1.5V. If successful, LCC violation cleared, continue countdown.
(3) If V76V0946A exceeds 1.5V, open cb Pnl O15 Row E Mn B Drag Chute Sys 2, which removes power from drag chute controller assy, and verify voltage returns to less than 1.5V. If successful, LCC violation cleared, continue countdown.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(4) The purpose of this redline is to ensure that the PICs are not prematurely charged.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Possible premature deployment of drag chute (multiple failures required). Possible catastrophic damage to SSME #1 (reference Hazard Report 342).

CAUSES OF EXCEEDING REDLINE:

(6) Circuit failure.
(7) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	Vdc								
V76V0940A	0.16	0	40						
V76V0946A	0.16	0	40						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: EPDC

SECTION 27

AUXILIARY POWER UNIT

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SECTION 27: AUXILIARY POWER UNIT

SSID No.	Description/Violation Call	Page
APU-01	APU Fuel Tank Pressure Anomaly	27-01.1
APU-02	APU Fuel Line Temperature Anomaly	27-02.1
APU-03	APU Gas Generator Chamber Pressure Anomaly	27-03.1
APU-04	APU Gas Generator Bed/Injector Tube Temperature Anomaly	27-04.1
APU-05	APU Fuel Line Temp No. 3/Supply Line Temperature Anomaly	27-05.1
APU-06	APU Turbine Speed Anomaly	27-06.1
APU-07	APU Turbine Exhaust Temperature (REQUIREMENT DELETED)	27-07.1
APU-08	Dynamic APU Lube Oil Temperature Anomaly	27-08.1
APU-09	Static APU Lube Oil Temperature Anomaly	27-09.1
APU-10	APU Gearbox Pressure Measurement Anomaly	27-10.1
APU-11	APU Gearbox Pressure Anomaly	27-11.1
APU-12	APU Bearing Temperature Anomaly	27-12.1
APU-13	APU GN2 Bottle Pressure Anomaly	27-13.1
APU-14	APU Fuel Test Line Temperature Anomaly	27-14.1
APU-15	APU Fuel Pump Drain Line Temperature Anomaly	27-15.1
APU-16	APU Fuel Pump Drain Line Pressure	27-16.1
APU-17	APU Pump Water Tank Pressures (REQUIREMENT DELETED)	27-17.1
APU-18	APU Fuel Valve/Fuel Pump Temperature Anomaly	27-18.1
APU-19	Injector Cooling System Heater Anomaly (REQUIREMENT DELETED)	27-19.1
APU-20	Injector Cooling System Pressure Anomaly	27-20.1

SECTION 27: AUXILIARY POWER UNIT (CONTINUED)

SSID No.	Description/Violation Call	Page
APU-21	APU Fuel Isolation Valve Temperature Anomaly (REQUIREMENT DELETED)	27-21.1
APU-22	Hot Restart Temperature Anomaly	27-22.1
APU-23	APU Fuel Tank Isolation Valve Anomaly	27-23.1
APU-24	PCA APU Controller RPC Power ON Anomaly	27-24.1
APU-25	APU Fuel Pump Inlet Pressure Anomaly	27-25.1
APU-FG01	Figure 27-01 Typical APU Gas Generator Chamber Pressure Profile	27-FG01.1

LCC VIOLATION CALL: APU Fuel Tank Pressure Anomaly | EMERG COND: Yellow (10)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V46P0100A	APU 1 Fuel Tank Pressure		(3)	NA	psia	CI
V46P0105A	APU 1 Fuel Tank Outlet Press		(3)	NA	psia	CI
V46P0200A	APU 2 Fuel Tank Pressure		(3)	NA	psia	CI
V46P0205A	APU 2 Fuel Tank Outlet Press		(3)	NA	psia	CI
V46P0300A	APU 3 Fuel Tank Pressure		(3)	NA	psia	CI
V46P0305A	APU 3 Fuel Tank Outlet Press		(3)	NA	psia	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for APU Start (T-5 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 measurements per APU acceptable for confirmed instrumentation failure. (4)

(3) Monitor to assure no leaks. A pressure decrease of 2 data bits or more without a corresponding temperature change indicates a potential leak and must be evaluated. (5)

PREPLANNED CONTINGENCY PROCEDURE:

(4) Instrumentation failure is confirmed for a measurement indicating off scale high or low, exhibiting a step function change, or functioning erratically. For confirmed instrumentation failure, LCC violation cleared, continue countdown.

(5) For indicated pressure leak, check applicable Fuel Tank Surface Temperatures for corresponding changes (see table below). (Ref S0007 VL 5)
- If temperatures track with pressure changes, LCC violation cleared, continue countdown.
- If Tank Pressure and/or Outlet Pressure decrease 2 bits or more with no corresponding temperature change, check Fuel Pump Inlet Pressure as follows:

Cycle applicable fuel isolation valve OPEN/CLOSE by ground command or cockpit switch. Read corresponding Fuel Pump Inlet Pressure and compare to remaining instrumentation to verify validity.
- If observed pressure change can be explained with observed temperature change, LCC violation cleared, continue countdown.

APU	Fuel Tank Surf Temp	Surf Temp at Htr	Fuel Pump Inlet Press
1	V46T0102A	V46T0130A	V46P0110A
2	V46T0202A	V46T0230A	V46P0210A
3	V46T0302A	V46T0330A	V46P0310A

NOTES:

(6) After APU start, fuel tank pressures are too dynamic to indicate small tank leakage.
(7) GN2 solubility in hydrazine can account for a decrease in GN2 pressure and is accounted for within 72 hours of servicing.
(8) Pnl R2, Fuel Isolation Valve switches.
APU FUEL TK VLV 1 sw - OPEN/CLOSE
APU FUEL TK VLV 2 sw - OPEN/CLOSE
APU FUEL TK VLV 3 sw - OPEN/CLOSE

REDLINE DERIVATION: CRITICALITY: 1

(9) Pressure redline ensures no leakage prior to APU start.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Minimum: A. Damage in aft fuselage if hydrazine (N2H4) leaks.
B. Insufficient fuel/GN2 to complete mission.

CAUSES OF EXCEEDING REDLINE:

(11) Minimum: Fuel and/or GN2 leak.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR APU 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
V46P0n00A	2.0	0	500						
V46P0n05A	2.0	0	500						

METER/DISPLAY RANGE - MSID: V46P0n00A LOW: 0 HIGH: 500
V46P0n05A LOW: 0 HIGH: 500

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 12.1 SHEET 2 ZONE V2
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-946099 SHEET 9 ZONE C21,C22
DWG NO VS70-946102 SHEET 9 ZONE C21,C22

ELEMENT: Orbiter SUBSYSTEM: APU

LCC VIOLATION CALL: APU Fuel Line Temperature Anomaly | EMERG COND: Yellow (18)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V46T0104A	APU 1 Fuel Line Temp No 2		46 (5)	95(3,4)	deg F	CI
V46T0108A	APU 1 Fuel Line Temp No 1		46 (5)	130 (4)	deg F	CI
V46T0204A	APU 2 Fuel Line Temp No 2		46 (5)	95(3,4)	deg F	CI
V46T0208A	APU 2 Fuel Line Temp No 1		46 (5)	130 (4)	deg F	CI
V46T0304A	APU 3 Fuel Line Temp No 2		46 (5)	95(3,4)	deg F	CI
V46T0308A	APU 3 Fuel Line Temp No 1		46 (5)	130 (4)	deg F	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 measurements per APU acceptable for confirmed instrumentation failure. (6)
(3) Violation of maximum redline, not exceeding purge gas temperature, is acceptable from Start of ET Cryo Tanking until temperature first decreases into the heater control range.
(4) Heater must not be Failed ON (as indicated by unexplained upward trending temperatures).
(5) Heater Failed OFF (as indicated by unexplained downward trending temperatures) requires evaluation. (7)

PREPLANNED CONTINGENCY PROCEDURE:

(6) Instrumentation failure is confirmed for a measurement indicating off scale high or low, exhibiting a step function change, or functioning erratically. For confirmed instrumentation failure, LCC violation cleared, continue countdown.
(7) Heater Failed OFF: (Ref S0007 VL 5)
A. Remove power from heaters by ground command.
B. Use cockpit switch to verify function of suspect heater A or B.
- If functional, use the cockpit switch to turn the heater OFF and configure to the alternate heater utilizing ground command; LCC violation cleared, continue countdown.
- If not functional, confirmed heater failure, LCC violation confirmed, no go for launch.

Panel A12 APU HEATER **
TANK/FUEL LINE/H2O SYS 1A sw - OFF/AUTO
TANK/FUEL LINE/H2O SYS 1B sw - OFF/AUTO
TANK/FUEL LINE/H2O SYS 2A sw - OFF/AUTO
TANK/FUEL LINE/H2O SYS 2B sw - OFF/AUTO
TANK/FUEL LINE/H2O SYS 3A sw - OFF/AUTO
TANK/FUEL LINE/H2O SYS 3B sw - OFF/AUTO
** Switches may not be accessible after hatch closure.

NOTES:

(8) A heater failed ON cannot be caused by a ground failure since the ground only activates the control circuit. For a Heater Failed ON, switch to backup heater for safing.
(9) V46T0108A, V46T0208A, V46T0308A are alternates to V46T0104A, V46T0204A, V46T0304A, respectively, due to the proximity of the controlling thermostat.
(10) V46T0104A & 0108A Monitor Heaters 14 and 15 on APU System 1.
V46T0204A & 0208A Monitor Heaters 24 and 25 on APU System 2.
V46T0304A & 0308A Monitor Heaters 34 and 35 on APU System 3.
(11) Maximum temperature at V46T0108A, V46T0208A, V46T0308A, may be higher due to reduced effectiveness of insulation on ground and effect of Payload Bay (PLB) circuit 2 GN2 purge.
(12) The 120 and 125 deg F Fault Detection and Annunciation (FDA) limit is to allow crew adequate time to perform on-orbit work-around procedures.
(13) The FDA limit may be exceeded prior to the LCC violation.

REDLINE DERIVATION: CRITICALITY: 1R

(14) Minimum: To detect a failed OFF heater system.
(15) Maximum: To detect a failed ON heater system.
(16) Redline development:

	Min	Max (V46T0n04A)	Min	Max (V46T0n08A)
Thermostat setting	50	70	50	70
Location delta	+ 1	+20	+ 1	+55
Instrumentation error	- 5	+ 5	- 5	+ 5
Redline limits	46	95	46	130

CONSEQUENCES OF EXCEEDING REDLINE:

(17) Minimum: Hydrazine (N2H4) leak or line rupture with greater than one freeze/thaw cycle.
(18) Maximum: Potential hydrazine (N2H4) decomposition/detonation.

CAUSES OF EXCEEDING REDLINE:

(19) Minimum: Failed OFF heater thermostats (two) or driver.
(20) Maximum: Failed ON heater thermostat or driver.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR APU 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.F								
V46T0n04A	.9997	-.7958	249.1					45	120
V46T0n08A	.9997	-.7958	249.1					45	125

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 12.1	SHEET 2	ZONE Q2,R2
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-946099	SHEET 9	ZONE F14,F16
	DWG NO VS70-946102	SHEET 9	ZONE F14,F16

ELEMENT: Orbiter SUBSYSTEM: APU

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LCC VIOLATION CALL: APU Gas Generator Chamber Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	At peak of pulse:					
V46P0120A	APU 1 Gas Generator Chamber Press	(3)	725	1450	psia	CI
V46P0220A	APU 2 Gas Generator Chamber Press	(3)	725	1450	psia	CI
V46P0320A	APU 3 Gas Generator Chamber Press	(3)	725	1450	psia	CI
	Lowest point between pulses:					
V46P0120A	APU 1 Gas Generator Chamber Press	(4)	NA	100	psid	CI
V46P0220A	APU 2 Gas Generator Chamber Press	(4)	NA	100	psid	CI
V46P0320A	APU 3 Gas Generator Chamber Press	(4)	NA	100	psid	CI

TIME PERIOD:

(1) From T-4 Minutes to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES: Figure 27-01

(2) Requires realtime Record and Playback System (RPS) recording and monitoring. (5)
(3) Requirements shown are peak values. (6) Reference Figure 27-01 for a typical APU gas generator chamber pressure profile.
(4) Requirement is for maximum pressure between pulses and is a delta pressure from the APU operating transducer bias level. This requirement does not apply during hydraulic loading. Reference Figure 27-01 for a typical APU gas generator chamber pressure profile. (7)

PREPLANNED CONTINGENCY PROCEDURE:

(5) For RPS failure, Mission Control Center - Houston will be used as backup to make the APU chamber pressure call.
(6) In case of anomalous condition, compare chamber pressure profile to other APUs and look for abnormal pulse shapes, frequencies or chamber pressure peaks. If no abnormalities exist or chamber pressure recovers, LCC violation cleared, continue countdown.
(7) To confirm acceptable transducer shift, perform the following for the affected APU:
    1. PNL R2, APU/HYD, APU SPEED SELECT - HIGH
    2. Monitor gas generator chamber pressure. If maximum observed pressure between pulses returns to the APU operating transducer bias level (i.e., drops by >= 100 psi), unacceptable Pulse Control Valve (PCV) Outlet or Shutoff Valve (SOV) Bypass leakage is indicated, LCC violation confirmed, No Go for launch. If not, transducer shift is indicated, return to normal speed (PNL R2, APU/HYD, APU SPEED SELECT - NORM), LCC violation cleared, continue countdown.

NOTES:

(8) Presence of a bubble in chamber pressure profile is acceptable.
(9) Periodic increases in chamber pressure while the APU is under a hydraulic load from T-3 minutes and 55 seconds to T-3 minutes and 20 seconds is normal.
(10) An operational transducer bias is a pressure value which is an off-set from the pre APU start zero set point of that transducer that manifests itself after APU start (induced by temperature and varies for each transducer).

REDLINE DERIVATION: CRITICALITY: 1R

(11) Minimum and Maximum at peak of pulse (psia):
  a) Measurement verifies proper gas generator operation, indication of proper fuel pump and control valve operation, and indication of proper catalytic bed condition.
  b) The minimum and maximum uncertainty represents an adjustment for differences between the supplier's and the vehicle data systems.
  c) The minimum basic redline is the minimum APU gas generator pressure that is required to support hydraulic pump flow demand under all vehicle operating conditions.
(12) Maximum between pulses (psid): Redline based on a failure of the pulse control valve to control turbine speed in the normal range. EASY5 analysis indicates that, under worst case conditions, at 115 psid (130 psia limit - 15 psia atmospheric pressure) this will result in the shutoff valve controlling the turbine at a higher speed and loss of speed control redundancy. The 15 psid uncertainty is based on engineering judgment.
(13) Redline development: (V46P0n20A)

	At Peak (psia)		Between Pulses (psid)
	Min	Max	Max
Basic Redline	750	1575	115
Uncertainty	-85	-65	-15
Instrumentation Error	+60	-60	0
Redline limits	725	1450	100

CONSEQUENCES OF EXCEEDING REDLINE:

(14) Minimum at peak (psia): APU will not generate maximum horsepower.
(15) Maximum at peak (psia): High exhaust gas temperature.
(16) Maximum between pulses (psid): Loss of speed control redundancy.

CAUSES OF EXCEEDING REDLINE:

(17) Minimum at peak (psia): Fuel pump degradation. Injector tube, chamber pressure transducer, fuel pump or GGVM bypass leak(s).
(18) Maximum at peak (psia): Deterioration of gas generator catalytic bed.
(19) Maximum between pulses (psid): Leaking gas generator valve module.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR APU 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
V46P0n20A	7.002	0	1751						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 12.1	SHEET 2	ZONE K2
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-946099	SHEET 9	ZONE E10
	DWG NO VS70-946102	SHEET 9	ZONE E9

ELEMENT: Orbiter SUBSYSTEM: APU

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LCC VIOLATION CALL: APU Gas Generator Bed/Injector Tube Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V46T0122A	APU 1 Gas Generator Bed Temp	1 of	258 (3)	456 (2)	deg F	CI
V46T0174A	APU 1 Inj Tube Temp	2	258 (3)	444 (2)	deg F	CI
V46T0222A	APU 2 Gas Generator Bed Temp	1 of	258 (3)	456 (2)	deg F	CI
V46T0274A	APU 2 Inj Tube Temp	2	258 (3)	444 (2)	deg F	CI
V46T0322A	APU 3 Gas Generator Bed Temp	1 of	258 (3)	456 (2)	deg F	CI
V46T0374A	APU 3 Inj Tube Temp	2	258 (3)	444 (2)	deg F	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) For maximum redline violation:
  A. Turn OFF Gas Generator/Fuel Pump heater power and turn ON controller power.
     - Verify Bed/Injector temperature decrease after heater power turned OFF.
       * If no Gas Generator Valve Module (GGVM) leak is detected, (temperature continues to decrease), determine cooldown rate (Deg F/min. for Gas Generator Bed and Injector Tube Temperatures) with heater OFF.
       * If a GGVM leak is detected, LCC violation confirmed, No Go for launch.
  B. Reactivate heater, deactivate controller. If no GGVM leak was indicated, LCC violation cleared, continue countdown. Temperatures are allowed to violate the maximum limit during the remainder of the countdown.
  C. If temperatures remain above the maximum limit, turn OFF the Gas Generator/Fuel Pump Heater prior to APU Start. This should be completed in a timeframe which ensures Injector and Bed temperatures are below the maximum limits at APU Start (based on cooldown rate determined above). The minimum LCC limits do not apply with heater turned OFF. The minimum limit for APU start is 84 deg. F.
(3) For minimum redline violation (heater A or B failed OFF): (Ref S0007 Vol 5)
  A. Switch to alternate Gas Generator/Fuel Pump heater using ground command. If function is verified, LCC violation cleared, continue countdown.
  B. For a second confirmed heater failure, LCC violation confirmed, No Go for launch.

NOTES:

(4) A low limit failure of Gas Generator Bed Temp (less than 190 deg F) will result in loss of APU READY, which in turn will cause loss of APU/HYD READY TO START Grey Talkback on Panel R2 following APU Pre-start. Inform the flight crew.
(5) Injector tube temperatures (V46T0174A, V46T0274A, V46T0374A) provide the only indication of cooling when injector water is applied.
(6) A failed ON heater system cannot be detected due to the heater duty cycle which may be 100 percent after cryogenic loading.
(7) Gas Generator Bed Heater output is very sensitive to applied voltage. For example, at 30 volts, a 1 volt change results in an Injector temperature change of 30 deg. Heater voltage, as measured at the Aft Power Control Assemblies (V76V3091A, 3092A, 3093A), will decrease upon "Fuel Cell Load Adjust" at T-20 minutes. This voltage decrease results in lower Gas Generator Bed Heater power and lower temperatures.

REDLINE DERIVATION: CRITICALITY: 1R

(8) Minimum: Detects failed OFF heater system. Redline of 258 deg. based on System Management (SM) limit.
(9) Maximum: Protects APU hot start limit or detects a shorted heater system.
(10) Maximum redline development:

	GG Bed Temp V46T0n22A	Injector Tube Temp V46T0n74A
Basic Redline	470	470
Instrumentation error	-14	-33
Uncertainty	0	+7
Redline limits	456	444

(11) There are no credible failure modes other than instrumentation failure which will result in only 1 of 2 measurements exceeding the LCC redlines.
(12) Differences between the bed temperature measurement and injector temperature measurement are known to exist due to location differences and measurement bias. Injector temperature is warmer than bed temperature when operating with the "A" heater system. Typical "A" system value for this location difference is 20 to 25 deg. based on flight experience. When a unique APU exceeds this difference, it is considered to have a bias. The actual bias (that above the typical 25 deg.) based on history for a given APU can be utilized for evaluating the injector temp limit.

CONSEQUENCES OF EXCEEDING REDLINE:

(13) Minimum: Possible loss of APU.
(14) Maximum:
A. Possible hot start for a heater driven high temperature.
B. Possible loss of APU from a GGVM leak.

CAUSES OF EXCEEDING REDLINE:

(15) Minimum: Heater failed OFF.

CAUSES OF EXCEEDING REDLINE: (Continued)

(16) Maximum: A. Heater Operation at high voltage and controlled by gearbox thermal switch.
B. Hydrazine leakage past the GGVM Shutoff Valve Outlet Seat into the GG.
C. GG Bed Heater short to ground at mid segment causing increased heater wattage.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR APU 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.F								
V46T0n22A	2.0	0	500					258	
V46T0n74A	6.048	7.958	1520					258	

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 12.1 SHEET 2 ZONE K2
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-946099 SHEET 9 ZONE E8,E9
DWG NO VS70-946102 SHEET 9 ZONE E8,E9

ELEMENT: Orbiter SUBSYSTEM: APU

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LCC VIOLATION CALL: APU Fuel Line Temp No. 3/Supply Line Temperature Anomaly | EMERG COND: Yellow (12)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V46T0128A	APU 1 Fuel Line Temp No. 3		45 (4)	129 (3)	deg F	CI
V46T1171A	APU 1 GGVM Fuel Supply Line Temp		56 (4)	123 (3)	deg F	CI
V46T0228A	APU 2 Fuel Line Temp No. 3		45 (4)	129 (3)	deg F	CI
V46T1271A	APU 2 GGVM Fuel Supply Line Temp		56 (4)	123 (3)	deg F	CI
V46T0328A	APU 3 Fuel Line Temp No. 3		45 (4)	129 (3)	deg F	CI
V46T1371A	APU 3 GGVM Fuel Supply Line Temp		56 (4)	123 (3)	deg F	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 measurements per APU acceptable for confirmed instrumentation failure. (5)
(3) Heater must not be Failed ON (as indicated by unexplained upward trending temperatures).
(4) Heater Failed OFF (as indicated by unexplained downward trending temperatures) requires evaluation. (6)

PREPLANNED CONTINGENCY PROCEDURE:

(5) Instrumentation failure is confirmed for a measurement indicating off scale high or low, exhibiting a step function change or functioning erratically. For confirmed instrumentation failure, LCC violation cleared, continue countdown.
(6) Heater Failed OFF: (Ref S0007 VL 5)
A. Remove power from heaters by ground command.
B. Use cockpit switch to verify function of suspect heater A or B.
- If functional, use the cockpit switch to turn the heater OFF and configure to the alternate heater utilizing ground command; LCC violation cleared, continue countdown.
- If not functional, confirmed heater failure, LCC violation confirmed, no go for launch.

Panel A12 APU HEATER **
GAS GEN/FUEL PUMP 1 sw - A AUTO/OFF/B AUTO
GAS GEN/FUEL PUMP 2 sw - A AUTO/OFF/B AUTO
GAS GEN/FUEL PUMP 3 sw - A AUTO/OFF/B AUTO
** Switches may not be accessible after hatch closure.

NOTES:

(7) A heater failed ON cannot be caused by a ground failure since the ground only activates the control circuit. For a Heater Failed ON, switch to backup heater for safing.

REDLINE DERIVATION: CRITICALITY: 1R

(8) Minimum: To detect a failed OFF heater system.
(9) Maximum: To detect a failed ON heater system. (May not be detectable due to the heater duty cycles which may be 100 percent after cryogenic loading).

(10)	(V46T0n28A)		(V46T1n71A)	
Redline development:	Min	Max	Min	Max
Thermostat setting	73.5	100	73.5	100
Uncertainty	-5	+5	-5	+10
Location delta	-10.0	+10	-3	+3
Instrumentation error	-14	+14	-10	+10
Redline limits	44.5	129	55.5	123

(11) The minimum and maximum uncertainty represents an adjustment for differences between the supplier's and the vehicle data systems.

CONSEQUENCES OF EXCEEDING REDLINE:

(12) Minimum: Hydrazine (N2H4) leak or line rupture with greater than one freeze/thaw cycle.
(13) Maximum: Potential hydrazine (N2H4) decomposition/detonation.

CAUSES OF EXCEEDING REDLINE:

(14) Minimum: Failed OFF heater thermostat or driver.
(15) Maximum: Failed ON heater thermostat or driver.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR APU 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.F								
V46T0n28A	1.6	-2	398.0					60	200
V46T1n71A	1.77	0.91	443.5						200

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 12.1 SHEET 2 ZONE M1,M2
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-946099 SHEET 9 ZONE D12,E11
DWG NO VS70-946102 SHEET 9 ZONE D12,E11

ELEMENT: Orbiter SUBSYSTEM: APU

LCC VIOLATION CALL: APU Turbine Speed Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V46R0135A	APU 1 Turbine Speed		95	111	pct	CI
V46R0235A	APU 2 Turbine Speed		95	111	pct	CI
V46R0335A	APU 3 Turbine Speed		95	111	pct	CI

TIME PERIOD:

(1) From Prior to Purge Sequence 4 (T-4 minutes, 5 seconds) to Go for SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) A Fault Detection and Annunciation (FDA) alarm provides indication of speed above upper limit for normal (112%), high (122%) and overspeed (129%) and speed below lower limit for underspeed (80%). Caution and Warning provides an indication of overspeed (129%) and underspeed (80%).
(3) An APU overspeed shutdown will occur above 129% turbine speed, ref C&W parameters 68, 78 & 88.
(4) An APU underspeed shutdown will occur below 80% turbine speed, ref C&W parameters 98, 108 & 118.
(5) APU Turbine speed shifts to 113 +8/-8.5% (high speed control mode) when the pulse control valve fails open.

REDLINE DERIVATION: CRITICALITY: 1R

(6) Minimum and Maximum: Turbine speed redlines established to verify that APU is in normal speed control mode. Measurement ensures that turbine speed meets hydraulic system requirements and gives an indication of proper system and control valve operation. Measurement also gives indication of proper catalytic bed condition and gas generator operation.
(7) The minimum and maximum limits reflect total system tolerances, including instrument tolerances and variations between APUs and APU controllers.
(8) Proper operation of the Turbine Speed Magnetic Pickup Unit 3 (MPU 3) does not confirm APU control redundancy because loss of MPU 1 or MPU 2 cannot be detected.
(9) An MPU 3 failure cannot be isolated from an instrumentation failure (signal conditioner, MDM channel, etc.) when an erratic, off-scale, or biased indication symptom is observed. An MDM card failure would result in other APU/HYD LCC violations.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) If overspeed or underspeed occurs, APU will shut down.
(11) If APU shifts to high speed, speed control redundancy is lost.
(12) If any MPU fails, control redundancy is lost. A second MPU failure will lead to APU shutdown.

CAUSES OF EXCEEDING REDLINE:

(13) Minimum and maximum:
A. Failure of APU Controller or Controller power RPC.
B. Failure of speed sensor (MPU 3).
C. Failure of pulse control valve.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR APU 1, 2, AND 3 RESPECTIVELY									
UNITS-->	pcnt								
APU IN NORM SPEED									
V46R0n35A	0.668	0	167	80	129	80			112
APU IN HIGH SPEED									
V46R0n35A	0.668	0	167	80	129	80	122		

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 12.1 SHEET 2 ZONE I2
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-946099 SHEET 9 ZONE F6
DWG NO VS70-946102 SHEET 9 ZONE F6

ELEMENT: Orbiter SUBSYSTEM: APU

APU Turbine Exhaust Temperature

(THIS REQUIREMENT HAS BEEN DELETED)

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LCC VIOLATION CALL: Dynamic APU Lube Oil Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V46T0154A	APU 1 Gearbox Lube Oil Out Temp		NA	283	deg F	CI
V46T0150A	APU 1 Gearbox Lube Oil Return Temp		NA	265	deg F	CI
V46T0254A	APU 2 Gearbox Lube Oil Out Temp		NA	283	deg F	CI
V46T0250A	APU 2 gearbox Lube Oil Return Temp		NA	265	deg F	CI
V46T0354A	APU 3 Gearbox Lube Oil Out Temp		NA	283	deg F	CI
V46T0350A	APU 3 Gearbox Lube Oil Return Temp		NA	265	deg F	CI

TIME PERIOD:

(1) From Prior to APU Start (T-5 minutes 25 seconds) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 measurements acceptable for confirmed instrumentation failure. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Instrumentation failure is confirmed for a measurement indicating off scale high or low, exhibiting a step function change, or functioning erratically. The following measurements are used to confirm APU gearbox lube oil temperature instrumentation failure post APU start. If these parameters are normal, LCC violation cleared, continue countdown. (Reference LCC SSIDs APU-11 and APU-12.)

- V46P0153A APU-1 Gearbox Lube Oil Out Press
- V46P0253A APU-2 Gearbox Lube Oil Out Press
- V46P0353A APU-3 Gearbox Lube Oil Out Press
- V46T0161A APU 1 Gearbox Bearing Temp No 1
- V46T0261A APU 2 Gearbox Bearing Temp No 1
- V46T0361A APU 3 Gearbox Bearing Temp No 1
- V46T0162A APU 1 Gearbox Bearing Temp No 2
- V46T0262A APU 2 Gearbox Bearing Temp No 2
- V46T0362A APU 3 Gearbox Bearing Temp No 2

NOTES:

(4) Expected delta temperature between Lube Oil Outlet Temp and Lube Oil Return Temp with standard WSB core load of 5 lb PGME during ground run is 15 - 25 deg F.

(5) Ref C&W parameters 38, 48 & 58 for Lube Oil Return Temps.

REDLINE DERIVATION: CRITICALITY: 1R

(6) SM limit of 290 deg. F is based on WSB set point (250 +3/-0 deg. F).

REDLINE DERIVATION: (Continued)

(7) Redline development:	Max (V46T0n50A)	Max (V46T0n54A)
Basic Redline	275	290
Instrumentation error	-10	-7
Redline limits	265	283

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Maximum: Exceeds lube oil temperature limit resulting in loss of APU.

CAUSES OF EXCEEDING REDLINE:

(9) Maximum: A. Water Spray Boiler malfunction.
B. Internal failure of the gearbox.
C. Lube oil overfill or underfill.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR APU 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.F								
V46T0n50A	2.0	-3.14	496.8		286.8	45	290		
V46T0n54A	1.6	-2	398.0					40	305

METER/DISPLAY RANGE - MSID: V46T0n50A LOW: 0 HIGH: 500

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 12.1 SHEET 2 ZONE F2
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-946099 SHEET 9 ZONE C5
DWG NO VS70-946102 SHEET 9 ZONE C5

ELEMENT: Orbiter SUBSYSTEM: APU

LCC VIOLATION CALL: Static APU Lube Oil Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V46T0150A	APU 1 Gearbox Lube Oil Return Temp		40	92 (3)	deg F	CI
V46T0154A	APU 1 Gearbox Lube Oil Out Temp		43	139	deg F	CI
V46T0250A	APU 2 Gearbox Lube Oil Return Temp		40	92 (3)	deg F	CI
V46T0254A	APU 2 Gearbox Lube Oil Out Temp		43	139	deg F	CI
V46T0350A	APU 3 Gearbox Lube Oil Return Temp		40	92 (3)	deg F	CI
V46T0354A	APU 3 Gearbox Lube Oil Out Temp		43	139	deg F	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 measurements acceptable for confirmed instrumentation failure. (4)
(3) Violation of maximum redline, not exceeding purge gas temperature, is acceptable from Start of ET Cryo Tanking until temperature first decreases into the heater control range.

PREPLANNED CONTINGENCY PROCEDURE:

(4) Instrumentation failure is confirmed for a measurement indicating off scale high or low, exhibiting a step function change, or functioning erratically. For confirmed instrumentation failure, LCC violation cleared, continue countdown.
(5) For redline violation (heater A or B failed): (ref S0007 VL 5)
   A. Switch to alternate heater using ground command. If function is verified, LCC violation cleared, continue countdown.
   B. If heater still not controlling correctly, turn OFF ground command and activate heater using cockpit switch. If function is verified, LCC violation cleared, continue countdown.
   C. If heater still not controlling correctly, switch to alternate heater using cockpit switch. If function is verified, LCC violation cleared, continue countdown.
   D. For a second confirmed heater failure, LCC violation confirmed, No Go for launch.

   Panel A12 APU HEATER **
   LUBE OIL LINE SYS 1 SW - A AUTO/OFF/B AUTO
   LUBE OIL LINE SYS 2 SW - A AUTO/OFF/B AUTO
   LUBE OIL LINE SYS 3 SW - A AUTO/OFF/B AUTO
   ** Switches may not be accessible after hatch closure.

NOTES:

(6) V46T0150A and 0154A Monitor Heaters 18 and 19 on APU System 1.
V46T0250A and 0254A Monitor Heaters 28 and 29 on APU System 2.
V46T0350A and 0354A Monitor Heaters 38 and 39 on APU System 3.

REDLINE DERIVATION: CRITICALITY: 2R

(7) Minimum: To detect a failed OFF heater system.
(8) Maximum: To detect a failed ON heater system.

(9) Redline development:	Min	Max (V46T0n50A)	Min	Max (V46T0n54A)
Thermostat setting	50	70	50	70
Location delta	0	+12	0	+62
Instrumentation error	-10	+10	-7	+7
Redline limits	40	92	43	139

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Minimum: Drop in oil temperature may cause lube oil viscosity to increase to unacceptable levels.
(11) Maximum: Potential heater damage if heater failed ON in addition to operational lube oil temperature.

CAUSES OF EXCEEDING REDLINE:

(12) Minimum: Failed OFF heater thermostat or driver.
(13) Maximum: Failed ON heater thermostat or driver.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR APU 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.F								
V46T0n50A	2.0	-3.14	496.8		286.8	45	290		
V46T0n54A	1.6	-2	398.0					40	305

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 12.1 SHEET 2 ZONE E2
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-946099 SHEET 9 ZONE B3,C3
DWG NO VS70-946102 SHEET 9 ZONE B3,C3

ELEMENT: Orbiter SUBSYSTEM: APU

LCC VIOLATION CALL: APU Gearbox Pressure Measurement Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V46P0151A	APU 1 Gearbox GN2 Press		NA	NA	psia	CI
V46P0251A	APU 2 Gearbox GN2 Press		NA	NA	psia	CI
V46P0351A	APU 3 Gearbox GN2 Press		NA	NA	psia	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for APU Start (T-5 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) Loss of ground visability (OI downlink) is acceptable but all 3 APU Gearbox Pressure measurements must be available to the respective APU controllers. (3,4)

PREPLANNED CONTINGENCY PROCEDURE:

(3) To confirm instrumentation function, compare to lube oil outlet pressure accounting for known transducer bias.
V46P0153A APU-1 Gearbox Lube Oil Out Press
V46P0253A APU-2 Gearbox Lube Oil Out Press
V46P0353A APU-3 Gearbox Lube Oil Out Press
If comparison indicates instrumentation is functioning properly, LCC violation cleared, continue countdown.

(4) To confirm acceptable failed low instrumentation: Issue start command with controller power ON and Fuel Isolation valves CLOSED. If controller detects low gearbox GN2 pressure, repress valve will activate, GN2 bottle pressure will decrease and lube oil out press will increase. If this does not occur, failure is in OI downlink, LCC violation cleared, continue countdown. (Ref S0007 VL 5)

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(5) Instrumentation failure: Gearbox GN2 pressure (V46P0151A, V46P0251A, V46P0351A) is required for activation of gearbox repress valve.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Instrumentation failure: Loss of ability to repressurize the gearbox resulting in possible loss of lube oil recirculation.

CAUSES OF EXCEEDING REDLINE:

(7) Instrumentation failure: Failed pressure transducer or signal processing data path.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR APU 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
V46P0n51A	0.12	0	30						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 12.1	SHEET 2	ZONE G2
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-946099	SHEET 9	ZONE G5
	DWG NO VS70-946102	SHEET 9	ZONE E5

ELEMENT: Orbiter SUBSYSTEM: APU

LCC VIOLATION CALL: APU Gearbox Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V46P0151A	APU 1 Gearbox GN2 Press		4.2 (6)	30	psia	CI
V46P0153A	APU 1 Gearbox Lube Oil Out Press	(2)	(3)	113	psia	CI
V46P0251A	APU 2 Gearbox GN2 Press		4.2 (6)	30	psia	CI
V46P0253A	APU 2 Gearbox Lube Oil Out Press	(2)	(3)	113	psia	CI
V46P0351A	APU 3 Gearbox GN2 Press		4.2 (6)	30	psia	CI
V46P0353A	APU 3 Gearbox Lube Oil Out Press	(2)	(3)	113	psia	CI

TIME PERIOD:

(1) From Post APU Start (T-5 minutes) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown. (5)

(3) Minimum redline is 20 psi delta with lube oil outlet pressure greater than gearbox GN2 pressure. Known instrumentation bias should be considered. A delay of up to 90 seconds may be required for lube oil system stabilization following APU start (chamber pressure increase).

(4) Gearbox GN2 repressurization is allowed during APU start. Post APU start, gearbox pressure trend must be verified as increasing.

PREPLANNED CONTINGENCY PROCEDURE:

(5) The following measurements are used to confirm APU gearbox lube oil outlet pressure instrumentation failure post APU start. If these parameters are normal, LCC violation cleared, continue countdown. (Reference LCC SSIDs APU-08 and APU-12.)

V46T0150A APU 1 Gearbox Lube Oil Return Temp
V46T0250A APU 2 Gearbox Lube Oil Return Temp
V46T0350A APU 3 Gearbox Lube Oil Return Temp
V46T0154A APU 1 Gearbox Lube Oil Out Temp
V46T0254A APU 2 Gearbox Lube Oil Out Temp
V46T0354A APU 3 Gearbox Lube Oil Out Temp
V46T0161A APU 1 Gearbox Bearing Temp No 1
V46T0261A APU 2 Gearbox Bearing Temp No 1
V46T0361A APU 3 Gearbox Bearing Temp No 1
V46T0162A APU 1 Gearbox Bearing Temp No 2
V46T0262A APU 2 Gearbox Bearing Temp No 2
V46T0362A APU 3 Gearbox Bearing Temp No 2

(6) If gearbox pressure decreases below 4.2 psia and then starts to increase with a corresponding decrease in the GN2 bottle pressure, LCC violation cleared, continue countdown. If not, LCC violation confirmed, No Go for launch.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(7) Minimum and Maximum: Redline required to ensure proper lubrication system operation.

(8) Redline Development:	Min (V46P0n51A)	Max (V46P0n53A)
Basic Redline	5.3	120
Instrumentation error	-1.1	-7
Redline limits	4.2	113

(9) 20 psid min is to ensure adequate lube oil flow for cooling. Gearbox Lube Oil Out Pressures can drop below the minimum redline during APU start.

(10) Gearbox GN2 pressure (V46P0151A, V46P0251A, V46P0351A) is required for activation of gearbox repress valve. The gearbox GN2 repress valve will activate during an APU Start or Run if the gearbox pressure decreases below 5.35 +/- 0.9 psia. Once activated, the GN2 repress valve will deactivate when gearbox pressure increases above 9.22 psia. The basic redline of 5.3 psia is based on nominal APU/CONTROLLER gearbox GN2 repressurization valve circuit activation pressure. Lube oil outlet pressure is used to detect lube oil pump failure, blockage of filter, or failure of bypass valve.

(11) Instrumentation error for gearbox GN2 pressure is the error between the controller and the V46P0n51A downlinked measurement.

(12) The 30 psia maximum limit for V46P0n51A is the highest value that can be indicated by these FDs and represents the maximum limit for normal gearbox GN2 pressure.

CONSEQUENCES OF EXCEEDING REDLINE:

(13) Minimum and Maximum: Inadequate lubrication and cooling of gearbox potentially leading to loss of APU.

CAUSES OF EXCEEDING REDLINE:

(14) Gearbox GN2 Pressure:
- Minimum:
  - A. Failed transducer or signal conditioner in controller.
  - B. External GN2 or lube oil leak.
- Maximum:
  - A. Contamination in lube oil.
  - B. Failed GN2 repress valve.
  - C. Failed transducer or signal conditioner in controller.

(15) Lube Oil Outlet Pressure:
- Minimum:
  - A. Improper lube pump operation.
  - B. Excessive ullage.
  - C. Transducer failure.
  - D. External GN2 or lube oil leak.
- Maximum:
  - A. Contamination in lube oil.
  - B. Plugged filter.
  - C. Failed filter bypass valve.
  - D. Failed GN2 repress valve.
  - E. Transducer failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR APU 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
V46P0n51A	0.12	0	30						
V46P0n53A	0.8	0	200					25	150

METER/DISPLAY RANGE - MSID: V46T0n50A LOW: 0 HIGH: 500

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 12.1	SHEET 2	ZONE F2,G2
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-946099	SHEET 9	ZONE 3B,4C,
	DWG NO	SHEET	ZONE 5D
	DWG NO VS70-946102	SHEET 9	ZONE 3B,4C,
	DWG NO	SHEET	ZONE 5D

ELEMENT: Orbiter SUBSYSTEM: APU

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LCC VIOLATION CALL: APU Bearing Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V46T0161A	APU 1 Gearbox Bearing Temp No 1		NA	289	deg F	CI
V46T0162A	APU 1 Gearbox Bearing Temp No 2		NA	289	deg F	CI
V46T0261A	APU 2 Gearbox Bearing Temp No 1		NA	289	deg F	CI
V46T0262A	APU 2 Gearbox Bearing Temp No 2		NA	289	deg F	CI
V46T0361A	APU 3 Gearbox Bearing Temp No 1		NA	289	deg F	CI
V46T0362A	APU 3 Gearbox Bearing Temp No 2		NA	289	deg F	CI

TIME PERIOD:

(1) From APU Start (T-5 minutes) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 measurements per APU acceptable for confirmed instrumentation failure (3).

PREPLANNED CONTINGENCY PROCEDURE:

(3) Instrumentation failure is confirmed for a measurement indicating off scale high or low, exhibiting a step function change, or functioning erratically. The following measurements are used to confirm APU gearbox bearing temperature instrumentation failure post APU start. If these parameters are normal, LCC violation cleared, continue countdown (Reference LCC SSIDs APU-06, APU-08 and APU-11).

V46R0135A APU 1 Turbine Speed
V46R0235A APU 2 Turbine Speed
V46R0335A APU 3 Turbine Speed
V46T0150A APU 1 Gearbox Lube Oil Return Temp
V46T0250A APU 2 Gearbox Lube Oil Return Temp
V46T0350A APU 3 Gearbox Lube Oil Return Temp
V46T0154A APU 1 Gearbox Lube Oil Out Temp
V46T0254A APU 2 Gearbox Lube Oil Out Temp
V46T0354A APU 3 Gearbox Lube Oil Out Temp
V46P0153A APU 1 Gearbox Lube Oil Out Press
V46P0253A APU 2 Gearbox Lube Oil Out Press
V46P0353A APU 3 Gearbox Lube Oil Out Press

NOTES:

(4) Previous experience (STS-61C) 11-minute APU run was 286 degrees F.

REDLINE DERIVATION: CRITICALITY: 1R

(5) Maximum: Redline verifies proper operation of gearbox cooling and lube system.

(6) Redline development: Max (V46T0n61A, V46T0n62A)

Basic Redline	300
Instrumentation error	-11
Redline limits	289

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Maximum: Violation of the redline results in potential bearing failure.

CAUSES OF EXCEEDING REDLINE:

(8) Maximum: A. Lube oil pump failed.
B. Bearing failure.
C. Overfill of lube oil system.
D. Underfill of lube oil system.
E. Plugged or partially plugged lubrication orifice.
F. Water Spray Boiler Malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR APU 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.F								
V46T0n61A	2.0	-3.14	496.8						
V46T0n62A	2.0	-3.14	496.8						

METER/DISPLAY RANGE - MSID: V46T0n50A LOW: 0 HIGH: 500

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 12.1	SHEET 2	ZONE H3,I3
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-946099	SHEET 9	ZONE 3B,4C,
	DWG NO	SHEET	ZONE 5D
	DWG NO VS70-946102	SHEET 9	ZONE 3B,4C,
	DWG NO	SHEET	ZONE 5D

ELEMENT: Orbiter SUBSYSTEM: APU

LCC VIOLATION CALL: APU GN2 Bottle Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V46P0152A	APU 1 GN2 Bottle Press		115 (3)	NA	psia	CI
V46P0252A	APU 2 GN2 Bottle Press		115 (3)	NA	psia	CI
V46P0352A	APU 3 GN2 Bottle Press		115 (3)	NA	psia	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Loss of measurement is acceptable for confirmed instrumentation failure.(4)
(3) Monitor to assure no leaks. A pressure decrease of 2 data bits or more without a corresponding temperature change indicates a potential leak. (5)

PREPLANNED CONTINGENCY PROCEDURE:

(4) Instrumentation failure is confirmed for a measurement indicating off scale high or low, exhibiting a step function change, or functioning erratically. For confirmed instrumentation failure, LCC violation cleared, continue countdown.
(5) For indicated pressure leak, check applicable Gearbox Bearing Temperatures (see table below). (Ref S0007 VL 5)
- If temperatures track with pressure changes, LCC violation cleared, continue countdown.
- If pressure decreases by 2 data bits or more without a corresponding temperature change, this indicates a potential leak, LCC violation confirmed, No Go for launch.

APU	Gearbox Bearing Temp No 1	Gearbox Bearing Temp No 2
1	V46T0161A	V46T0162A
2	V46T0261A	V46T0262A
3	V46T0361A	V46T0362A

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(6) Minimum: Measurement verifies sufficient GN2 for gearbox repressurization a minimum of two times.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Minimum: Insufficient GN2 for gearbox repressurization for on-orbit operations.

CAUSES OF EXCEEDING REDLINE:

(8) Minimum: A. GN2 bottle leak (fill QD).
B. GN2 repress valve leak.
C. Instrumentation failed low.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR APU 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
V46P0n52A	1.2	0	300						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 12.1 SHEET 2 ZONE I1
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-946099 SHEET 9 ZONE G7
DWG NO VS70-946102 SHEET 9 ZONE G7

ELEMENT: Orbiter SUBSYSTEM: APU

LCC VIOLATION CALL: APU Fuel Test Line Temperature Anomaly | EMERG COND: Yellow (14)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V46T0183A	APU 1 Fuel Test Line Temp 1		45 (5)	95(3,4)	deg F	CI
V46T0184A	APU 1 Fuel Service Line Temp		45 (5)	105(3,4	deg F	CI
V46T0283A	APU 2 Fuel Test Line Temp 1		45 (5)	95(3,4)	deg F	CI
V46T0284A	APU 2 Fuel Service Line Temp		45 (5)	105(3,4	deg F	CI
V46T0383A	APU 3 Fuel Test Line Temp 1		45 (5)	95(3,4)	deg F	CI
V46T0384A	APU 3 Fuel Service Line Temp		45 (5)	105(3,4	deg F	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 measurements per APU acceptable for confirmed instrumentation failure. (6)
(3) Violation of maximum redline, not exceeding purge gas temperature, is acceptable from Start of ET Cryo Tanking until temperature first decreases into the heater control range.
(4) Heater must not be Failed ON (as indicated by unexplained upward trending temperatures).
(5) Heater Failed OFF (as indicated by unexplained downward trending temperatures) requires evaluation. (7)

PREPLANNED CONTINGENCY PROCEDURE:

(6) Instrumentation failure is confirmed for a measurement indicating off scale high or low, exhibiting a step function change, or functioning erratically. For confirmed instrumentation failure, LCC violation cleared, continue countdown.
(7) Heater Failed OFF: (Ref S0007 VL 5)
A. Remove power from heaters by ground command.
B. Use cockpit switches to verify function of suspect heater A or B.
- If functional, use the cockpit switch to turn the heater OFF and configure to the alternate heater utilizing ground command; LCC violation cleared, continue countdown.
- If not functional, confirmed heater failure, LCC violation confirmed, no go for launch.

Panel A12 APU HEATER **
TANK/FUEL LINE/H2O SYS 1A sw - OFF/AUTO
TANK/FUEL LINE/H2O SYS 1B sw - OFF/AUTO
TANK/FUEL LINE/H2O SYS 2A sw - OFF/AUTO
TANK/FUEL LINE/H2O SYS 2B sw - OFF/AUTO
TANK/FUEL LINE/H2O SYS 3A sw - OFF/AUTO
TANK/FUEL LINE/H2O SYS 3B sw - OFF/AUTO
** Switches may not be accessible after hatch closure.

NOTES:

(8) A heater failed ON cannot be caused by a ground failure since the ground only activates the control circuit. For a Heater Failed ON, switch to backup heater for safing.
(9) V46T0183A and 0184A Monitor Heaters 116 and 117 on APU System 1.
V46T0283A and 0284A Monitor Heaters 126 and 127 on APU System 2.
V46T0383A and 0384A Monitor Heaters 136 and 137 on APU System 3.

REDLINE DERIVATION: CRITICALITY: 1R

(10) Minimum: To detect a failed OFF heater system.
(11) Maximum: To detect a failed ON heater system (may not be detectable due to the heater duty cycles which may be 100 percent after cryogenic loading).

(12)

Redline development:	(V46T0n83A) Min	(V46T0n83A) Max	(V46T0n84A) Min	(V46T0n84A) Max
Thermostat setting	50	70	50	70
Location delta	0	+20	0	+30
Instrumentation error	-5	+5	-5	+5
Redline limits	45	95	45	105

CONSEQUENCES OF EXCEEDING REDLINE:

(13) Minimum: Hydrazine (N2H4) leak or line rupture with greater than one freeze/thaw cycle.
(14) Maximum: Potential hydrazine (N2H4) decomposition/detonation.

CAUSES OF EXCEEDING REDLINE:

(15) Minimum: Failed OFF heater thermostat or driver.
(16) Maximum: Failed ON heater thermostat or driver.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR APU 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.F								
V46T0n83A	.9997	-.7958	249.1					45	110
V46T0n84A	.9997	-.7958	249.1					45	150

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 12.1	SHEET 2	ZONE S2,U2
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-946099	SHEET 9	ZONE C15,D15
	DWG NO VS70-946102	SHEET 9	ZONE C15,D15

ELEMENT: Orbiter SUBSYSTEM: APU

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LCC VIOLATION CALL: APU Fuel Pump Drain Line Temperature Anomaly | EMERG COND: Yellow (17)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V46T0186A	APU 1 Fuel Pump Drain Line Temp 1		42 (5)	90(3,4)	deg F	CI
V46T0170A	APU 1 F/P Drn Ln Temp 2		42 (5)	90(3,4)	deg F	CI
V46T0286A	APU 2 Fuel Pump Drain Line Temp 1		42 (5)	90(3,4)	deg F	CI
V46T0270A	APU 2 F/P Drn Ln Temp 2		42 (5)	120 (4)	deg F	CI
V46T0386A	APU 3 Fuel Pump Drain Line Temp 1		42 (5)	90(3,4)	deg F	CI
V46T0370A	APU 3 F/P Drn Ln Temp 2		42 (5)	90(3,4)	deg F	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 measurements per APU acceptable for confirmed instrumentation failure. (6)
(3) Violation of maximum redline, not exceeding purge gas temperature, is acceptable from Start of ET Cryo Tanking until temperature first decreases into the heater control range.
(4) Heater must not be Failed ON (as indicated by unexplained upward trending temperatures).
(5) Heater Failed OFF (as indicated by unexplained downward trending temperatures) requires evaluation. (7)

PREPLANNED CONTINGENCY PROCEDURE:

(6) Instrumentation failure is confirmed for a measurement indicating off scale high or low, exhibiting a step function change, or functioning erratically. For confirmed instrumentation failure, LCC violation cleared, continue countdown.
(7) Heater Failed OFF: (Ref S0007 VL 5)
A. Remove power from heaters by ground command.
B. Use cockpit switch to verify function of suspect heater A or B.
- If functional, use the cockpit switch to turn the heater OFF and configure to the alternate heater utilizing ground command; LCC violation cleared, continue countdown.
- If not functional, confirmed heater failure, LCC violation confirmed, no go for launch.

Panel A12 APU HEATER **
TANK/FUEL LINE/H2O SYS 1A sw - OFF/AUTO
TANK/FUEL LINE/H2O SYS 1B sw - OFF/AUTO
TANK/FUEL LINE/H2O SYS 2A sw - OFF/AUTO
TANK/FUEL LINE/H2O SYS 2B sw - OFF/AUTO
TANK/FUEL LINE/H2O SYS 3A sw - OFF/AUTO
TANK/FUEL LINE/H2O SYS 3B sw - OFF/AUTO
** Switches may not be accessible after hatch closure.

NOTES:

(8) A heater failed ON cannot be caused by a ground failure since the ground only activates the control circuit. For a Heater Failed ON, switch to backup heater for safing.
(9) V46T0186A and V46T0170A Monitor heaters 111 and 112 on APU System 1. V46T0286A and V46T0270A Monitor heaters 121 and 122 on APU System 2. V46T0386A and V46T0370A Monitor heater 131 on APU System 3.
(10) The Fault Detection and Annunciation (FDA) limits may be exceeded prior to the LCC violation.

REDLINE DERIVATION: CRITICALITY: 1R

(11) Minimum: To detect a failed OFF heater system.
(12) Maximum: To detect a failed ON heater system.
(13) Redline Development:

	V46T0n86A		V46T0170A,V46T0370A		V46T0270A	
	Min	Max	Min	Max	Min	Max
Thermostat setting	50	70	50	70	50	70
Location delta	-3	+15	-3	+16	-3	+45
Instrumentation error	-5	+5	-5	+4	-5	+5
Redline limits	42	90	42	90	42	120

(14) V46T0170A and V46T0370A are at midspan.
(15) V46T0270A is at support away from thermostat.
(16) V46T0270A location delta is due to temperature sensor proximity to APU-1 and may be affected by APU-1 temp.

CONSEQUENCES OF EXCEEDING REDLINE:

(17) Minimum: Hydrazine (N2H4) leak or line rupture with greater than one freeze/thaw cycle.
(18) Maximum: Potential hydrazine (N2H4) decomposition/detonation.

CAUSES OF EXCEEDING REDLINE:

(19) Minimum: Failed OFF heater thermostat or driver.
(20) Maximum: Failed ON heater thermostat or driver.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR APU 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.F								
V46T0n86A	.9997	-.7958	249.1					43	95
V46T0170A	.9997	-.7958	249.1					43	140
V46T0270A	.9997	-.7958	249.1					48	195
V46T0370A	.9997	-.7958	249.1					43	140

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 12.1	SHEET 2	ZONE N1,P1
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-946099	SHEET 9	ZONE D13
	DWG NO VS70-946102	SHEET 9	ZONE D13

ELEMENT: Orbiter SUBSYSTEM: APU

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LCC VIOLATION CALL: APU Fuel Pump Drain Line Pressure | EMERG COND: Yellow (9)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V46P0190A	APU 1 Fuel Pump Drain Line Press 1	1 of	NA	26 (2)	psia	CI
V46P0191A	APU 1 Fuel Pump Drain Line Press 2	2	NA	26 (2)	psia	CI
V46P0290A	APU 2 Fuel Pump Drain Line Press 1	1 of	NA	26 (2)	psia	CI
V46P0291A	APU 2 Fuel Pump Drain Line Press 2	2	NA	26 (2)	psia	CI
V46P0390A	APU 3 Fuel Pump Drain Line Press 1	1 of	NA	26 (2)	psia	CI
V46P0391A	APU 3 Fuel Pump Drain Line Press 2	2	NA	26 (2)	psia	CI

TIME PERIOD:

(1) From APU Isolation Valve Open (T-6 minutes) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) While the APU is running, the maximum allowable rate of pressure increase is 0.6 psi/minute.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) A gross fuel leakage may result in a temperature increase as well as a pressure increase in the remaining sensor. If warm fuel leaks into seal cavity drain system, the alternate measurement (as shown below) will increase in temperature due to contact with fuel. Drain system temperature is typically low during launch countdown, but above the thermostat set point, therefore, there is no heater cycling.

Alternate Measurements:

APU	F/P DRAIN LINE TEMP 1	F/P DRAIN LINE TEMP 2
1	V46T0186A1	V46T0170A1
2	V46T0286A1	V46T0270A1
3	V46T0386A1	V46T0370A1

(4) Fault Detection and Annunciation (FDA) may be violated prior to reaching LCC limit.

REDLINE DERIVATION: CRITICALITY: 1R

(5) Maximum: The 26-psia redline ensures against gross fuel pump leakage (24 cc/min).

REDLINE DERIVATION: (Continued)

(6) Redline development: Max (V46P0n90A, V46P0n91A)

Basic redline	28
Instrumentation error	-2
Redline limit	26

(7) Assures leak rate will not increase pressure to burst disk rupture prior to MECO.

(8) The 0.6 psi/min. pressure rise rate will allow monitoring leakage for extended APU runs (hold time) and avoids burst disk rupture prior to MECO.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Maximum: Launch with defective fuel pump seal resulting in possible dumping of hydrazine overboard.

CAUSES OF EXCEEDING REDLINE:

(10) Maximum: APU Fuel Pump seal failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR APU 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
V46P0n90A	0.2	0	50						25
V46P0n91A	0.2	0	50						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 12.1	SHEET 2	ZONE P1
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-946099	SHEET 9	ZONE C13
	DWG NO VS70-946102	SHEET 9	ZONE C13

ELEMENT: Orbiter SUBSYSTEM: APU

APU Pump Water Tank Pressures

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LCC VIOLATION CALL: APU Fuel Valve/Fuel Pump Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V46T0112A	APU 1 Fuel Pump Discharge Temp		NA	NA	deg F	CI
V46T0192A	APU 1 Fuel Pump Temp		NA	NA	deg F	CI
V46T1172A	APU 1 GGVM Heat Sink Temperature		NA	NA	deg F	CI
V46T0212A	APU 2 Fuel Pump Discharge Temp		NA	NA	deg F	CI
V46T0292A	APU 2 Fuel Pump Temp		NA	NA	deg F	CI
V46T1272A	APU 2 GGVM Heat Sink Temperature		NA	NA	deg F	CI
V46T0312A	APU 3 Fuel Pump Discharge Temp		NA	NA	deg F	CI
V46T0392A	APU 3 Fuel Pump Temp		NA	NA	deg F	CI
V46T1372A	APU 3 GGVM Heat Sink Temperature		NA	NA	deg F	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 3 measurements per APU acceptable for confirmed instrumentation failure. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Instrumentation failure is confirmed for a measurement indicating off scale high or low, exhibiting a step function change, functioning erratically, or not consistent with other APU temperatures. For confirmed instrumentation failure, LCC violation cleared, continue countdown.

NOTES:

(4) Requirement is used only to verify instrumentation function.

REDLINE DERIVATION: CRITICALITY: 1R

(5) To assure critical instrumentation is functional to give visibility during soakback.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Loss of capability to monitor soakback and restart limit.

CAUSES OF EXCEEDING REDLINE:

(7) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR APU 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.F								
V46T0n12A	.9997	-.7958	249.1					50	210
V46T1n72A	.9997	-.7958	249.1						
V46T0n92A	.9997	-.7958	249.1						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 12.1 SHEET 2 ZONE M2,N2
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-946099 SHEET 9 ZONE E10,F11
DWG NO VS70-946102 SHEET 9 ZONE E10,F11

ELEMENT: Orbiter SUBSYSTEM: APU

Injector Cooling System Heater Anomaly

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LCC VIOLATION CALL: Injector Cooling System Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V46P0504A	APU H2O Tank Pressure		73 (3)	NA	psia	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) Loss of measurement is acceptable for confirmed instrumentation failure.(4)
(3) Monitor to assure no leaks. A pressure decrease of 2 data bits or more without a corresponding temperature change indicates a potential leak. (5)

PREPLANNED CONTINGENCY PROCEDURE:

(4) Instrumentation failure is confirmed for a measurement indicating off scale high or low, exhibiting a step function change, or functioning erratically. For confirmed instrumentation failure, LCC violation cleared, continue countdown.
(5) For indicated pressure leak, check APU H2O Tank Temp (V46T0500A), and APU Injector H2O Line Temps (V46T0501A, V46T0502A, and V46T0503A). (Ref S0007 VL 5)
- If temperature(s) track with pressure changes, LCC violation cleared, continue countdown.
- If pressure decreases by 2 data bits or more without a corresponding temperature change, this indicates a potential leak, LCC violation confirmed, No Go for launch.

NOTES:

(6) System is Criticality 1 for contingency hot restart.

REDLINE DERIVATION: CRITICALITY: 3

(7) Minimum: Redline limit assures sufficient pressure for minimum of three hot restarts after launch.
(8) Redline development:

	Min (V46P0504A)
Basic redline	66
Instrumentation error	+7
Redline limit	73

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Minimum: Insufficient pressure to provide for a minimum of three hot restarts (1 for each APU) 209 seconds water delivery. (On-orbit.)

CAUSES OF EXCEEDING REDLINE:

(10) Minimum: Leakage at tank, QD or water valves.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	psia								
V46P0504A	0.8	0	200						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 12.1	SHEET 1	ZONE G2
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-946099	SHEET 9	ZONE B18
	DWG NO VS70-946102	SHEET 9	ZONE B18

ELEMENT: Orbiter SUBSYSTEM: APU

APU Fuel Isolation Valve Temperature Anomaly

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LCC VIOLATION CALL: Hot Restart Temperature Anomaly | EMERG COND: Yellow (10)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V46T0174A	APU 1 Inj Tube Temp	(4)	NA	382(3)	deg F	CI
V46T0274A	APU 2 Inj Tube Temp	(4)	NA	382(3)	deg F	CI
V46T0374A	APU 3 Inj Tube Temp	(4)	NA	382(3)	deg F	CI
V46P0504A	APU H2O Tank Pressure	(4)	NA	(7)	psia	BU
V46T0112A	APU 1 Fuel Pump Discharge Temp	(2)	NA	204(5)	deg F	CI
V46T0192A	APU 1 Fuel Pump Temp	(2)	NA	204(5)	deg F	CI
V46T1172A	APU 1 GGVM Heat Sink Temperature	(2)	NA	187(5)	deg F	CI
V46T0212A	APU 2 Fuel Pump Discharge Temp	(2)	NA	204(5)	deg F	CI
V46T0292A	APU 2 Fuel Pump Temp	(2)	NA	204(5)	deg F	CI
V46T1272A	APU 2 GGVM Heat Sink Temperature	(2)	NA	187(5)	deg F	CI
V46T0312A	APU 3 Fuel Pump Discharge Temp	(2)	NA	204(5)	deg F	CI
V46T0392A	APU 3 Fuel Pump Temp	(2)	NA	204(5)	deg F	CI
V46T1372A	APU 3 GGVM Heat Sink Temperature	(2)	NA	187(5)	deg F	CI

TIME PERIOD:

(1) From Recycle to APU Hot Restart (T-5 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 3 measurements per APU acceptable for confirmed instrumentation failure. (5)

(3) A. If no injector cooling is used, injector tube temperature must be below maximum for APU restart.
B. If injector cooling is used, injector tube temperature does not have to be below maximum for APU hot restart, but must be verified as decreasing during water flow. (6)

(4) APU H2O Tank Pressure can be used as a backup for any failed APU Injector Tube Temperature measurement. Measurement failure is confirmed for a measurement indicating off scale high or low, exhibiting a step function change, or functioning erratically. (7)

PREPLANNED CONTINGENCY PROCEDURE:

(5) Instrumentation failure is confirmed for a measurement indicating off scale high or low, exhibiting a step function change, or functioning erratically. For confirmed instrumentation failure, LCC violation cleared, continue countdown.

(6) Injector tube cooling requires 209 seconds of water flow prior to restarting a hot APU. The APU restart must be initiated immediately (within 1 second) after termination of water flow. If Injector Tube Temperature decreases during water flow, LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

(7) If an Injector Tube Temperature sensor fails on any APU, initiate water cooling on that APU first for a minimum of 30 seconds to verify V46P0504A pressure decay, then start injector water flow to the remaining APUs prior to restart. If H2O Tank Pressure decreases during water flow, LCC violation cleared, continue countdown.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(8) Redline Development:	Max	Max	Max
Measurement - V46T	0n74A	0n12A/0n92A	1n72A
Basic Redline	415	210	200
Uncertainty	0	0	-7
Instrumentation Error	-33	-6	-6
Redline (deg F)	382	204	187

(9) Maximum: Redlines derived to ensure safe hot restart.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Maximum: Possible detonation of hydrazine (N2H4) within gas generator, creating potential for N2H4 leakage in aft compartment.

CAUSES OF EXCEEDING REDLINE:

(11) Maximum: Inadequate injector cooling.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR APU 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.F								
V46T0n74A	6.05	7.96	1520					258	
V46T0n12A	.9997	-.7958	249.1					50	210
V46T1n72A	.9997	-.7958	249.1						
V46T0n92A	.9997	-.7958	249.1						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 12.1	SHEET 2	ZONE L1,M2,
	DWG NO	SHEET	ZONE N2
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-946099	SHEET 9	ZONE E10,E11
	DWG NO VS70-946099	SHEET 9	ZONE B19
	DWG NO VS70-946102	SHEET 9	ZONE E10,E11
	DWG NO VS70-946102	SHEET 9	ZONE B19

ELEMENT: Orbiter SUBSYSTEM: APU

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LCC VIOLATION CALL: APU Fuel Tank Isolation Valve Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V46X0115E	APU 1 Fuel Isln Vlv A Open/Pwr On		ON	NA	Event	CI
V46X0134E	APU 1 Fuel Isln Vlv B Open/Pwr On		ON	NA	Event	CI
V46X0215E	APU 2 Fuel Isln Vlv A Open/Pwr On		ON	NA	Event	CI
V46X0234E	APU 2 Fuel Isln Vlv B Open/Pwr On		ON	NA	Event	CI
V46X0315E	APU 3 Fuel Isln Vlv A Open/Pwr On		ON	NA	Event	CI
V46X0334E	APU 3 Fuel Isln Vlv B Open/Pwr On		ON	NA	Event	CI

TIME PERIOD:

(1) From APU Pre-Start (T-6 minutes) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Loss of measurement is acceptable for confirmed instrumentation failure. (3,4)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Prior to APU Start: (Ref S0007 VL 5)
- If one or both valve(s) indicate close (unpowered), have PLT cycle Fuel Iso Valve switch (CLOSED/OPEN).
  - If problem clears, perform APU start, LCC violation cleared, continue countdown.
  - If problem does not clear, perform APU start and continue with contingency procedure. (4)

(4) After APU Start: (Ref S0007 VL 5)
- If one valve indicates closed (unpowered): Open appropriate circuit breaker on the "good" valve.
  - If no shutdown occurs, close circuit breaker (re-opening the "good" valve). Instrumentation failure is confirmed; LCC violation cleared, continue countdown.
  - If shutdown occurs, position APU OPERATE switch to OFF, close the fuel tank valve switch and power down the controller. Valve is failed; LCC violation confirmed, No Go for launch.
- If both valves indicate closed: Open one of the two applicable Valve Enable circuit breakers, then reset to CLOSE. Open the remaining circuit breaker.
  - If no shutdown occurs, close the remaining circuit breaker. Instrumentation failure is confirmed; LCC violation cleared, continue countdown.
  - If shutdown occurs, position APU OPERATE switch to OFF, close the fuel tank valve switch and power down the controller. Valve is failed; LCC violation confirmed, No Go for launch.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(5) Minimum: Both fuel tank isolation valves in a system must be functional to maintain redundancy.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Minimum: A. Both valves indicate closed (unpowered) - no APU ready indication, APU will not start.
B. One valve indicates closed (unpowered) - APU will start but failure of other valve will result in loss of APU.

CAUSES OF EXCEEDING REDLINE:

(7) Minimum: A. Switch failure.
B. Valve failure.
C. Instrumentation failure.
D. Driver failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 12.1	SHEET 2	ZONE U4
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-946099	SHEET 10	ZONE C8,G7
	DWG NO VS70-946102	SHEET 10	ZONE C8,G7

ELEMENT: Orbiter SUBSYSTEM: APU

LCC VIOLATION CALL: PCA APU Controller RPC Power ON Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76X4001E	PCA APU Controller 1 RPC A ON		ON(4)	NA	Event	CI
V76X4002E	PCA APU Controller 1 RPC B ON		ON(3,5)	NA	Event	CI
V76X4004E	PCA APU Controller 2 RPC B ON		ON(4)	NA	Event	CI
V76X4005E	PCA APU Controller 2 RPC C ON		ON(3,5)	NA	Event	CI
V76X4007E	PCA APU Controller 3 RPC A ON		ON(3,5)	NA	Event	CI
V76X4008E	PCA APU Controller 3 RPC C ON		ON(4)	NA	Event	CI

TIME PERIOD:

(1) From completion of APU Pre-Start (approximately T-6 minutes) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) A PCA APU Controller RPC power ON anomaly is acceptable provided instrumentation failure can be confirmed. If the anomaly is identified during APU Pre-Start, then instrumentation failure must be confirmed prior to APU Start.

PREPLANNED CONTINGENCY PROCEDURE:

(3) For Controller side B PCA APU Controller RPC indicating OFF (V76X4002E, 4005E or 4007E) after APU Pre-Start but before APU Start:
- Close Fuel Isolation Valves, perform Auto BIT test, and Re-open Fuel Isolation Valves.
- If BIT test is successful, RPC instrumentation failure is confirmed, LCC violation cleared, continue countdown.

(4) For Controller side A PCA APU Controller RPC indicating OFF (V76X4001E, 4004E, or 4008E) before or after APU Start, remove Ground GG/Fuel Pump Heater power and monitor Gearbox GN2 Pressure (V46P0n51A, where n=APU 1,2 or 3). If Gearbox GN2 Pressure indicates greater than 0 psia (ref. SSID APU-11), RPC instrumentation failure is confirmed, LCC violation cleared, continue countdown.

(5) For Controller side B PCA APU Controller RPC indicating OFF (V76X4002E, 4005E, or 4007E) after APU Start, monitor APU Turbine Speed (V46R0n35A, where n=APU 1,2 or 3) with affected APU running (ref. SSID: APU-06). If affected APU Turbine Speed indicates greater than 0 pct, RPC instrumentation failure is confirmed, LCC violation cleared, continue countdown.

NOTES:

(6) Measurement nomenclature for each RPC is associated with the main bus power source and not the A/B side of the APU Controller. The Space Shuttle Systems Handbook uses A/B nomenclature for the RPCs to reflect the side of the controller being powered by the RPC.

REDLINE DERIVATION: CRITICALITY: 1R

(7) a. SSID Intent Summary - The intent of this SSID is to ensure that both redundant power inputs to the controller are present prior to and after APU start until T-31 seconds, to ensure integrity of critical APU speed control circuitry. Redundant speed control circuitry within the APU controller ensures that a single speed sensor or controller component failure does not result in loss of critical APU speed control functionality. The system is single fault tolerant. If redundant controller power inputs were not protected by this SSID, loss of redundant power would result in operation of an APU without critical speed control redundancy. This could lead to an additional failure resulting in APU shutdown during ascent or descent flight modes, affecting main engine throttle control or landing gear deploy functions. The PCA APU Controller RPC power on indication is not mandatory for full controller functionality, therefore instrumentation failure of a PCA APU Controller RPC power indication is acceptable before or after APU start, provided the presence of the power inputs into the controller can be verified by confirming downstream functionality.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - The minimum requirement that both APU controller V76X400nE PCA APU Controller RPC indications are ON ensures that the APU controller is being provided with redundant power inputs from the orbiter main electrical busses. No maximum redline is required for these discrete measurements.

d. Time Period - APU Controller power is OFF prior to performance of APU Pre-Start at approximately T-6 minutes 15 seconds, thus redundant power inputs to the controller can not be verified. After APU Pre-Start has been performed, both V76X400nE PCA APU Controller RPC measurements should indicate ON for each controller. These measurements are indications that the APU controller is receiving redundant power from the orbiter main electrical busses prior to starting the APU at T-5 minutes. If redundant power to the controller cannot be verified, then proceeding to APU Start results in increased risk due to operation of the APU without redundant speed control functions.

The ending time period of T-31 seconds was selected because by this milestone the APU controller has been configured and active for sufficient time to verify it is functionally stable.

e. Requirements - Instrumentation failure (OFF) of a PCA APU Controller RPC A, B, or C indication is an acceptable condition, both before and after APU Start, provided instrumentation failure can be confirmed by verification of the power input to the controller through secondary means. Should an APU-24 violation occur prior to APU Start that cannot be confirmed as instrumentation failure, proceeding through APU Start is not allowed due to the increased risk of potentially operating an APU without redundant speed control. Operation of an APU without redundant speed control will not lead to APU or controller damage.

REDLINE DERIVATION: (Continued)

f. Preplanned Contingency Procedures - PCP (3) may be performed prior to APU Start for Controller side B PCA APU Controller RPC A, B, or C indicating OFF. Performance of the APU Controller BIT Test will screen for Controller side B power input failures; if the B side power input is not present, the BIT GO indication will remain OFF during the duration of the test (approx. 30s). The fuel tank isolation valves for the affected APU are closed by crew action prior to performance of the BIT test to preclude their being latched closed as a result of a BIT Test induced APU overspeed indication; after the BIT test is complete the isolation valves are re-opened. C&W alarms for underspeed and overspeed will occur as a result of a successful BIT Test.

PCP (4) may be performed before or after APU Start for any APU Controller side A PCA APU Controller RPC A, B, or C indicating OFF. Determining the status of the A side power input, before or after APU Start, requires removal of the APU Gas generator/Fuel Pump/Line Heater A or B ground power commands (the A heater is normal launch configuration per V46AL0.900). The Controller's internal power supply C can be powered from the APU Controller A side power input and from the APU Gas Generator/Fuel Pump/Line Heater A or B logic power inputs to the Controller. Power supply C provides power to the APU Gearbox GN2 Pressure (V46P0n51A) and Gas Generator Bed Temperature (V46T0x22A) signal conditioners. Before the APU Start command is issued, if the heater ground commands are OFF, any valid indication from the V46P0n51A sensor proves the Controller is receiving power from the Controller A side power input and instrumentation failure of the PCA APU Controller RPC measurement is confirmed.

After APU Start, under nominal conditions, the presence of the APU Start command will result in a Command All Heaters OFF signal being output from the Controller, which in turn will disable the APU heater circuitry in the associated AFT LCA, thus turning off the heaters and removing the heater power inputs to the Controller Power Supply C. In the case of a true failure of the PCA APU Controller RPC, the absence of APU Controller side A power will prevent the Start command from being able to deactivate the heater power circuits. Under these conditions, APU Gearbox GN2 Pressure V46P0n51A and Gas Gen Bed Temp V46T0n22A indications will remain powered by the ground heater A power input. To screen for a Controller side A power failure after APU Start, it is necessary to remove the ground heater power command to determine instrumentation failure versus a failure of the RPC.

PCP (5) - For a failed OFF Controller side B power input occurring after APU Start, proper operation of APU Turbine Speed V46R0n35A can be used to confirm instrumentation failure of the side B PCA APU Controller RPC indication. The downlinked APU turbine speed indication V46R0n35A is generated from the APU Magnetic Pickup Unit 3 (MPU) signal from the APU. The Controller's MPU amplification and filtering circuitry that preprocesses the MPU 3 signal before it leaves the Controller relies on power from the Controller B side power input for operation; without power from the side B PCA APU Controller RPC, the MPU 3 signal from the Controller will indicate 0 percent speed (GOAL lower limit).

CONSEQUENCES OF EXCEEDING REDLINE:

(8) RPC failed OFF - APU will start but one failure away from loss of APU due to loss of speed control capability (RPC, MPU, driver).
(9) Reference Orbiter Hazard Reports ORBI 031 and ORBI 040.

CAUSES OF EXCEEDING REDLINE:

(10) Switch failure.
(11) RPC failure.
(12) Instrumentation failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 12.1	SHEET 2	ZONE Q8
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-946099	SHEET 7	ZONE G11,B12

ELEMENT: Orbiter SUBSYSTEM: APU

LCC VIOLATION CALL: APU Fuel Pump Inlet Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V46P0110A	APU 1 Fuel Pump Inlet Pressure		N/A	N/A	psia	CI
V46P0210A	APU 2 Fuel Pump Inlet Pressure		N/A	N/A	psia	CI
V46P0310A	APU 3 Fuel Pump Inlet Pressure		N/A	N/A	psia	CI

TIME PERIOD:

(1) From start of ET Cryo Tanking (T-6 hours) to Go for APU Start (T-5 minutes).

REQUIREMENTS: FIGURES/TABLES: N/A

(2) For confirmed instrumentation failure, LCC violation confirmed, No Go for Launch. Instrumentation failure is confirmed for a measurement indicating off scale high (600 psia) or low (0 psia), exhibiting a step function change, functions erratically, or does not react as expected to Fuel Isolation Valve (FIV) opening. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) (a) An off scale high indication due to heater cycling when the manifold is locked up at high pressure is acceptable. For a confirmed off scale high indication due to heater cycling, LCC violation cleared, continue countdown.
(b) A step function corresponding with opening of the FIV or FIV relief valve is acceptable. For a confirmed step function corresponding with opening of the FIV or FIV relief valve, LCC violation cleared, continue countdown.

NOTES:

(4) Requirement is only used to identify instrumentation failure of instrumentation necessary for safe APU starts.

REDLINE DERIVATION: CRITICALITY: 1

(5) a. SSID Intent Summary - Auxiliary Power Unit (APU) Fuel Pump Inlet Pressure (FPIP) measurement is necessary on-orbit to assess minimum redline for monitoring Adiabatic Bubble Compression Detonation (ABCD) risk and assess fuel leakage from manifold; both potentially criticality 1 failure modes. There is only one transducer measuring fuel manifold pressure downstream of the Fuel Isolation Valve (FIV).

b. Voting Logic - N/A.

c. Minimum and Maximum Redline Derivation - N/A

REDLINE DERIVATION: (Continued)

d. Time Period - Maximum surge on FPIP will occur while opening APU FIV, which normally occurs at T-6 minutes. FPIP becomes dynamic after APU Start at T-5 minutes. Monitoring the FPIP measurements between T-6 hours and T-5 minutes insures that all types of instrumentation failure are detectable.

e. Requirements - This requirement ensures that all three of the FPIP sensors and instrumentation paths for each of the three APU systems are functional in support of on-orbit APU start operations. This requirement provides the definition for instrumentation failure.

f. Preplanned Contingency Procedures - The PCP provides the definition for conditions which are acceptable but might otherwise be interpreted as instrumentation failures.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Loss of capability to monitor ABCD risk and to assess fuel leakage into aft.

CAUSES OF EXCEEDING REDLINE:

(7) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
X = 1, 2, AND 3 FOR APU 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
V46P0x10A	2.4	0	600						

METER/DISPLAY RANGE - MSID: LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 12.1 SHEET 2 ZONE O2
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS700-946099 SHEET 9 ZONE F13

ELEMENT: Orbiter SUBSYSTEM: APU

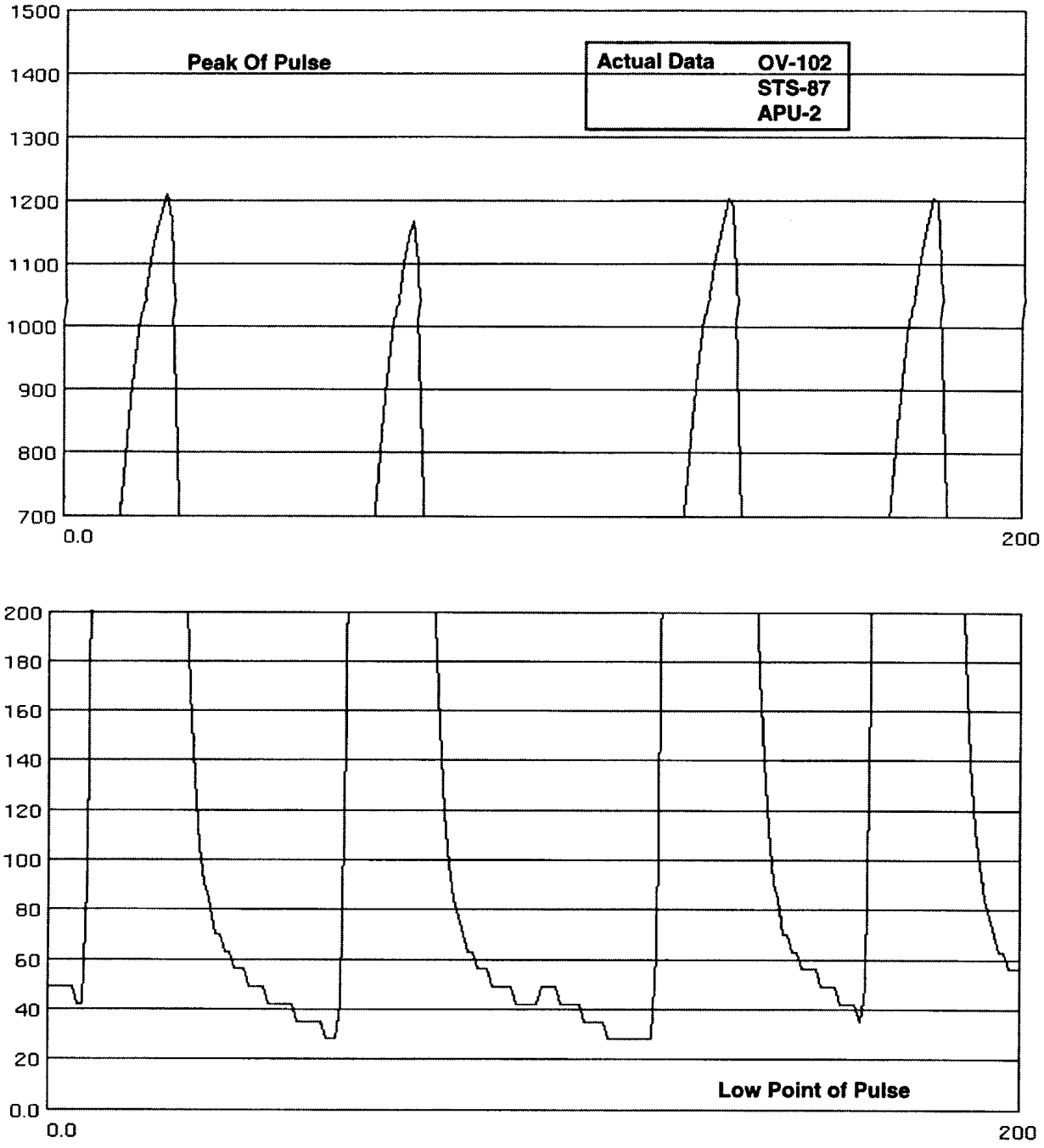

Figure 27-01 Typical APU Gas Generator Chamber Pressure Profile

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SECTION 28

HYDRAULICS

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SECTION 28: HYDRAULICS

SSID No.	Description/Violation Call	Page
HYD-01	Hydraulic System Reservoir Fluid Volume Anomaly	28-01.1
HYD-02	Hydraulic System Supply Pressure Anomaly	28-02.1
HYD-03	Hydraulic System Circulation Pump Pressure Anomaly	28-03.1
HYD-04	Hydraulic System Water Spray Boiler GN2 Tank Anomaly	28-04.1
HYD-05	Hydraulic System Water Spray Boiler Temperature Anomaly	28-05.1
HYD-06	Hydraulic System Water Spray Boiler Vent Temperatures (REQUIREMENT DELETED)	28-06.1
HYD-07	Hydraulic Accumulator/Reservoir Fluid Pressure Anomaly	28-07.1
HYD-08	Hydraulic System 1 Landing Gear Extend Isolation Valve Anomaly	28-08.1
HYD-09	PCA Hydraulic Pump RPC Anomaly	28-09.1
HYD-10	Hydraulic Water Spray Boiler OK Anomaly	28-10.1
HYD-FG01	Figure 28-01 Water Spray Boiler Nitrogen Storage Tank Pressure vs. Temperature	28-FG01.1

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LCC VIOLATION CALL: Hydraulic System Reservoir Fluid Volume Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V58Q0102A	Hydr Sys 1 Rsvr Fluid Volume	(3)	51(1)	NA	Pcnt	CI
			46(2)	NA	Pcnt	CI
V58Q0202A	Hydr Sys 2 Rsvr Fluid Volume	(3)	51(1)	NA	Pcnt	CI
			46(2)	NA	Pcnt	CI
V58Q0302A	Hydr Sys 3 Rsvr Fluid Volume	(3)	51(1)	NA	Pcnt	CI
			46(2)	NA	Pcnt	CI

TIME PERIOD:

(1) From Circulation Pumps ON (before T-6 hours) to Go for APU Start (T-5 minutes)
(2) From Go for APU Start (T-5 minutes) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(3) Confirmed downlink instrumentation failure is acceptable if onboard display is available. (4,5)

PREPLANNED CONTINGENCY PROCEDURE:

(4) Downlink instrumentation failure can be confirmed using onboard displays (F8A8 meter or Multifunction Electronic Display Subsystem (MEDS), depending on Vehicle configuration)

NOTES:

(5) Reservoir fluid volume is confirmed by comparison of reservoir and accumulator pressures.
(6) Reservoirs are initially serviced to 61 +/- 5% at 70 deg F.
(7) Volume may increase due to heat exchanger freon leak.

REDLINE DERIVATION: CRITICALITY: 1R

(8) These redlines ensure adequate Hydraulic fluid quantity for flight.
(9) Minimum for circulation pump ON:

Compressibility	95	(Reserve for sys expansion under main pump press)
External leakage	56	(Per SODB)
Intersystem leakage	507	(Per SODB)
Thermal contraction	282	(Reserve for on-orbit thermal effects)
	---	
	940 in3 = 51% at 70 deg F	(Vmin = 51%)

(10) Minimum for MAIN pump ON:

External leakage	56	(Per SODB)
Intersystem leakage	507	(Per SODB)
Thermal contraction	282	(Reserve for on-orbit thermal effects)
	---	
	845 in3 = 46% at 70 deg F	(Vmin = 46%)

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Insufficient volume to complete mission.
(12) Pump cavitation.
(13) If reservoir volume instrumentation is lost, will have reduced ability to determine system leakage.

CAUSES OF EXCEEDING REDLINE:

(14) External leakage.
(15) Intersystem leakage.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR HYDRAULIC SYSTEM 1, 2, AND 3 RESPECTIVELY									
UNITS-->	pcnt								
V58Q0n02A	0.4	0	100					40	95

METER/DISPLAY RANGE - MSID: V58Q0n02A LOW: 0 HIGH: 100

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 12.3 SHEET 1 ZONE C6
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-958102 SHEET 66 ZONE D6

ELEMENT: Orbiter SUBSYSTEM: Hydraulic

LCC VIOLATION CALL: Hydraulic System Supply Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V58P0115A	Hydr Sys 1 Supply Press B	1 of	2850	3400	psia	CI
V58P0116C	Hydr Sys 1 Supply Press C	2	2800	3400	psia	CI
V58P0215A	Hydr Sys 2 Supply Press B	1 of	2850	3400	psia	CI
V58P0216C	Hydr Sys 2 Supply Press C	2	2800	3400	psia	CI
V58P0315A	Hydr Sys 3 Supply Press B	1 of	2850	3400	psia	CI
V58P0316C	Hydr Sys 3 Supply Press C	2	2800	3400	psia	CI
N/A	C&W Parameter (099,109,119)		OFF (2)	N/A	N/A	CI

TIME PERIOD:

(1) After Hydraulics Pressurized (T-5 minutes) to Go for Main Engine Start (T-10 seconds)
(2) After Hydraulics Pressurized (T-5 minutes) to Go for RSLS Start (T-31 seconds) (5)

REQUIREMENTS: FIGURES/TABLES:

(3) LCC redline does not apply during aerosurface and main engine gimbal profile (T-3 minutes, 55 seconds to T-3 minutes, 3 seconds).
(4) Allow 5 seconds for hydraulic system pressurization and pump stabilization following placing panel switch to "NORM" position. (6)

PREPLANNED CONTINGENCY PROCEDURE:

(5) If C&W hydraulic pressure master alarm (V73X1567E1) occurs after APU start and pump stabilization, evaluate for Depress Solenoid Reactivation or Instrumentation Failure per S0007 vol 5 "HYD-02 C&W" procedure. Instrumentation failure is confirmed for a measurement indicating off scale high or low, exhibiting a step function change, or functioning erratically.
   (Go conditions)
   - For confirmed instrumentation failure (V58P0n14C, n=1,2,3), C&W parameter(s) (099,109,119) indicating "ON" is(are) acceptable, LCC violation cleared, continue countdown.
   - If Depress Solenoid activation by the crew, then LCC violation cleared, continue countdown.
   (No Go conditions)
   - If Hyd Main Pump Switch/circuitry failure, then LCC violation confirmed, No Go for launch.
   - If Depress Solenoid/circuitry failure, then LCC violation confirmed, No Go for launch.
(6) For hydraulic pressure C&W master alarms which may occur during the transition of PNL R2 HYD MN PUMP PRESS switch to "NORM", LCC violation cleared, continue countdown. Master alarms should be reset and are the result of one of the following:

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

A. Switch sensitivity causing reactivation of pump depress solenoid, or
B. Pressure fluctuations due to the dynamic conditions associated with the initial system pressurization and pump compensator stabilization.

NOTES:

(7) C&W parameter has approximately a 100 millisecond delay.
(8) 50 psia allowance is made for delta pressure drop across a filter installed between the pump outlet and SSME interface.
(9) A. In OPS 2 and OPS 3, Pressures A, B and C are available to ground.
B. In OPS 1, only Pressure B and Pressure C are available to ground.
C. In any OPS format, Supply Press A is available on Panel F8A8 (or on HYD/APU display for MEDs configured Orbiters) and is non-mandatory for flight.
(10) Detection of RPC or switch scan activation is dependent on software sample rate. RPC or switch scan activation duration of less than one second may not be detectable.

REDLINE DERIVATION: CRITICALITY: 1R

(11) Maximum: Maximum limit is established per engine Interface Control Document (ICD) requirement of 3500 psia (maximum limit of engine interface functional test).
(12) Minimum: Minimum limit is established per engine ICD requirement of 2700 psia steady state.
(13)

	Maximum	Minimum (V58P0n15A) (n=1,2,3)	Minimum (V58P0n16C) (n=1,2,3)
Basic Redline	3500 psia	2700 psia	2700 psia
In-line filter allow	0	50	0
Instrumentation error (2.5%)	100	100	100
Redline	3400 psia	2850 psia	2800 psia

CONSEQUENCES OF EXCEEDING REDLINE:

(14) Maximum: A. Hydraulic line/component fatigue/failure.
B. Exceedance of maximum SSME ICD.
(15) Minimum: A. Degradation of Valve/Aerosurface/TVC response.
B. Loss of one Hydraulic System.
C. Failure to meet minimum SSME ICD.

CAUSES OF EXCEEDING REDLINE:

(16) Maximum: Pump compensator malfunction.
(17) Minimum: A. APU-driven main pump instability or cavitation.
B. Inadequate pump inlet suction pressure flow.
C. Pump compensator malfunction.

CAUSES OF EXCEEDING REDLINE: (Continued)

D. APU failure.
E. Electronic depressurizing valve solenoid valve failure.
F. External leakage.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR HYDRAULIC SYSTEM 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
V58P0n15A	16	0	4000			2400			
V58P0n16C	8	0	4000						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 12.3 SHEET 1 ZONE G2
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-958102 SHEET 6 ZONE E11-D11

ELEMENT: Orbiter SUBSYSTEM: HYDRAULIC

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LCC VIOLATION CALL: Hydraulic System Circulation Pump Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V58P0137A	Hydr Sys 1 Circ Pump Press		330(1)	140(2)	psia	CI(5
V58P0237A	Hydr Sys 2 Circ Pump Press		330(1)	140(2)	psia	CI(5
V58P0337A	Hydr Sys 3 Circ Pump Press		330(1)	140(2)	psia	CI(5

TIME PERIOD:

(1) From Circulation Pumps ON to APU Start (T-5 minutes). Maximum is not applicable.
(2) APU start (T-5 minutes) plus 30 seconds to RSLS Start (T-31 seconds) (6). Minimum is not applicable.

REQUIREMENTS: FIGURES/TABLES:

(3) If redline is exceeded, depressurize main pump. Minimum is NA. For confirmed instrumentation failure, LCC violation cleared, continue countdown.
(4) Hydraulic pressure is allowed to drop below 264 psia/200 psid (ICD values) during major mode transition from OPS G9 to OPS G1 (approximately T-19 minutes). During prelaunch, the elevons drift from the null position. At OPS G1, the elevons are commanded to null. This elevon movement creates a momentary pressure drop that will not affect thermal conditioning.

PREPLANNED CONTINGENCY PROCEDURE:

(5) Hydraulic system supply pressures B and C may be used as backups prior to APU start where an instrumentation failure is confirmed: V58P0115A, 0215A, 0315A; V58P0116C, 0216C, 0316C, respectively. Hydraulic reservoir quantity measurements (V58Q0102A, 0202A, 0302A) may be used for backup to circulation pump pressures. Monitor reservoir during initial hydraulic system stabilization. If reservoir volume decreases by 6 percent or greater during system stabilization, LCC violation confirmed, No Go for launch. Monitor reservoir volume after system stabilization. If reservoir volume decreases, LCC violation confirmed, No Go for launch.

NOTES:

(6) Circulation pumps automatically shutdown 4 seconds after APU start.
(7) 330 psia is derived from Flight Control Hydraulics Lab (FCHL) test data.

REDLINE DERIVATION: CRITICALITY: 1R

(8) Maximum:

Maximum return line pressure	89 psia
Margin	11 psia
Instrumentation error (5%)	40 psi
	---
	140 psia

REDLINE DERIVATION: (Continued)

(9) Minimum:

SSME ICD delta pressure	200 psid
Return line pressure	65 psia
	---
	265 psia
System pressure drop	65 psi
	---
	330 psia (7)

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Maximum: Physical damage to circulation pump because of overpressure during APU operation caused by check-valve leakage and subsequent loss of hydraulic fluid.

(11) Minimum: Violation of SSME ICD requirement for warmant flow, which may result in freezing of hydraulic fluid.

CAUSES OF EXCEEDING REDLINE:

(12) Maximum: A. Check-valve leakage.
B. Circulation pump failed ON.

(13) Minimum: A. Circulation pump failed OFF.
B. Leakage.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR HYDRAULIC SYSTEM 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
V58P0n37A	3.2	0	800						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 12.3 SHEET 1 ZONE D4
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-958099 SHEET 6 ZONE E11

ELEMENT: Orbiter SUBSYSTEM: HYDRAULIC

LCC VIOLATION CALL:	EMERG COND:
Hydraulic System Water Spray Boiler GN2 Tank Anomaly	None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V58P0147A	Hyd Sys 1 H2O Blr GN2 Tk Press		(2)	NA	psia	CI
V58T0105A	Hyd Sys 1 H2O Blr GN2 Tank Temp 1		(2)	NA	deg F	CI
V58T0106A	Hyd Sys 1 H2O Blr GN2 Tank Temp 2		(2)	NA	deg F	CI
V58P0247A	Hyd Sys 2 H2O Blr GN2 Tk Press		(2)	NA	psia	CI
V58T0205A	Hyd Sys 2 H2O Blr GN2 Tank Temp 1		(2)	NA	deg F	CI
V58T0206A	Hyd Sys 2 H2O Blr GN2 Tank Temp 2		(2)	NA	deg F	CI
V58P0347A	Hyd Sys 3 H2O Blr GN2 Tk Press		(2)	NA	psia	CI
V58T0305A	Hyd Sys 3 H2O Blr GN2 Tank Temp 1		(2)	NA	deg F	CI
V58T0306A	Hyd Sys 3 H2O Blr GN2 Tank Temp 2		(2)	NA	deg F	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES: Figure 28-01

(2) Refer to Figure 28-01 "Water Spray Boiler (WSB) Nitrogen Storage Tank Pressure vs Temperature," for minimum redlines.
(3) For any decrease in pressure greater than 2 data bits (1 bit = 14 psi) without a corresponding temperature change (exclusive of ullage volume repressurization when the GN2 valve is opened at approximately T-30 minutes), LCC violation confirmed, No Go for launch.
(4) 1 of 3 H2O boiler GN2 tank measurements per system acceptable for confirmed instrumentation failure. (5)

PREPLANNED CONTINGENCY PROCEDURE:

(5) Instrumentation failure is defined as a measurement indicating off-scale high or low, or indicating erratically.
   a) For loss of H2O Blr GN2 Tk Press, utilize pressure data prior to instrumentation failure and current temperature data for GN2 tank quantity assessment and leak evaluation.
   b) For loss of both H2O Blr GN2 Tank Temp measurements for a system, utilize the temperature measurements of the two remaining systems for GN2 tank quantity assessment and leak evaluation. The following method will be used for calculating GN2 Tank temperature:

      GN2 Tank 1 Temp = The average temp of GN2 Tanks(2 & 3)+ 3 deg F.
      GN2 Tank 2 Temp = The average temp of GN2 Tanks(1 & 3)+ 2 deg F.
      GN2 Tank 3 Temp = The average temp of GN2 Tanks(1 & 2)+ 11 deg F.

NOTES:

(6) Flight serviced to a range of 2440 - 2813 psia at 70 deg F.

NOTES: (Continued)

(7) If a system GN2 tank pressure measurement is lost, the associated GN2 tank temperature measurements will only detect large leaks (loss of function).

REDLINE DERIVATION: CRITICALITY: 1R

(8) This LCC monitors GN2 tank quantity to ensure sufficient WSB consumables for APU/Hydraulic cooling.

(9) Redline value is based on regulator inlet/outlet GN2 temperatures and regulator mass flow rate with the following assumptions (Ref. Water Spray Boiler Nitrogen Tank Pressure LCC Derivation, JSC 26818 (Nov. 1994)).
   a) AOA mission timeline assumed (WSB spray time averaged over 101.5 minutes - spray start 2 minutes post MECO).
   b) WSB water usage per system = 118 lb with no residual.
   c) No heat transferred through WSB structure during blowdown and water expulsion operations (adiabatic process).
   d) Regulated pressure downstream of the WSB regulator is 26 psia for first 92.5 minutes, then 40.7 psia for 8 minutes (based on nominal entry data), and 39.2 psia for the last minute of spray.
   e) Initial tank gas temperature = 45 deg F. Initial water tank ullage temperature = 55 deg F (based on worst case prelaunch data).
   f) Final GN2 regulator inlet pressure = 175 psia at end of AOA mission (minimum regulator operating inlet pressure, Ref. Shuttle Operational Data Book, JSC 08934).
   g) Constant 1 sccm leakage overboard through the relief valve during spray operation (Ref. OMRS V58AKO.045).

(10) Minimum:
   a) Minimum at 70 deg F:

GN2 tank pressure	1,500 psia
Modeling variations	100 psi
Instrumentation error (5%)	175 psi
Redline limit	1,775 psia

   b) The formula for the minimum pressure at any constant temperature for a specific system is P = 3.35 T + 1,540 psia, where T is the respective hydraulic system WSB GN2 tank temperature (V58T0X05A,V58T0X06A, X = 1, 2, or 3 respectively). The resultant pressure includes the 5% instrumentation error.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Insufficient consumables to support WSB function which may result in loss of APU prior to end of mission.

CAUSES OF EXCEEDING REDLINE:

(12) GN2 leak.
(13) Water leak.
(14) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR HYDRAULIC SYSTEM 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
V58P0n47A	14	0	3500						
UNITS-->	deg.F								
V58T0n05A	.76	32.66	222.4						
V58T0n06A	.76	32.66	222.4						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 12.4 SHEET 1 ZONE T6
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-958102 SHEET 14 ZONE E11

ELEMENT: Orbiter SUBSYSTEM: HYDRAULIC

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LCC VIOLATION CALL: Hydraulic System Water Spray Boiler Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V58T0162A	Hyd Sys 1 H2O Blr Temp No. 1	(2)	40	200	deg F	CI
V58T0163A	Hyd Sys 1 H2O Blr Temp No. 2	(2)	40	200	deg F	CI
V58T0262A	Hyd Sys 2 H2O Blr Temp No. 1	(2)	40	200	deg F	CI
V58T0263A	Hyd Sys 2 H2O Blr Temp No. 2	(2)	40	200	deg F	CI
V58T0362A	Hyd Sys 3 H2O Blr Temp No. 1	(2)	40	200	deg F	CI
V58T0363A	Hyd Sys 3 H2O Blr Temp No. 2	(2)	40	200	deg F	CI

TIME PERIOD:

(1) From Start of ET Cyro Tanking (T-6 hours) to Go for GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) One of two measurements acceptable for confirmed instrumentation failure (exclusive of transducer). (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) For measurements indicating off scale high or low, functioning erratically, or exhibiting a step function change, where MDM Card/Channel Failure is the cause, the mandatory heater sets (H2O Boiler and H2O Tank) remain functional, LCC violation cleared, continue countdown.

NOTES:

(4) Each measurement controls two mandatory heater sets (H2O Boiler and H2O Tank). Both heater systems 1 and 2 are activated by GSE and are mandatory prelaunch. After the removal of GSE power, only controller A is powered; therefore, only temperature measurement A is valid on the downlink.

REDLINE DERIVATION: CRITICALITY: 1R

(5) Maximum: To detect a failed High measurement.
(6) Minimum: To detect a failed OFF heater system.

	Minimum
Controller setting	50
Location delta	-5
Instrumentation error (2.5%)	-5
Redline limit	40 deg F

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Minimum: Frozen Water Tank and Water Boiler lines and subsequent over temperature of the APU lube oil, hydraulic fluid and loss of boiler water tank possible.

CONSEQUENCES OF EXCEEDING REDLINE: (Continued)

(8) Maximum: Possible loss of water tank due to overtemp/over pressurization.

CAUSES OF EXCEEDING REDLINE:

(9) Failed control measurement or controller.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR HYDRAULIC SYSTEM 1, 2, AND 3 RESPECTIVELY									
UNITS-->	deg.F								
V58T0n62A	NL	30.77	209.6						
V58T0n63A	NL	30.77	209.6						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 12.4 SHEET 1 ZONE Q4, K4
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: HYDRAULIC

Hydraulic System Water Spray Boiler Vent Temperatures

(THIS REQUIREMENT HAS BEEN DELETED)

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LCC VIOLATION CALL: Hydraulic Accumulator/Reservoir Fluid Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V58P0167A	Hyd Sys 1 Bootstrap Accumulator P	(3)	1906(1) 2706(2)	3233(1) NA	psia	CI
V58P0131A	Hyd Sys 1 Rsvr Fluid Press	(3)	43 (1) 60 (2)	120(1) 120(2)	psia	CI
V58P0267A	Hyd Sys 2 Bootstrap Accumulator P	(3)	1906(1) 2706(2)	3233(1) NA	psia	CI
V58P0231A	Hyd Sys 2 Rsvr Fluid Press	(3)	43 (1) 60 (2)	120(1) 120(2)	psia	CI
V58P0367A	Hyd Sys 3 Bootstrap Accumulator P	(3)	1906(1) 2706(2)	3233(1) NA	psia	CI
V58P0331A	Hyd Sys 3 Rsvr Fluid Press	(3)	43 (1) 60 (2)	120(1) 120(2)	psia	CI

TIME PERIOD:

(1) From circulation pump Start to APU Start (T-5 minutes)
(2) From APU ON and main pump pressure NORMAL to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(3) One of two measurements acceptable for confirmed instrumentation failure only. (4)

PREPLANNED CONTINGENCY PROCEDURE:

(4) Instrumentation failure is confirmed for a measurement indicating off-scale high or low, exhibiting a step function change or functioning erratically.

NOTES:

(5) Unloader valve settings:
to accumulator 2050-2153 psia.
to system 2460-2563 psia.

REDLINE DERIVATION: CRITICALITY: 1R

(6) These Redlines ensure that the Bootstrap system performance is within operating limits.

REDLINE DERIVATION: (Continued)

(7) Accumulator Pressure:

Pre-APU start:

Circulation pump pressure unloader valve set point pressure	2050 psia
Instrumentation error	-144 psia
	1906 psia MINIMUM REDLINE
Maximum priority valve cracking pressure	3000 psia
Return pressure	+ 89 psia
Instrumentation error	+144 psia
	3233 psia MAXIMUM REDLINE

After main pump NORMAL:

Minimum pump outlet pressure	2850 psia
Instrumentation error	-144 psia
	2706 psia MINIMUM REDLINE

(8) Reservoir Pressure:

Pre-APU start:

Reservoir Pressure	= 0.0243(2050)+0.975(14.7)
	= 64 psia
Instrumentation error	- 13 psia
Accumulator seal friction	- 6 psia
Reservoir seal friction	- 2 psia
	43 psia MINIMUM REDLINE
Reservoir Pressure	= 120.0 psid relief valve cracking pressure
	+14.7 psia Ambient Air Pressure
	134.7 psia
Instrumentation error	-13.0 psia
Margin	- 1.7 psia
	120.0 psia MAXIMUM REDLINE

After main pump NORMAL:

Reservoir Pressure	= 0.0243(2850)+0.975(14.7)
	= 83 psia
Instrumentation error	- 13 psia
Accumulator seal friction	- 8 psia
Reservoir seal friction	- 2 psia
	60 psia MINIMUM REDLINE

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Maximum: Loss of reservoir fluid via relief valve to leakage collection system with potential loss of affected Hydraulic system.

(10) Minimum: A. Main pump cavitation - may damage hardware.
B. May inhibit APU start on-orbit because of failure in bootstrap replenish system.

CAUSES OF EXCEEDING REDLINE:

(11) Minimum: A. Bootstrap leak.
B. Unloader valve failure.
C. Circulation pump failure.
D. Priority valve failure.
E. GN2 leak.

(12) Maximum: A. Priority valve failure in combination with unloader valve failure.
B. Main pump overpressure after APU start.
C. Freon heat exchanger leak.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
n = 1, 2, AND 3 FOR HYDRAULIC SYSTEM 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psia								
V58P0n67A	16	0	4000					1930	
V58P0n31A	1	0	250						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 12.3 SHEET 1 ZONE C3
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-958099 SHEET 6 ZONE G19,D18

ELEMENT: Orbiter SUBSYSTEM: HYDRAULIC

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LCC VIOLATION CALL: Hydraulic System 1 Landing Gear Extend Isolation Valve Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V58X0199E	Hyd Sys 1 Ldg/NWS Isln Vlv CL Ind		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) For open indication, LCC violation confirmed, No Go for launch. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) CAUTION: THE LANDING GEAR EXTEND ISOLATION VALVE SHOULD NOT BE CYCLED OPEN ON MAIN PUMP PRESSURE DUE TO POSSIBLE INADVERTENT GEAR DEPLOY WITH FAILED EXTEND VALVE #1.

Request crew to:
Panel R4: LG Extend Isol Valve sw-CLOSE (hold for 5 seconds); tb - CL
(If tb does not indicate CLOSE, LCC violation confirmed, No Go for launch).

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(4) Ensure landing gear extend isolation valve is closed.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Loss of redundancy; additional failure (failure of extend valve #1) would cause premature landing gear deployment.

CAUSES OF EXCEEDING REDLINE:

(6) Inadvertent command caused by failed switch or software, failure of the latching mechanism, or failure of the opening solenoid plunger.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: Hydraulic

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LCC VIOLATION CALL: PCA Hydraulic Pump RPC Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76X4020E	PCA Hydraulic Pump 1 RPC A ON		(1)	NA	Event	DI
V76X4021E	PCA Hydraulic Pump 1 RPC B ON		(1)	NA	Event	DI
V76X4024E	PCA Hydraulic Pump 2 RPC B ON		(1)	NA	Event	DI
V76X4025E	PCA Hydraulic Pump 2 RPC C ON		(1)	NA	Event	DI
V76X4027E	PCA Hydraulic Pump 3 RPC C ON		(1)	NA	Event	DI
V76X4028E	PCA Hydraulic Pump 3 RPC A ON		(1)	NA	Event	DI

TIME PERIOD:

(1) Verify ON at APU Pre-Start (T-5 minutes, 25 seconds). Verify OFF After Main Pump Pressure Normal (T-4 minutes, 5 seconds).

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(2) Prior to APU start, loss of one depress capability results in system being one failure away from losing APU restart capability, either hot restart or entry. AOA must be run in the depress mode.

(3) After APU start, if depress comes ON, loss of redundancy. One more failure will reduce hydraulics to 800 psi which results in loss of function of the system.

CONSEQUENCES OF EXCEEDING REDLINE:

(4) One failure away from losing one hydraulic system prelaunch. If system is lost, NO GO for launch.

CAUSES OF EXCEEDING REDLINE:

(5) Failure of the surge suppression diode, hybrid driver (type 4), isolation diode, or switch in the main pump depress control circuitry.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: HYDRAULIC

LCC VIOLATION CALL: Hydraulic Water Spray Boiler OK Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V58X0182E	Hydr Sys 1 H2O Boiler OK		ON	NA	Event	DI
V58X0282E	Hydr Sys 2 H2O Boiler OK		ON	NA	Event	DI
V58X0382E	Hydr Sys 3 H2O Boiler OK		ON	NA	Event	DI

TIME PERIOD:

(1) Verify ON Prior to Start of ET Cryo Tanking (T-6 hours) and Again Prior to Go For APU Start (T-5 minutes)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) If H2O Boiler OK is lost due to a confirmed primary vent heater failure, switch to alternate heater, confirm primary heater failure by comparison to other H2O Boiler Vent Temperatures (V58T0n65A1/n66A1). For confirmed primary heater failure, LCC violation cleared, continue countdown.

(3) If H2O Boiler OK "ON" is lost between T-30 Minutes and APU pre-start (approx. T-6 minutes), and it was verified "ON" prior to ET Cryo Tanking and the H2O Boiler Vent Temperatures have decreased to less than or equal to 133 deg F due to thermal effects, LCC violation cleared, continue countdown.

(4) If, at APU pre-start, no H2O Boiler OK "ON" is present, if the following are true, LCC violation cleared, continue countdown:
   (a) If H2O Boiler OK "ON" was verified prior to start of ET Cryo Tanking.
   (b) If H2O Boiler Vent Temperatures are less than 133 deg F and as long as time history indicates trend is consistent with other H2O Boiler Vent Temperatures (i.e., heater is functional).
   (c) If Other inputs (besides the Hydr Sys H2O Boiler OK) to APU/Hyd Ready to Start talkback (panel R2) are verified.
      o HYD Main Pump Press Low-Enbl (A/B, B/C, C/A) (V58S0n72E1/n73E1) - ON
      o APU Fuel Isln Vlv A (B) Open/Pwr On (V46X0n15E1, (0n34E1)) - ON
      o APU Ready (V46X0n25E1) - ON

   Inform Flight Crew of lack of APU/Hyd Ready to Start talkback.

NOTES:

(5) H2O Boiler OK "ON" verification is initiated by taking the Boiler Cntlr/Htr switch to "A" (V58S0n49A = ON), four hours prior to ET Cryo Tanking. One hour later, with the Steam Vents temperature at 133 deg F minimum, the Boiler N2 Supply switch is taken to ON, the H2O Boiler OK is verified ON, then the Boiler N2 Supply switch is taken back to OFF. At approx. T-30 minutes the Boiler N2 Supply switch is taken to the final ON position for the remainder of the countdown and again verified that the H2O Boiler OK indication is ON.

NOTES: (Continued)

(6) H2O Boiler OK is an input into the APU/HYD Ready To Start talkback, but is not an inhibit to starting an APU.
(7) After Start of ET Cryo Tanking (T-6 hours), the Orbiter aft-fuselage environment may prevent the 50W heater from maintaining a vent temperature greater than 130 +/- 3 degrees F.

REDLINE DERIVATION: CRITICALITY: 1R

(8) Logic supplied to Hydr Sys H2O Boiler OK
  - o Hyd H2O Boiler Controller A or B enabled:
    - Hyd Sys H2O Blr Cont Pwr/Htr A or B (V58Son49E1 or n50E1) - ON
    - Hydr Sys H2O Blr Contlr A On (V58S0n51E1) - ON (no telemetry for B controller)
  - o Hydr Sys H2O Blr N2 Supply Off B (V58S0n53E1) - OFF
  - o Hydr Sys H2O Blr Bypass CL Ind 1 (V58S0n81E1) - in proper position
  - o Hydr Sys H2O Blr Vent Temp 1 or 2 (V58T0n65A1 or n66A1) > 130 deg F

(9) For N2 supply valve OPEN, only switch scan available to controller and ground, no talkback directly on valve.
(10) For hydraulic bypass valve, only heat exchanger position available to ground, no telemetry on bypass position or hydraulic fluid temperature.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Potential loss of one APU/HYD system during mission if one critical logic parameter not satisfied.

CAUSES OF EXCEEDING REDLINE:

(12) Failed steam vent heater, temperature transducer, controller, or boiler power switch.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 12.4	SHEET 1	ZONE M6
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-958099	SHEET 11,24,	ZONE D4
	DWG NO	SHEET 36	ZONE D4

ELEMENT: Orbiter SUBSYSTEM: HYDRAULIC

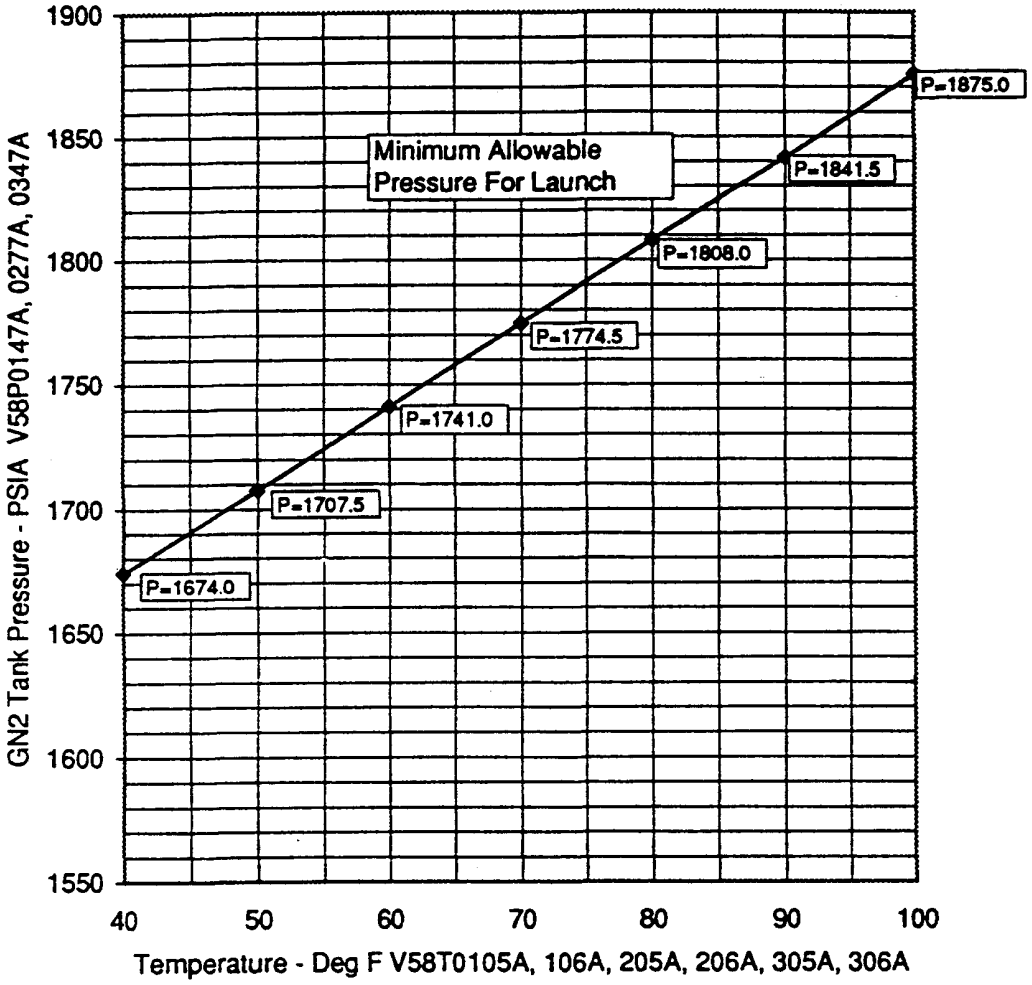

Figure 28-01 Water Spray Boiler Nitrogen Storage Tank Pressure vs Temperature

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SECTION 29

MECHANICAL SYSTEMS

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SECTION 29: MECHANICAL SYSTEMS

SSID No.	Description/Violation Call	Page
AFM-01	ET Centerline Door Latch Indication Anomaly	29-01.1
AFM-02	ET Door Position Indication Anomaly	29-02.1
AFM-03	ET Door Latch Indication Anomaly	29-03.1
AFM-04	Radiator Drive Indication Anomaly	29-04.1
AFM-05	Radiator Latch Indication Anomaly	29-05.1
AFM-06	Payload Bay Door Open Indication Anomaly	29-06.1
AFM-07	Payload Bay Door Bulkhead Latch Indication Anomaly	29-07.1
AFM-08	Payload Bay Door Ready-To-Latch Indication Anomaly	29-08.1
AFM-09	Payload Bay Door Centerline Latch Indication Anomaly	29-09.1
AFM-10	Landing Gear Uplock Indication Anomaly	29-10.1
AFM-11	Landing Gear Shuttle Valve Indication Anomaly	29-11.1
AFM-12	RMS Deploy/Stow Mechanism Indication Anomaly	29-12.1
AFM-13	RMS Retention Latch Indication Anomaly	29-13.1
AFM-14	Star Tracker Door Indication Anomaly	29-14.1
AFM-15	Air Data Probe Deploy/Stow Indication Anomaly	29-15.1
AFM-16	Forward Motor Control Assembly Operational Status Anomaly	29-16.1
AFM-17	Mid Motor Control Assembly Operational Status Anomaly	29-17.1
AFM-18	Aft Motor Control Assembly Operational Status Anomaly	29-18.1
AFM-19	OBSS Deploy/Stow Mechanism Indication Anomaly	29-19.1
AFM-20	OBSS Retention Latch Indication Anomaly	29-20.1

SECTION 29: MECHANICAL SYSTEMS (CONTINUED)

SSID No.	Description/Violation Call	Page
AFM-21	SSIDs AFM-21 thru AFM-29 Reserved	29-21.1
AFM-30	Orbiter Vent Door Indication Anomaly	29-30.1

LCC VIOLATION CALL: ET Centerline Door Latch Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V56X1205X	ET Umb Dr CL Lch 1 Stowed Ind 1	(2)	OFF	NA	Event	CI
V56X1215X	ET Umb Dr CL Lch 1 Stowed Ind 2	(2)	OFF	NA	Event	CI
V56X1255X	ET Umb Dr CL Lch 1 Locked Ind 1	(3)	ON	NA	Event	CI
V56X1265X	ET Umb Dr CL Lch 1 Locked Ind 2	(3)	ON	NA	Event	CI
V56X1305X	ET Umb Dr CL Lch 2 Stowed Ind 1	(2)	OFF	NA	Event	CI
V56X1315X	ET Umb Dr CL Lch 2 Stowed Ind 2	(2)	OFF	NA	Event	CI
V56X1355X	ET Umb Dr CL Lch 2 Locked Ind 1	(3)	ON	NA	Event	CI
V56X1365X	ET Umb Dr CL Lch 2 Locked Ind 2	(3)	ON	NA	Event	CI

TIME PERIOD:

(1) From OPS 1 Transition (T-19 minutes) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown.
(3) For confirmed instrumentation failure, verify dual motor function, LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE:

(4) Failure type: Stowed indication ON/should be OFF.
   A. Leave AC power ON and issue GPC stow commands 1 and 2, one at a time. Monitor MCA operational status. (PDU isolated from AC power unless both commands issued simultaneously).
   B. If the MCA operational status inverts, the relay has activated (MCA does not see the indication ON), the failure is confirmed instrumentation loss. Motor function is not lost (still have dual motor stow capability), LCC violation cleared, continue countdown.
   C. If the MCA operational status does not invert, the relay is being inhibited by the stow indication and dual motor stow capability is lost. LCC violation confirmed, No Go for launch.
(5) Failure type: Locked indication OFF/should be ON.
   A. Leave AC power ON and issue GPC lock commands 1 and 2, one at a time. Monitor MCA operational status.
   B. If the MCA operational status does not invert, the relay is still being inhibited by a locked indication in the MCA, the failure is confirmed instrumentation loss. Connector integrity is good, dual motor function maintained and latch position is verified. Latch position is also confirmed by the other limit switch. LCC violation cleared, continue countdown.
   C. If the MCA operational status does invert, issue both lock commands and monitor AC power (5 seconds max).
   D. If the limit switch is picked up, LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

E. If the limit switch is not picked up but the other limit switch is ON (CONF POSN) and there is AC power draw on all 3 phases (connector integrity), LCC violation cleared, continue countdown. (possible blown fuse).
F. If there is no AC power draw, LCC violation confirmed, No Go for launch. There may be a demated connector and loss of dual motor stow capability.

NOTES:

(6) Measurements are only available in G1 format (no backup BFS measurements).
(7) Centerline latches must partially stow to clear the doors so that doors may close.
(8) If centerline latches partially stow to clear the doors, but do not fully stow - not catastrophic - may have thermal damage.

REDLINE DERIVATION: CRITICALITY: 1R

(9) Failure type: Indication ON/should be OFF. Ensures dual motor operation capability for ET centerline latch stowing.
(10) Failure type: Indication OFF/should be ON. Ensures that the ET centerline door latch is properly locked for launch and ascent. Ensures connector integrity, and therefore, dual motor capability.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Failure type: Indication ON/should be OFF. Presence of faulty stow indication results in loss of dual motor capability for stowing the ET door centerline latch. Failure of both indications for the same group of ET door centerline latches results in loss of capability to stow the associated ET door centerline latch.
(12) Failure type: Indication OFF/should be ON. An ET door latch improperly configured for launch and ascent may incur structural damage. A faulty indication has the potential for a demated connector at the PDU resulting in loss of motor function.

CAUSES OF EXCEEDING REDLINE:

(13) Failure type: Indication ON/should be OFF. Instrumentation failure.
(14) Failure type: Indication OFF/should be ON. Instrumentation failure, open circuit or improperly positioned latch/door.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 15.2 SHEET 2 of 2 ZONE C-V
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS72-956099 SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: Mechanical

LCC VIOLATION CALL: ET Door Position Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V56X3110X1	ET L Umb Cout Door Closed Ind 1	(2)	OFF	NA	Event	CI
V56X3115X1	ET L Umb Cout Door Closed Ind 2	(2)	OFF	NA	Event	CI
V56X3010X1	ET L Umb Cout Door Open Ind 1	(3)	ON	NA	Event	CI
V56X3015X1	ET L Umb Cout Door Open Ind 2	(3)	ON	NA	Event	CI
V56X4110X1	ET R Umb Cout Door Closed Ind 1	(2)	OFF	NA	Event	CI
V56X4115X1	ET R Umb Cout Door Closed Ind 2	(2)	OFF	NA	Event	CI
V56X4010X1	ET R Umb Cout Door Open Ind 1	(3)	ON	NA	Event	CI
V56X4015X1	ET R Umb Cout Door Open Ind 2	(3)	ON	NA	Event	CI

TIME PERIOD:

(1) From OPS 1 Transition (T-19 minutes) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown.
(3) For confirmed instrumentation failure, verify dual motor function, LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE:

(4) Failure type: Closed indication ON/should be OFF.
   A. Crew member needs to unstrap and get out of his/her seat to open the AC circuit breaker on panel MA73C and issue door closed switch command. Monitor MCA operational status.
   B. If the MCA operational status inverts, the relay has activated (MCA does not see the indication ON), the failure is confirmed instrumentation loss. Motor function is not lost (still have dual motor close capability), LCC violation cleared, continue countdown.
   C. If MCA operational status does not invert, the relay is being inhibited by the closed indication and dual motor close capability is lost, LCC violation confirmed, No Go for launch.
(5) Failure type: Open indication OFF/should be ON.
   A. Leave AC power ON and issue door open switch command. Monitor MCA operational status and AC current (5 seconds maximum).
   B. If the MCA operational status does not invert, the relay is still being inhibited by an open indication in the MCA, the failure is confirmed instrumentation loss. Connector integrity is good, dual motor function maintained and door position is verified. Door position is also confirmed by the other limit switch. LCC violation cleared, continue countdown.
   C. If the MCA operational status does invert and the limit switch is picked up, LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

D. If the limit switch is not picked up but the other limit switch is ON (CONF POSN) and there is AC power draw on all 3 phases (connector integrity). LCC violation cleared, continue countdown (possible blown fuse).
E. If there is no AC power draw, LCC violation confirmed, No Go for launch. There may be a demated connector and loss of dual motor close capability.

NOTES:

(6) Backup BFS measurement equivalents:

V56X3110X1 - V98X4090X1	V56X4110X1 - V98X4130X1
V56X3115X1 - V98X4150X1	V56X4115X1 - V98X4110X1
V56X3010X1 - V98X4089X1	V56X4010X1 - V98X4129X1
V56X3015X1 - V98X4149X1	V56X4015X1 - V98X4109X1

(7) Measurements are only available in G1 format.

REDLINE DERIVATION: CRITICALITY: 1R

(8) Failure type: Indication ON/should be OFF. Ensures dual motor operational capability for ET door closing.
(9) Failure type: Indication OFF/should be ON. Ensures that the ET door is properly configured for launch and ascent. Ensures connector integrity, and therefore, dual motor capability.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Failure type: Indication ON/should be OFF. Presence of faulty close indication results in loss of dual motor capability for closing that ET door. Failure of both indications for the same ET door results in loss of capability to close that ET door.
(11) Failure type: Indication OFF/should be ON. ET doors improperly configured for launch and ascent may incur structural damage. A faulty indication has the potential for a demated connector at the PDU resulting in loss of motor function.

CAUSES OF EXCEEDING REDLINE:

(12) Failure type: Indication ON/should be OFF. Instrumentation failure.
(13) Failure type: Indication OFF/should be ON. Instrumentation failure, open circuit or improperly positioned door.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: Mechanical

LCC VIOLATION CALL: ET Door Latch Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V56X3550X1	ET L Umb Cout Dr Latched Ind 1	(2)	OFF	NA	Event	CI
V56X3560X1	ET L Umb Cout Dr Latched Ind 2	(2)	OFF	NA	Event	CI
V56X3650X1	ET L Umb Cout Dr Latch Rel Ind 1	(3)	ON	NA	Event	CI
V56X3660X1	ET L Umb Cout Dr Latch Rel Ind 2	(3)	ON	NA	Event	CI
V56X4550X1	ET R Umb Cout Dr Latched Ind 1	(2)	OFF	NA	Event	CI
V56X4560X1	ET R Umb Cout Dr Latched Ind 2	(2)	OFF	NA	Event	CI
V56X4650X1	ET R Umb Cout Dr Latch Rel Ind 1	(3)	ON	NA	Event	CI
V56X4660X1	ET R Umb Cout Dr Latch Rel Ind 2	(3)	ON	NA	Event	CI

TIME PERIOD:

(1) From OPS 1 Transition (T-19 minutes) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown.
(3) For confirmed instrumentation failure, verify dual motor function capability, LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE:

(4) Failure type: Latched indication ON/should be OFF.
   A. Leave AC power ON and issue GPC arm commands.
   B. Issue GPC latch command "A" ("B" relays are inhibited by missing ready-to-latch indications).
   C. If the MCA operational status inverts, the relay has activated (MCA does not see the indication ON), the failure is confirmed instrumentation loss. Motor function is not lost (still have dual motor latch capability), LCC violation cleared, continue countdown.
   D. If MCA operational status does not invert, the relay is being inhibited by the latched indication and dual motor capability is lost, LCC violation confirmed, No Go for launch.
(5) Failure type: Latch Release indication OFF/should be ON.
   A. Leave the AC power ON and issue release switch command. Monitor MCA operational status and AC current (5 seconds maximum).
   B. If MCA operational status does not invert, the relay is still being inhibited by a release indication in the MCA, the failure is confirmed instrumentation loss. Connector integrity is good, dual motor function maintained and latch position is verified. Latch position is also confirmed by the other limit switch, LCC violation cleared, continue countdown.
   C. If the MCA operational status does invert and the limit switch is picked up, LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

D. If the limit switch is not picked up but the other limit switch is ON (CONF POSN) and there is AC power draw on all 3 phases (connector integrity), LCC violation cleared, continue countdown (possible blown fuse).
E. If there is no AC draw, LCC violation confirmed, No Go for launch. There may be a demated connector and loss of dual motor latch capability.

NOTES:

(6) Backup BFS measurement equivalents:

V56X3550X1 - V98X4091X1	V56X4550X1 - V98X4151X1
V56X3560X1 - V98X4131X1	V56X4560X1 - V98X4111X1
V56X3650X1 - V98X4092X1	V56X4650X1 - V98X4152X1
V56X3660X1 - V98X4132X1	V56X4660X1 - V98X4112X1

(7) Measurements are only available in G1 format.

REDLINE DERIVATION: CRITICALITY: 1R

(8) Failure type: Indication ON/should be OFF. Ensures dual motor operational capability for ET door latching.
(9) Failure type: Indication OFF/should be ON. Ensures that the ET door latches are properly released for launch. Ensures connector integrity, and therefore, dual motor capability.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Failure type: Indication ON/should be OFF. Presence of faulty latch indication results in loss of dual motor capability for latching the ET door latches. Failure of both indications for the same group of ET door latches results in loss of capability to latch that ET door.
(11) Failure type: Indication OFF/should be ON. May indicate that ET door latches are out of configuration for launch. A latch that is partially latched may inhibit door roller from entering latch envelope and result in an unlatched door. A faulty indication has the potential for a demated connector at the PDU resulting in loss of motor function.

CAUSES OF EXCEEDING REDLINE:

(12) Failure type: Indication ON/should be OFF. Instrumentation failure.
(13) Failure type: Indication OFF/should be ON. Instrumentation failure, open circuit or improperly positioned latch.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: Mechanical

LCC VIOLATION CALL: Radiator Drive Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V37X3500E1	Port Rdtr Deploy 1	(2)	OFF	NA	Event	CI
V37X3501E1	Port Rdtr Deploy 2	(2)	OFF	NA	Event	CI
V37X3505E1	Port Rdtr Stow 1	(3)	ON	NA	Event	CI
V37X3506E1	Port Rdtr Stow 2	(3)	ON	NA	Event	CI
V37X3510E1	Stbd Rdtr Deploy 1	(2)	OFF	NA	Event	CI
V37X3511E1	Stbd Rdtr Deploy 2	(2)	OFF	NA	Event	CI
V37X3515E1	Stbd Rdtr Stow 1	(3)	ON	NA	Event	CI
V37X3516E1	Stbd Rdtr Stow 2	(3)	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 radiator deploy indications failed ON is acceptable (only need single motor deploy capability). If the second associated deploy indication fails on, instrumentation failure must be confirmed by one of the two indications.
(3) For confirmed instrumentation failure, verify dual motor function, LCC violation cleared, continue countdown.
(4) Mission dependent: Radiator deploy indications are required for missions which plan a radiator deployment only.

PREPLANNED CONTINGENCY PROCEDURE:

(5) Failure type: Deploy indication ON/should be OFF.
   A. Leave AC power ON and issue radiator deploy switch command (PDU is isolated from AC power by PLB mechanical power switch). Monitor MCA operational status.
   B. If the MCA operational status inverts, the relay has activated (MCA does not see the indication ON), the failure is confirmed instrumentation loss. Motor function is not lost (still have single motor deploy capability), LCC violation cleared, continue countdown.
   C. If MCA operational status does not invert, the relay is being inhibited by the deploy indication and single motor deploy capability is lost. LCC violation confirmed, No Go for launch.
(6) Failure type: Stow indication OFF/should be ON.
   A. Leave AC power ON and issue stow switch command. Monitor MCA operational status.
   B. If MCA operational status does not invert, the relay is still being inhibited by a stow indication in the MCA, the failure is confirmed instrumentation loss. Connector integrity is good, dual motor function maintained and drive mechanism position is verified. Drive mechanism position is also confirmed by the other limit switch. LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

C. If the MCA operational status does invert, turn on PLB mechanical power switch and monitor AC current (5 seconds max).
D. If the limit switch is picked up, LCC violation cleared, continue countdown.
E. If the limit switch is not picked up but the other limit switch is ON (CONF POSN) and there is AC power draw on all 3 phases (connector integrity), LCC violation cleared, continue countdown.
F. If there is no AC power draw, LCC violation confirmed, No Go for launch. There may be a demated connector and loss of dual motor stow capability.

NOTES:

(7) Measurements are available in OI.
(8) Failure of the radiator stow indications after deployment of radiator (both stow indications remain ON after radiator is deployed) results in loss of being able to stow radiators. EVA capability exists for radiator stow.

REDLINE DERIVATION: CRITICALITY: 1R

(9) Failure type: Indication ON/should be OFF. Ensures single motor operational capability for radiator deployment (mission dependent).
(10) Failure type: Indication OFF/should be ON. Ensures that the radiators are properly stowed for launch and ascent. Ensures connector integrity, and therefore, dual motor capability.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Failure type: Indication ON/should be OFF. Presence of faulty deploy indication results in loss of dual motor capability for deploying that radiator. Failure of both indications for the same radiator drive results in loss of capability to deploy that radiator. (Mission dependent.)
(12) Failure type: Indication OFF/should be ON. Radiator improperly configured for launch and ascent may incur structural damage and result in loss of the freon coolant loop.

CAUSES OF EXCEEDING REDLINE:

(13) Failure type: Indication ON/should be OFF. Instrumentation failure.
(14) Failure type: Indication OFF/should be ON. Instrumentation failure, open circuit or improperly positioned latch/radiator.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 14.1 SHEET 3 ZONE K-P
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS72-960099 SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: Mechanical

LCC VIOLATION CALL: Radiator Latch Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V37X3545E1	Stbd Rdtr Lch No 1-6 Rel 1	(2)	OFF	NA	Event	CI
V37X3550E1	Stbd Rdtr Lch No 1-6 Rel 2	(2)	OFF	NA	Event	CI
V37X3548E1	Stbd Rdtr Lch No 1-6 Lch 1	(3)	ON	NA	Event	CI
V37X3553E1	Stbd Rdtr Lch No 1-6 Lch 2	(3)	ON	NA	Event	CI
V37X3555E1	Stbd Rdtr Lch No 7-12 Rel 1	(2)	OFF	NA	Event	CI
V37X3560E1	Stbd Rdtr Lch No 7-12 Rel 2	(2)	OFF	NA	Event	CI
V37X3558E1	Stbd Rdtr Lch No 7-12 Lch 1	(3)	ON	NA	Event	CI
V37X3563E1	Stbd Rdtr Lch No 7-12 Lch 2	(3)	ON	NA	Event	CI
V37X3525E1	Port Rdtr Lch No 1-6 Rel 1	(2)	OFF	NA	Event	CI
V37X3530E1	Port Rdtr Lch No 1-6 Rel 2	(2)	OFF	NA	Event	CI
V37X3528E1	Port Rdtr Lch No 1-6 Lch 1	(3)	ON	NA	Event	CI
V37X3533E1	Port Rdtr Lch No 1-6 Lch 2	(3)	ON	NA	Event	CI
V37X3535E1	Port Rdtr Lch No 7-12 Rel 1	(2)	OFF	NA	Event	CI
V37X3540E1	Port Rdtr Lch No 7-12 Rel 2	(2)	OFF	NA	Event	CI
V37X3538E1	Port Rdtr Lch No 7-12 Lch 1	(3)	ON	NA	Event	CI
V37X3543E1	Port Rdtr Lch No 7-12 Lch 2	(3)	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) To Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 radiator latch release indications failed ON is acceptable (only need single motor release capability). If the second associated latch release indication fails on, instrumentation failure must be confirmed for one of the two indications.
(3) For confirmed instrumentation failure, verify dual motor function, LCC violation cleared, continue countdown.
(4) Mission dependent: Radiator latch releasing is required on missions where there is a planned radiator deployment only.

PREPLANNED CONTINGENCY PROCEDURE:

(5) Failure type: Release indication ON/should be OFF.
   A. Leave AC power ON and issue radiator release switch command (PDU is isolated from AC power by PLB mechanical power switch). Monitor MCA operational status.
   B. If the MCA operational status inverts, the relay has activated (MCA does not see the indication ON), the failure is confirmed instrumentation loss. Motor function is not lost (still have single motor release capability), LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

C. If the MCA operational status does not invert, the relay is being inhibited by the release indication and single motor release capability is lost, LCC violation confirmed, No Go for launch.

(6) Failure type: Latch indication OFF/should be ON.

A. Leave AC power ON and issue latch switch command. Monitor MCA operational status.

B. If the MCA operational status does not invert, the relay is still being inhibited by a latched indication in the MCA, the failure is confirmed instrumentation loss. Connector integrity is good, dual motor function maintained and latch position is verified. Latch position is also confirmed by the other limit switch, LCC violation cleared, continue countdown.

C. If the MCA operational status does invert, turn ON PLB mechanical power switch and monitor AC current (5 seconds max).

D. If the limit switch is picked up, LCC violation cleared, continue countdown.

E. If the limit switch is not picked up but the other limit switch is ON (CONF POSN) and there is AC power draw on all 3 phases (connector integrity), LCC violation cleared, continue countdown.

F. If there is no AC power draw, LCC violation confirmed, No Go for launch. There may be a demated connector and loss of dual motor latch capability.

NOTES:

(7) Measurements available in OI.

(8) Failure of radiator latch - LATCH indications after release (both indications remain on) results in loss of latch capability.

REDLINE DERIVATION: CRITICALITY: 1R

(9) Failure type: Indication ON/should be OFF. Ensures single motor operational capability for radiator latch release.

(10) Failure type: Indication OFF/should be ON. Ensures that the radiator latches are properly latched for launch and ascent. Ensures connector integrity, and therefore, dual motor capability.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Failure type: Indication ON/should be OFF. Presence of faulty release indication results in loss of dual motor capability for releasing the radiator latches. Failure of both indications results in loss of capability to release those radiator latches. (Mission dependent.)

(12) Failure type: Indication OFF/should be ON. Radiator latches improperly configured for launch and ascent may incur structural damage and result in loss of the freon coolant loop. A faulty indication has the potential for a demated connector at the PDU resulting in loss of motor function.

CAUSES OF EXCEEDING REDLINE:

(13) Failure type: Indication ON/should be OFF. Instrumentation failure.
(14) Failure type: Indication OFF/should be ON. Instrumentation failure, open circuit or improperly positioned latch/radiator.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: Mechanical

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LCC VIOLATION CALL: Payload Bay Door Open Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V98X3307X	PBD Right Open 1	(2)	OFF	NA	Event	CI
V98X3327X	PBD Right Open 2	(2)	OFF	NA	Event	CI
V98X3367X	PBD Left Open 1	(2)	OFF	NA	Event	CI
V98X3347X	PBD Left Open 2	(2)	OFF	NA	Event	CI

TIME PERIOD:

(1) From BFS OPS 101 Transition (T-17 minutes) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown. (4)

PREPLANNED CONTINGENCY PROCEDURE:

(3) All troubleshooting will require transition to G9 format 42 or equivalent for ability to send commands and observe indications.
(4) Failure type: Open indication ON/should be OFF.
   A. Leave AC power ON and issue PLB door open commands (PDU is isolated from AC power by enable relays). Monitor MCA operational status.
   B. If the MCA operational status inverts, the relay has activated (MCA does not see the indication ON), the failure is confirmed instrumentation loss. Motor function is not lost (still have dual motor opening capability), LCC violation cleared, continue countdown.
   C. If MCA operational status does not invert, the relay is being inhibited by the open indication and dual motor opening capability is lost, LCC violation confirmed, No Go for launch.

NOTES:

(5) OFI measurement number equivalents (unavailable downlink):
V98X3307X - PBD Right Open 1 - V37X3300Y
V98X3327X - PBD Right Open 2 - V37X3301Y Available in
V98X3367X - PBD Left Open 1 - V37X3305Y OPS 2
V98X3347X - PBD Left Open 2 - V37X3306Y

REDLINE DERIVATION: CRITICALITY: 1R

(6) Redline ensures two-motor opening capability for Payload Bay doors.
(7) Flight rules require as a minimum 1 of 2 motors opening capability and 2 of 2 motors closing capability.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Presence of faulty open indication results in loss of dual motor capability for opening the Payload Bay Door drive system. Failure of both indications for the same group of Payload Bay Door drive system indications results in loss of capability to open that Payload Bay Door drive system.

CAUSES OF EXCEEDING REDLINE:

(9) Instrumentation failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 14.2	SHEET 1	ZONE B-I
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS72-956099	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: Mechanical

LCC VIOLATION CALL: Payload Bay Door Bulkhead Latch Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V98X3343X1	PBD Left Fwd Bhd Latch - Rel 1	(2)	OFF	NA	Event	CI
V98X3363X1	PBD Left Fwd Bhd Latch - Rel 2	(2)	OFF	NA	Event	CI
V98X3344X1	PBD Left Fwd Bhd Latch - Lch 1	(3)	ON	NA	Event	CI
V98X3364X1	PBD Left Fwd Bhd Latch - Lch 2	(3)	ON	NA	Event	CI
V98X3345X1	PBD Left Aft Bhd Latch - Rel 1	(2)	OFF	NA	Event	CI
V98X3365X1	PBD Left Aft Bhd Latch - Rel 2	(2)	OFF	NA	Event	CI
V98X3346X1	PBD Left Aft Bhd Latch - Lch 1	(3)	ON	NA	Event	CI
V98X3366X1	PBD Left Aft Bhd Latch - Lch 2	(3)	ON	NA	Event	CI
V98X3303X1	PBD Right Fwd Bhd Latch - Rel 1	(2)	OFF	NA	Event	CI
V98X3323X1	PBD Right Fwd Bhd Latch - Rel 2	(2)	OFF	NA	Event	CI
V98X3304X1	PBD Right Fwd Bhd Latch - Lch 1	(3)	ON	NA	Event	CI
V98X3324X1	PBD Right Fwd Bhd Latch - Lch 2	(3)	ON	NA	Event	CI
V98X3325X1	PBD Right Aft Bhd Latch - Rel 1	(2)	OFF	NA	Event	CI
V98X3305X1	PBD Right Aft Bhd Latch - Rel 2	(2)	OFF	NA	Event	CI
V98X3326X1	PBD Right Aft Bhd Latch - Lch 1	(3)	ON	NA	Event	CI
V98X3306X1	PBD Right Aft Bhd Latch - Lch 2	(3)	ON	NA	Event	CI

TIME PERIOD:

(1) From BFS OPS 101 Transition (T-17 minutes) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown.
(3) For confirmed instrumentation failure, verify dual motor function, LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE:

(4) All troubleshooting will require transition to G9 format 42 or equivalent for ability to send commands and observe indications.
(5) Failure type: Release indication ON/should be OFF.
   A. Leave AC power ON and issue release command (PDU is isolated from AC power by enable relays). Monitor MCA operational status.
   B. If the MCA operational status inverts, the relay has activated (MCA does not see the indication ON), the failure is confirmed instrumentation loss. Motor function is not lost (still have dual motor release capability), LCC violation cleared, continue countdown.
   C. If the MCA operational status does not invert, the relay is being inhibited by the release indication and dual motor release capability is lost. LCC violation confirmed, No Go for launch.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

(6) Failure type: Latch indication OFF/should be ON.
   A. Leave AC power ON and turn ON PLB door enables and issue latch command. Monitor MCA operational status and AC currents (5 seconds max).
   B. If the MCA operational status does not invert, the relay is still being inhibited by a latched indication in the MCA, the failure is confirmed instrumentation loss. Connector integrity is good, dual motor function maintained and latch position is verified. Latch position is also confirmed by the other limit switch. LCC violation cleared, continue countdown.
   C. If the MCA operational status does invert and the limit switch is picked up, LCC violation cleared, continue countdown.
   D. If the limit switch is not picked up but the other limit switch is ON (CONF POSN) and there is AC power draw on all 3 phases (connector integrity), LCC violation cleared, continue countdown.
   E. If there is no AC power draw, LCC violation confirmed, No Go for launch. There may be a demated connector and loss of dual motor release and latch capability.

NOTES:

(7) OFI Measurement number equivalents:

V98X3343X1 - V37X3320Y1	V98X3346X1 - V37X3360Y1	V98X3324X1 - V37X3441Y1
V98X3363X1 - V37X3321Y1	V98X3366X1 - V37X3361Y1	V98X3325X1 - V37X3450Y1
V98X3344X1 - V37X3330Y1	V98X3303X1 - V37X3430Y1	V98X3305X1 - V37X3451Y1
V98X3364X1 - V37X3331Y1	V98X3323X1 - V37X3431Y1	V98X3326X1 - V37X3460Y1
V98X3345X1 - V37X3350Y1	V98X3304X1 - V37X3440Y1	V98X3306X1 - V37X3461Y1
V98X3365X1 - V37X3351Y1		

(8) Measurements are only available in G9 format. V37 measurements are not accessible in OPS 1.

REDLINE DERIVATION: CRITICALITY: 1R

(9) Failure type: Indication ON/should be OFF. Ensures dual motor operational capability for Payload Bay Door bulkhead latch release.
(10) Failure type: Indication OFF/should be ON. Ensures that the Payload Bay Door bulkhead latches are properly latched for launch and ascent. Ensures connector integrity and, therefore, dual motor capability.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Failure type: Indication ON/should be OFF. Presence of faulty release indication results in loss of dual motor capability for releasing the Payload Bay Door bulkhead latch. Failure of both indications for the same group of Payload Bay Door bulkhead latches results in loss of capability to release that group of Payload Bay Door bulkhead latches.
(12) Failure type: Indication OFF/should be ON. Payload Bay Door bulkhead latches improperly configured for launch and ascent may incur structural damage. A faulty indication has the potential for a demated connector at the PDU resulting in loss of motor function.

CAUSES OF EXCEEDING REDLINE:

(13) Failure type: Indication ON/should be OFF. Instrumentation failure.
(14) Failure type: Indication OFF/should be ON. Instrumentation failure, open circuit or improperly positioned latch.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: Mechanical

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LCC VIOLATION CALL: Payload Bay Door Ready-To-Latch Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V98X3301X	PBD R Fwd Bhd Ready For Lch 1	2	ON	NA	Event	CI
V98X3321X	PBD R Fwd Bhd Ready For Lch 2	of	ON	NA	Event	CI
V98X3401X	PBD R Fwd Bhd Ready For Lch 3	3	ON	NA	Event	CI
V98X3302X	PBD R Aft Bhd Ready For Lch 1	2	ON	NA	Event	CI
V98X3322X	PBD R Aft Bhd Ready For Lch 2	of	ON	NA	Event	CI
V98X3402X	PBD R Aft Bhd Ready For Lch 3	3	ON	NA	Event	CI
V98X3341X	PBD L Fwd Bhd Ready For Lch 1	2	ON	NA	Event	CI
V98X3381X	PBD L Fwd Bhd Ready For Lch 2	of	ON	NA	Event	CI
V98X3361X	PBD L Fwd Bhd Ready For Lch 3	3	ON	NA	Event	CI
V98X3342X	PBD L Aft Bhd Ready For Lch 1	2	ON	NA	Event	CI
V98X3382X	PBD L Aft Bhd Ready For Lch 2	of	ON	NA	Event	CI
V98X3362X	PBD L Aft Bhd Ready For Lch 3	3	ON	NA	Event	CI

TIME PERIOD:

(1) From BFS OPS 101 Transition (T-17 minutes) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) 2 of 3 ready-to-latch indications ON is acceptable for each location.

PREPLANNED CONTINGENCY PROCEDURE:

(3) Failure type: Ready-To-Latch indication OFF/should be ON.
A. There is no troubleshooting for this anomaly without opening the PLB doors.

NOTES:

(4) OFI measurement number equivalents:

V98X3301X - V37X3435Y	V98X3341X - V37X3325Y	
V98X3321X - V37X3436Y	V98X3381X - V37X3326Y	
V98X3401X - V37X3437Y	V98X3361X - V37X3327Y	Available in
V98X3302X - V37X3455Y	V98X3342X - V37X3355Y	OPS 2
V98X3322X - V37X3456Y	V98X3382X - V37X3356Y	
V98X3402X - V37X3457Y	V98X3362X - V37X3357Y	

(5) Measurements are only available in G9 format. V37 measurements are not accessible in OPS 1.

REDLINE DERIVATION: CRITICALITY: 1R

(6) Ensures redundant visibility to door position during closure.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Payload Bay doors auto mode latching operations (in-flight) will be lost, requiring use of manual mode. Aft bulkhead has ID marks to indicate when door is in capture range of bulkhead latches. ID marks may not be visible with some payloads.

CAUSES OF EXCEEDING REDLINE:

(8) Instrumentation failure.
(9) Open circuit.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 14.2	SHEET 1	ZONE A-K
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS72-956099	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: Mechanical

LCC VIOLATION CALL: Payload Bay Door Centerline Latch Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V98X3383X1	PBD Centerline Lch 1-4 Rel 1	(2)	OFF	NA	Event	CI
V98X3403X1	PBD Centerline Lch 1-4 Rel 2	(2)	OFF	NA	Event	CI
V98X3384X1	PBD Centerline Lch 1-4 Lch 1	(3)	ON	NA	Event	CI
V98X3404X1	PBD Centerline Lch 1-4 Lch 2	(3)	ON	NA	Event	CI
V98X3385X1	PBD Centerline Lch 5-8 Rel 1	(2)	OFF	NA	Event	CI
V98X3405X1	PBD Centerline Lch 5-8 Rel 2	(2)	OFF	NA	Event	CI
V98X3386X1	PBD Centerline Lch 5-8 Lch 1	(3)	ON	NA	Event	CI
V98X3406X1	PBD Centerline Lch 5-8 Lch 2	(3)	ON	NA	Event	CI
V98X3388X1	PBD Centerline Lch 9-12 Rel 1	(2)	OFF	NA	Event	CI
V98X3408X1	PBD Centerline Lch 9-12 Rel 2	(2)	OFF	NA	Event	CI
V98X3387X1	PBD Centerline Lch 9-12 Lch 1	(3)	ON	NA	Event	CI
V98X3407X1	PBD Centerline Lch 9-12 Lch 2	(3)	ON	NA	Event	CI
V98X3410X1	PBD Centerline Lch 13-16 Rel 1	(2)	OFF	NA	Event	CI
V98X3390X1	PBD Centerline Lch 13-16 Rel 2	(2)	OFF	NA	Event	CI
V98X3409X1	PBD Centerline Lch 13-16 Lch 1	(3)	ON	NA	Event	CI
V98X3389X1	PBD Centerline Lch 13-16 Lch 2	(3)	ON	NA	Event	CI

TIME PERIOD:

(1) From BFS OPS 101 Transition (T-17 minutes) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown.
(3) For confirmed instrumentation failure, verify dual motor function, LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE:

(4) All troubleshooting will require transition to G9 format 42 or equivalent for ability to send commands and observe indications.
(5) Failure type: Release indication ON/should be OFF.
   A. Leave AC power ON and issue release command (PDU is isolated from the AC power by enable relays). Monitor MCA operational status.
   B. If the MCA operational status inverts, the relay has activated (MCA does not see the indication ON), the failure is confirmed instrumentation loss. Motor function is not lost (still have dual motor release capability), LCC violation cleared, continue countdown.
   C. If the MCA operational status does not invert, the relay is being inhibited by the release indication and dual motor release capability is lost. LCC violation confirmed, No Go for launch.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

(6) Failure type: Latch indication OFF/should be ON.
   A. Leave AC power ON and turn on PLB door enables and issue latch command. Monitor MCA operational status and AC current (5 seconds max).
   B. If the MCA operational status does not invert, the relay is still being inhibited by a latched indication in the MCA, the failure is confirmed instrumentation loss. Connector integrity is good, dual motor function maintained and latch position is verified. Latch position is also confirmed by the other limit switch, LCC violation cleared, continue countdown.
   C. If the MCA operational status does invert and the limit switch is picked up, LCC violation cleared, continue countdown.
   D. If the limit switch is not picked up but the other limit switch is ON (CONF POSN) and there is AC power draw on all 3 phases (connector integrity), LCC violation cleared, continue countdown.
   E. If there is no AC power draw, LCC violation confirmed, No Go for launch. There may be a demated connector and loss of dual motor release and latch capability.

NOTES:

(7) OFI measurement number equivalents:

V98X3383X1 - V37X3380Y1	V98X3386X1 - V37X3395Y1	V98X3407X1 - V37X3401Y1
V98X3403X1 - V37X3381Y1	V98X3406X1 - V37X3396Y1	V98X3410X1 - V37X3415Y1
V98X3384X1 - V37X3385Y1	V98X3388X1 - V37X3405Y1	V98X3390X1 - V37X3416Y1
V98X3404X1 - V37X3386Y1	V98X3408X1 - V37X3406Y1	V98X3409X1 - V37X3410Y1
V98X3385X1 - V37X3390Y1	V98X3387X1 - V37X3400Y1	V98X3389X1 - V37X3411Y1
V98X3405X1 - V37X3391Y1		

(8) V37 measurements are not accessible in OPS 1.

REDLINE DERIVATION: CRITICALITY: 1R

(9) Failure type: Indication ON/should be OFF. Ensure dual motor operational capability for Payload Bay Door centerline latch release.
(10) Failure type: Indication OFF/should be ON. Ensures that the Payload Bay Door centerline latches are properly latched for launch and ascent. Ensures connector integrity, and therefore, dual motor capability.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Failure type: Indication ON/should be OFF. Presence of faulty release indication results in loss of dual motor capability for releasing the Payload Bay Door centerline latches. Failure of both indications for the same group of Payload Bay Door centerline latches results in loss of capability to release that group of Payload Bay Door centerline latches.
(12) Failure type: Indication OFF/should be ON. Payload Bay Door centerline latch improperly configured for launch and ascent could incur structural damage. A faulty indication has the potential for a demated connector at the PDU resulting in loss of motor function.

CAUSES OF EXCEEDING REDLINE:

(13) Failure type: Indication ON/should be OFF. Instrumentation failure.
(14) Failure type: Indication OFF/should be ON. Instrumentation failure, open circuit or improperly positioned latch/door.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: Mechanical

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LCC VIOLATION CALL: Landing Gear Uplock Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V51X0115E	LMG/Door Uplocked		ON	NA	Event	CI
V51X0215E	RMG/Door Uplocked		ON	NA	Event	CI
V51X0315E	NLG/Door Uplocked		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown.(3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Failure type: Indication OFF/should be ON.
A. If associated GEAR UPLOCK and DOOR UPLOCK indications are both ON, failure is confirmed instrumentation loss only, LCC violation cleared, continue countdown.
Constituent indications (inputs) for gear/door uplock indications are as follows:

	GEAR/DOOR UPLOCK		GEAR UPLOCK		DOOR UPLOCK
L MAIN	V51X0115E	=	V51X0100X 1 = ON	AND	V51X0116X 0 = ON
R MAIN	V51X0215E	=	V51X0200X 1 = ON	AND	V51X0216X 0 = ON
NOSE	V51X0315E	=	V51X0300X 1 = ON	AND	V51X0310X 1 = ON

B. For all other conditions, LCC violation confirmed, No Go for Launch.

NOTES:

(4) Panel F6 and F8 Landing Gear Talkbacks use V51X0X15E ("UP") and V51X0X25E ("DOWN") as inputs.

REDLINE DERIVATION: CRITICALITY: 1

(5) Redline confirms position of landing gear and doors. It ensures all landing gear struts and doors are in proper configuration for flight, and all proximity sensors associated with the gear uplock and door uplock are functional.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Loss of gear/door uplock indication could indicate non-secure landing gear, resulting in inadvertent landing gear extension.
(7) Loss of either gear or door uplock proximity sensor will result in loss of one of two redundant strings within the back up pyrotechnic method of landing gear deployment for the gear associated with the lost indication. Next failure will result in only one method for gear deployment (zero fault tolerant) and requires next PLS contingency landing per flight rule A2-301 and A10-1001.
(8) Reference Orbiter Hazard Reports ORBI 182 (Premature Landing Gear Deployment) and ORBI 188 (Lack of or Imcomplete Landing Gear Deployment).

CAUSES OF EXCEEDING REDLINE:

(9) Instrumentation Failure
(10) Open Circuit
(11) Landing gear may be improperly positioned.
(12) Proximity sensor failure.
(13) Improper rigging adjustment of sensor

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 13.1	SHEET 2	ZONE A-H
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-958099	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: Mechanical

LCC VIOLATION CALL: Landing Gear Shuttle Valve Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V58X1725E	LMG Str Actr Shuttle V Gr Dn Rdy		ON	NA	Event	CI
V58X1775E	RMG Str Actr Shuttle V Gr Dn Rdy		ON	NA	Event	CI
V58X1825E	NLG Str Actr Shuttle V Gr Dn Rdy		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE:

(3) Connect a breakout box at the landing gear ground support unit interface connector on the crew deck. Check for voltage on the shuttle valve indication pins. If indications are ON (28 Vdc from shuttle valves), shuttle valves are in the proper launch configuration, the anomaly is an instrumentation failure, LCC violation cleared, continue countdown. If any indication is OFF (0 Vdc), LCC violation confirmed, No Go for launch. This procedure must be implemented prior to cabin closeout. Flight deck access is required to perform this procedure.

NOTES:

(4) Measurements are available in OI.

REDLINE DERIVATION: CRITICALITY: 1

(5) Ensures shuttle valve is properly positioned for landing gear deployment.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Presence of faulty shuttle valve indication results in possibility that landing gear cannot be deployed. Shuttle valve improperly positioned prohibits gear deployment.

CAUSES OF EXCEEDING REDLINE:

(7) Instrumentation failure or open circuit.
(8) Improperly positioned shuttle valve.
(9) Presence of hydraulic pressure on landing gear retract circuit.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 13.1	SHEET 2	ZONE A-H
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-958099	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: Mechanical

LCC VIOLATION CALL: RMS Deploy/Stow Mechanism Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V54X0810E1	Port RMS Shld Pos Mech Depl Ind 1	(2)	OFF	NA	Event	CI
V54X0811E1	Port RMS Shld Pos Mech Depl Ind 2	(2)	OFF	NA	Event	CI
V54X0820E1	Port RMS Shld Pos Mech Stowed Ind1	(3)	ON	NA	Event	CI
V54X0821E1	Port RMS Shld Pos Mech Stowed Ind2	(3)	ON	NA	Event	CI
V54X0822E1	Port RMS Fwd Pos Mech Stowed Ind 1	(4)	ON	NA	Event	CI
V54X0823E1	Port RMS Fwd Pos Mech Stowed Ind 2	(4)	ON	NA	Event	CI
V54X0824E1	Port RMS Mid Pos Mech Stowed Ind 1	(4)	ON	NA	Event	CI
V54X0825E1	Port RMS Mid Pos Mech Stowed Ind 2	(4)	ON	NA	Event	CI
V54X0826E1	Port RMS Aft Pos Mech Stowed Ind 1	(4)	ON	NA	Event	CI
V54X0827E1	Port RMS Aft Pos Mech Stowed Ind 2	(4)	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown (for planned mission use).
(3) For confirmed instrumentation failure verify single motor function capability, LCC violation cleared, continue countdown (if RMS is installed).
(4) 1 of 2 indications acceptable.
(5) Mission dependent: This SSID is effective on missions with RMS installed and with required mission use. Reference Appendix H, SSID MEL-13, for mission specific requirements.

PREPLANNED CONTINGENCY PROCEDURE:

(6) Failure type: Forward, mid or aft Pedestal Stow indication OFF/should be ON.
A. No troubleshooting this failure.
(7) Failure type: Shoulder Deploy indication ON/should be OFF.
A. Leave AC power ON and issue MPM deploy switch command (PDU is isolated from AC power by PLB mechanical power switch). Monitor MCA operational status.
B. If the MCA operational status inverts, the relay has activated (MCA does not see the indication ON), the failure is confirmed instrumentation loss. Motor function is not lost (still have dual motor deploy capability), LCC violation cleared, continue countdown.
C. If MCA operational status does not invert, the relay is being inhibited by the deploy indication and dual motor deploy capability is lost. LCC violation confirmed, No Go for launch.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

(8) Failure type: Shoulder Stowed indication OFF/should be ON.
   A. Leave AC power ON and issue stow switch command. Monitor MCA operational status.
   B. If the MCA operational status does not invert, the relay is still being inhibited by the stowed indication in the MCA, the failure is confirmed instrumentation loss. Connector integrity is good, dual motor function maintained and drive mechanism position is verified. Drive mechanism position is also confirmed by the other limit switch, LCC violation cleared, continue countdown.
   C. If the MCA operational status does invert, turn ON PLB mechanical power and monitor AC current (5 seconds max).
   D. If the limit switch is picked up, LCC violation cleared, continue countdown.
   E. If the limit switch is not picked up but the other limit switch is ON (CONF POSN) and there is AC power draw on all 3 phases (connector integrity), LCC violation cleared, continue countdown.
   F. If there is no AC power draw, LCC violation confirmed, No Go for launch. There may be a demated connector and loss of dual motor capability.

NOTES:

(9) Measurements available in OI.
(10) Stow/deploy indications are not on the PDU AC connector; therefore, indications do not verify connector integrity.

REDLINE DERIVATION: CRITICALITY: 1R

(11) Failure type: Indication ON/should be OFF. Ensures dual motor operational capability for RMS deploy.
(12) Failure type: Indication OFF/should be ON. Ensures that the RMS is properly stowed for launch and ascent. Ensures connector integrity and therefore dual motor capability.

CONSEQUENCES OF EXCEEDING REDLINE:

(13) Failure type: Indication ON/should be OFF. Presence of faulty shoulder deploy indications results in loss of dual motor capability for deploying the RMS. Failure of both indications for shoulder deploy results in loss of capability to deploy the RMS.
(14) Failure type: Indication OFF/should be ON. RMS improperly configured for launch and ascent may cause RMS to deploy prematurely resulting in structural damage.

CAUSES OF EXCEEDING REDLINE:

(15) Failure type: Indication ON/should be OFF. Instrumentation failure.
(16) Failure type: Indication OFF/should be ON. Instrumentation failure, open circuit or improperly positioned RMS pedestal/shoulder.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: Mechanical

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LCC VIOLATION CALL: RMS Retention Latch Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V54X0870E1	Port RMS Fwd Retnn Lch-Rel Ind 1	(2)	OFF	NA	Event	CI
V54X0871E1	Port RMS Fwd Retnn Lch-Rel Ind 2	(2)	OFF	NA	Event	CI
V54X0860E1	Port RMS Fwd Retnn Lch-Lch Ind 1	(3)	ON	NA	Event	CI
V54X0861E1	Port RMS Fwd Retnn Lch-Lch Ind 2	(3)	ON	NA	Event	CI
V54X0872E1	Port RMS Mid Retnn Lch-Rel Ind 1	(2)	OFF	NA	Event	CI
V54X0873E1	Port RMS Mid Retnn Lch-Rel Ind 2	(2)	OFF	NA	Event	CI
V54X0862E1	Port RMS Mid Retnn Lch-Lch Ind 1	(3)	ON	NA	Event	CI
V54X0863E1	Port RMS Mid Retnn Lch-Lch Ind 2	(3)	ON	NA	Event	CI
V54X0874E1	Port RMS Aft Retnn Lch-Rel Ind 1	(2)	OFF	NA	Event	CI
V54X0875E1	Port RMS Aft Retnn Lch-Rel Ind 2	(2)	OFF	NA	Event	CI
V54X0864E1	Port RMS Aft Retnn Lch-Lch Ind 1	(3)	ON	NA	Event	CI
V54X0865E1	Port RMS Aft Retnn Lch-Lch Ind 2	(3)	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure (for planned mission use), LCC violation cleared, continued countdown.
(3) For confirmed instrumentation failure (if RMS is installed), LCC violation cleared, continue countdown.
(4) Mission dependent: This SSID is effective on missions with the RMS installed and mandatory for mission success. See Appendix H, SSID MEL-13, for mission specific requirements.

PREPLANNED CONTINGENCY PROCEDURE:

(5) Failure type: Latch indication ON/should be OFF.
   A. Leave AC power ON, issue MPM release switch command (PDU is isolated from AC power by PLB mechanical power switch). Monitor MCA operational status.
   B. If the MCA operational status inverts, the relay has activated (MCA does not see the indication ON), the failure is confirmed instrumentation loss. Motor function is not lost (still have dual motor release capability), LCC violation cleared, continue countdown.
   C. If MCA operational status does not invert, the relay is being inhibited by the latch indication and dual motor release capability is lost. LCC violation confirmed, No Go for launch.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

(6) Failure type: Latch indication OFF/should be ON.
   A. Leave AC power ON and issue latch switch command. Monitor MCA operational status.
   B. If the MCA operational status does not invert, the relay is still being inhibited by the latched indication in the MCA, the failure is confirmed instrumentation loss. Connector integrity is good and latch position is verified. Latch position is also confirmed by the other limit switch, LCC violation cleared, continue countdown.
   C. If the MCA operational status does invert, turn ON PLB mechanical power and monitor AC current (5 seconds max).
   D. If the limit switch is picked up, LCC violation cleared, continue countdown.
   E. If the limit switch is not picked up but the other limit switch is ON (CONF POSN) and there is AC power draw on all 3 phases (connector integrity verified) LCC violation cleared, continue countdown.
   F. If there is no AC power draw, LCC violation confirmed, No Go for launch. There may be a demated connector and loss of dual motor capability.

NOTES:

(7) Measurements available in OI.
(8) Release/latch indications are not on PDU AC connectors; therefore, indications do not verify connector integrity.

REDLINE DERIVATION: CRITICALITY: 1R

(9) Failure type: Indication ON/should be OFF. Ensures dual motor operational capability for RMS retention latch release.
(10) Failure type: Indication OFF/should be ON. Ensures that the RMS is properly latched for launch and ascent. Ensures connector integrity therefore dual motor capability.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Failure type: Indication ON/should be OFF. Presence of faulty release indication results in loss of dual motor capability for releasing the RMS retention latches. Failure of both indications for the same group of RMS retention latches results in loss of capability to release the RMS.
(12) Failure type: Indication OFF/should be ON. RMS retention latches improperly configured for launch and ascent may allow the RMS to become unrestrained causing structural damage.

CAUSES OF EXCEEDING REDLINE:

(13) Failure type: Indication ON/should be OFF. Instrumentation failure.
(14) Failure type: Indication OFF/should be ON. Instrumentation failure, open circuit or improperly positioned retention latch.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: Mechanical

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LCC VIOLATION CALL: Star Tracker Door Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V59X1005X	Star Trkr-Y Door Closed 1		ON	NA	Event	CI
V59X1015X	Star Trkr-Y Door Closed 2		ON	NA	Event	CI
V59X1055X	Star Trkr-Y Door Open 1		OFF	NA	Event	CI
V59X1065X	Star Trkr-Y Door Open 2		OFF	NA	Event	CI
V59X1205X	Star Trkr-Z Door Closed 1		ON	NA	Event	CI
V59X1215X	Star Trkr-Z Door Closed 2		ON	NA	Event	CI
V59X1255X	Star Trkr-Z Door Open 1		OFF	NA	Event	CI
V59X1265X	Star Trkr-Z Door Open 2		OFF	NA	Event	CI

TIME PERIOD:

(1) From OPS 1 Transition complete (T-19 minutes) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) 7 of 8 indications are acceptable. If instrumentation failure can be confirmed for subsequent indication failures, LCC violation cleared, continue countdown.
(3) Two-fault tolerance for alignment capability is required.
(4) Doors must be CLOSED for launch.
(5) The capability to open both star tracker doors is required and one-fault tolerance for opening one door is required.
(6) For confirmed connector integrity, LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE:

(7) Failure type: Open indication ON/should be OFF.
   A. Verify star tracker power is OFF and issue open switch command. Monitor MCA operational status.
   B. If the MCA operational status inverts, the relay has activated (MCA does not see the indication ON), the failure is confirmed instrumentation loss. Motor function is not lost (still have single motor opening capability), LCC violation cleared, continue countdown.
   C. If MCA operational status does not invert, the relay is being inhibited by the open indication and single motor opening capability is lost. LCC violation confirmed, No Go for launch.
(8) Failure type: Closed indication OFF/should be ON.
   A. Leave AC power ON and issue door close switch command. Monitor MCA operational status and AC current (5 seconds maximum).
   B. If MCA operational status does not invert, the relay is still being inhibited by a closed indication in the MCA, the failure is confirmed instrumentation loss. Connector integrity is good, LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

C. If the MCA operational status does invert and the limit switch is picked up, LCC violation cleared, continue countdown. Full-up capability remains to close the door.
D. If the limit switch is not picked up but there is AC power draw on all 3 phases (connector integrity) and close is verified via alternate close discrete on same door, LCC violation cleared, continue countdown.
E. If there is no AC power draw, LCC violation confirmed, No Go for launch. There may be a demated connector and loss of single motor close capability.

NOTES:

(9) The open and closed indications pass through the same connectors which supply power to the motors. An indication failed OFF could indicate a demated connector at one motor. An open indication failed ON will inhibit that motor in the OPEN direction.
(10) The star tracker doors must be closed for launch to prevent damage during ascent. 3 of 4 motors are required to provide sufficient fault tolerance for opening and closing doors. This ensures capability to open both doors and redundancy for opening one door. One star tracker door must be closed for entry. Entry with both doors failed open could be potentially catastrophic. If one door fails open, flight rules require closure of the other door to ensure at least one door is closed for entry. Launch with 3 of 4 motors operative provides redundant capability to close at least one door. This satisfies the two-fault avionics requirement for IMU alignment capability (considering the COAS as a back-up for the startrackers).
(11) This SSID does not protect one-fault tolerance for closing both doors for entry. In choosing to launch with one door motor failed or suspect, the option exists on-orbit to open only the door with redundant close capability. Using only one star tracker for IMU alignments will impact the attitude timeline and RCS budget.

REDLINE DERIVATION: CRITICALITY: 1R

(12) Failure type: Indication ON/should be OFF. Ensures dual motor opening capability for one star tracker door and single motor opening capability for the other door.
(13) Failure type: Indication OFF/should be ON. Ensures that star tracker doors are closed for launch. Ensures connector integrity and therefore dual motor control capability for one door and single motor control of the other door.

CONSEQUENCES OF EXCEEDING REDLINE:

(14) Failure type: Indication ON/should be OFF. Presence of faulty open indication results in loss of dual motor opening capability for that door. Failure of both indications on the same door results in loss of capability to open that door.

CONSEQUENCES OF EXCEEDING REDLINE: (Continued)

(15) Failure type: Indication OFF/should be ON. Star tracker door improperly configured for launch and ascent could result in damage to the star tracker. A faulty indication has the potential for a demated connector at the PDU resulting in loss of motor function.

CAUSES OF EXCEEDING REDLINE:

(16) Failure type: Indication ON/should be OFF. Instrumentation failure.
(17) Failure type: Indication OFF/should be ON. Instrumentation failure, open circuit or improperly positioned star tracker door.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 9.6	SHEET 1 of 2	ZONE 3,8/M,L
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: Mechanical

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LCC VIOLATION CALL: Air Data Probe Deploy/Stow Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V59X2600X	LH Air Data Probe Deploy 1	(2)	OFF	NA	Event	CI
V59X2602X	LH Air Data Probe Deploy 2	(2)	OFF	NA	Event	CI
V59X2604X	LH Air Data Probe Stow 1	(3)	ON	NA	Event	CI
V59X2606X	LH Air Data Probe Stow 2	(3)	ON	NA	Event	CI
V59X2700X	RH Air Data Probe Deploy 1	(2)	OFF	NA	Event	CI
V59X2702X	RH Air Data Probe Deploy 2	(2)	OFF	NA	Event	CI
V59X2704X	RH Air Data Probe Stow 1	(3)	ON	NA	Event	CI
V59X2706X	RH Air Data Probe Stow 2	(3)	ON	NA	Event	CI

TIME PERIOD:

(1) From Ops 1 Transition (T-19 minutes) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown.
(3) For confirmed instrumentation failure, verify dual motor function, LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE:

(4) Failure type: Deploy indication ON/should be OFF.
   A. Deploy and then stow the air data probe. Monitor MCA operational status and limit switches. Record timing.
   B. If the MCA operational status inverts and air data probe cycles within nominal dual motor time (15 seconds), the relay has activated (MCA does not see the indication ON), the failure is confirmed instrumentation loss. Motor function is not lost (still have dual motor deploy capability), LCC violation cleared, continue countdown.
   C. If the MCA operational status does not invert and the air data probe runs in single motor time, loss of two-fault tolerance, LCC violation confirmed, No Go for launch. There may be a demated connector and loss of dual motor deploy capability.
(5) Failure type: Stow indication OFF/should be ON.
   A. If a limit switch is lost in the MCA an operational status will be inverted due to the air data probe switch being in the stow position for launch.
   B. If the MCA operational status does not invert, the relay is still being inhibited by a stow indication in the MCA, the failure is confirmed instrumentation loss. Connector integrity is good, LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

C. If the MCA operational status does invert, leave the AC power ON and issue air data probe stow switch command and monitor the MCA operational status and AC current (5 seconds maximum).
D. If the limit switch is picked up, LCC violation cleared, continue countdown.
E. If the limit switch is not picked up but there is AC draw on all 3 phases (connector integrity), and stow is verified via alternate stow discrete on same side, LCC violation cleared, continue countdown.
F. If there is no AC power draw, LCC violation confirmed, No Go for launch. There may be a demated connector and loss of dual motor deploy capability.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(6) Failure type: Indication ON/should be OFF. Ensures dual motor deploy capability for air data probes.
(7) Failure type: Indication OFF/should be ON. Ensures that air data probe is stowed for launch. Ensures connector integrity and therefore dual motor deploy capability.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Failure type: Indication ON/should be OFF. Presence of faulty deploy indication results in loss of dual motor deploy capability. Failure of both indications on the same probe results in loss of capability to deploy that probe.
(9) Failure type: Indication OFF/should be ON. Air data probe improperly configured for launch and ascent could result in damage to probe. A faulty indication has the potential for a demated connector at the PDU resulting in loss of motor function.

CAUSES OF EXCEEDING REDLINE:

(10) Failure type: Indication ON/should be OFF. Instrumentation failure.
(11) Failure type: Indication OFF/should be ON. Instrumentation failure, open circuit or improperly positioned air data probe.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 9.9 SHEET 1 of 1 ZONE U-Q
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-971102 SHEET 69 ZONE

ELEMENT: Orbiter SUBSYSTEM: Mechanical

LCC VIOLATION CALL: Forward Motor Control Assembly Operational Status Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76X2111E	Fwd MCA 1 Operational Status 1		ON	NA	Event	CI
V76X2112E	Fwd MCA 1 Operational Status 2		ON	NA	Event	CI
V76X2113E	Fwd MCA 1 Operational Status 3		ON	NA	Event	CI
V76X2114E	Fwd MCA 1 Operational Status 4		ON	NA	Event	CI
V76X2121E	Fwd MCA 2 Operational Status 1		ON	NA	Event	CI
V76X2122E	Fwd MCA 2 Operational Status 2		ON	NA	Event	CI
V76X2123E	Fwd MCA 2 Operational Status 3		ON	NA	Event	CI
V76X2124E	Fwd MCA 2 Operational Status 4		ON	NA	Event	CI
V76X2131E	Fwd MCA 3 Operational Status 1		ON	NA	Event	CI
V76X2132E	Fwd MCA 3 Operational Status 2		ON	NA	Event	CI
V76X2133E	Fwd MCA 3 Operational Status 3		ON	NA	Event	CI
V76X2134E	Fwd MCA 3 Operational Status 4		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown.
(3) These criteria shall not apply during periods when vent doors are operated as part of planned launch procedures.

PREPLANNED CONTINGENCY PROCEDURE:

(4) Failure type: MCA Operational Status (Op Stat) OFF/should be ON:
   A. If any GPC or switch command associated with a subsystem function utilizing the affected MCA Op Stat string is found ON that should be off, then correct the command problem, verify proper end function position, LCC violation cleared, continue countdown.
   B. If troubleshooting can confirm instrumentation failure by verifying serial relay redundancy for all relays in the MCA Op Stat string (by commanding each affected MCA function), LCC violation cleared, continue countdown.

NOTES:

(5) Loss of all status indicators in a group represents possible loss of dc logic power.
(6) An OPERATE STATUS of "ON" is the "NO-OP" state. An "OFF" indicates closure of one or more relays providing 3-phase power to a drive motor.

REDLINE DERIVATION: CRITICALITY:

(7) This SSID ensures that uncommanded motor drive power is not present at FWD RCS Isolation valves. It also protects serial redundancy for Vent Door, Air Data Probe, and Star Tracker drive motor power.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Possible inadvertent operation of FWD RCS Isolation valves.
(9) Loss of redundant protection against inadvertent operation of Vent Doors, Star Tracker Doors, and Air Data Probes.
(10) Possible loss of critical LRU redundancy.

CAUSES OF EXCEEDING REDLINE:

(11) Instrumentation failure or open indicator circuit.
(12) Relay driver failed on.
(13) MDM output channel failed on.
(14) Loss of MCA logic power.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 2.4	SHEET 1	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: Mechanical

LCC VIOLATION CALL: Mid Motor Control Assembly Operational Status Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76X2211E	Mid MCA 1 Operational Status 1		ON	NA	Event	CI
V76X2212E	Mid MCA 1 Operational Status 2		ON	NA	Event	CI
V76X2213E	Mid MCA 1 Operational Status 3		ON	NA	Event	CI
V76X2214E	Mid MCA 1 Operational Status 4		ON	NA	Event	CI
V76X2215E	Mid MCA 1 Operational Status 5		ON	NA	Event	CI
V76X2216E	Mid MCA 1 Operational Status 6		ON	NA	Event	CI
V76X2217E	Mid MCA 1 Operational Status 7		ON	NA	Event	CI
V76X2218E	Mid MCA 1 Operational Status 8		ON	NA	Event	CI
V76X2221E	Mid MCA 2 Operational Status 1		ON	NA	Event	CI
V76X2222E	Mid MCA 2 Operational Status 2		ON	NA	Event	CI
V76X2223E	Mid MCA 2 Operational Status 3		ON	NA	Event	CI
V76X2224E	Mid MCA 2 Operational Status 4		ON	NA	Event	CI
V76X2225E	Mid MCA 2 Operational Status 5		ON	NA	Event	CI
V76X2226E	Mid MCA 2 Operational Status 6		ON	NA	Event	CI
V76X2227E	Mid MCA 2 Operational Status 7		ON	NA	Event	CI
V76X2228E	Mid MCA 2 Operational Status 8		ON	NA	Event	CI
V76X2231E	Mid MCA 3 Operational Status 1		ON	NA	Event	CI
V76X2232E	Mid MCA 3 Operational Status 2		ON	NA	Event	CI
V76X2233E	Mid MCA 3 Operational Status 3		ON	NA	Event	CI
V76X2234E	Mid MCA 3 Operational Status 4		ON	NA	Event	CI
V76X2235E	Mid MCA 3 Operational Status 5		ON	NA	Event	CI
V76X2236E	Mid MCA 3 Operational Status 6		ON	NA	Event	CI
V76X2237E	Mid MCA 3 Operational Status 7		ON	NA	Event	CI
V76X2238E	Mid MCA 3 Operational Status 8		ON	NA	Event	CI
V76X2241E	Mid MCA 4 Operational Status 1		ON	NA	Event	CI
V76X2242E	Mid MCA 4 Operational Status 2		ON	NA	Event	CI
V76X2243E	Mid MCA 4 Operational Status 3		ON	NA	Event	CI
V76X2244E	Mid MCA 4 Operational Status 4		ON	NA	Event	CI
V76X2245E	Mid MCA 4 Operational Status 5		ON	NA	Event	CI
V76X2246E	Mid MCA 4 Operational Status 6		ON	NA	Event	CI
V76X2247E	Mid MCA 4 Operational Status 7		ON	NA	Event	CI
V76X2248E	Mid MCA 4 Operational Status 8		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown.
(3) These criteria shall not apply during periods when vent doors are operated as part of planned launch procedures.

PREPLANNED CONTINGENCY PROCEDURE:

(4) Failure type: MCA Operational Status (Op Stat) OFF/should be ON:
   A. If any GPC or switch command associated with a subsystem function utilizing the affected MCA Op Stat string is found ON that should be off, then correct the command problem, verify proper end function position, LCC violation cleared, continue countdown.
   B. If troubleshooting can confirm instrumentation failure by verifying serial relay redundancy for all relays in the MCA Op Stat string (by commanding each affected MCA function), LCC violation cleared, continue countdown.

NOTES:

(5) Loss of all status indicators in a group represents possible loss of dc logic power.
(6) An OPERATE STATUS of "ON" is the "NO-OP" state. An "OFF" indicates closure of one or more relays providing 3-phase power to a driver motor.

REDLINE DERIVATION: CRITICALITY:

(7) This SSID provides visibility of serial redundancy for Vent Door, Payload Bay Door latches, Freon Radiator, RMS Retention Latch, and Ku-Band Antenna drive motor power.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Loss of visibility into redundant protection against inadvertent operation of Vent Doors, Payload Bay Doors latches, Freon Radiators, RMS and Ku-Band Antenna deploy.
(9) Possible loss of critical LRU redundancy.

CAUSES OF EXCEEDING REDLINE:

(10) Instrumentation failure or open indicator circuit.
(11) Relay failed on.
(12) MDM output channel failed on.
(13) Loss of MCA logic power.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 2.4	SHEET 2,3	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: Mechanical

LCC VIOLATION CALL: Aft Motor Control Assembly Operational Status Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76X2251E	Aft MCA 1 Operational Status 1		ON	NA	Event	CI
V76X2252E	Aft MCA 1 Operational Status 2		ON	NA	Event	CI
V76X2253E	Aft MCA 1 Operational Status 3		ON	NA	Event	CI
V76X2254E	Aft MCA 1 Operational Status 4		ON	NA	Event	CI
V76X2261E	Aft MCA 2 Operational Status 1		ON	NA	Event	CI
V76X2262E	Aft MCA 2 Operational Status 2		ON	NA	Event	CI
V76X2263E	Aft MCA 2 Operational Status 3		ON	NA	Event	CI
V76X2264E	Aft MCA 2 Operational Status 4		ON	NA	Event	CI
V76X2271E	Aft MCA 3 Operational Status 1		ON	NA	Event	CI
V76X2272E	Aft MCA 3 Operational Status 2		ON	NA	Event	CI
V76X2273E	Aft MCA 3 Operational Status 3		ON	NA	Event	CI
V76X2274E	Aft MCA 3 Operational Status 4		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown.
(3) These criteria shall not apply during periods when vent doors and cross feed valves are operated as part of planned launch procedures.

PREPLANNED CONTINGENCY PROCEDURE:

(4) Failure type: MCA Operational Status (Op Stat) OFF/should be ON:
   A. If any GPC or switch command associated with a subsystem function utilizing the affected MCA Op Stat string is found ON that should be OFF, then correct the command problem, verify proper end function position, LCC violation cleared, continue countdown.
   B. If troubleshooting can confirm instrumentation failure by verifying serial relay redundancy for all relays in the MCA Op Stat string (by commanding each affected MCA function), LCC violation cleared, continue countdown.

NOTES:

(5) Loss of all status indicators in a group represents possible loss of dc logic power.
(6) AN OPERATE STATUS of "ON" is the "NO-OP" state. An "OFF" indicates closure of one or more relays providing 3-phase power to a drive motor.

REDLINE DERIVATION: CRITICALITY:

(7) This SSID provides visibility that uncommanded motor drive power is not present at Aft RCS Isolation and Crossfeed Valves, and OMS Isolation and Crossfeed Valves. It provides visibility of serial redundancy for Vent Door, ET Umbilical Door and latch motor power.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Possible inadvertent operation of Aft RCS Isolation or Crossfeed Valves, or OMS Isolation or Crossfeed Valves.
(9) Loss of visibility into redundant protection against inadvertent operation of Vent doors and ET Umbilical door latches.
(10) Possible loss of critical LRU redundancy.

CAUSES OF EXCEEDING REDLINE:

(11) Instrumentation failure or open indicator circuit.
(12) Relay failed on.
(13) MDM output channel failed on.
(14) Loss of Aft MCA logic power.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 2.4	SHEET 1	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: Mechanical

LCC VIOLATION CALL: OBSS Deploy/Stow Mechanism Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V54X1010E1	STBD RMS Shld Pos Mech Depl Ind 1	(2)	OFF	NA	Event	CI
V54X1011E1	STBD RMS Shld Pos Mech Depl Ind 2	(2)	OFF	NA	Event	CI
V54X1020E1	STBD RMS Shld Pos Mech Stowed Ind1	(3)	ON	NA	Event	CI
V54X1021E1	STBD RMS Shld Pos Mech Stowed Ind2	(3)	ON	NA	Event	CI
V54X1022E1	STBD RMS Fwd Pos Mech Stowed Ind 1	1	ON	NA	Event	CI
V54X1023E1	STBD RMS Fwd Pos Mech Stowed Ind 2	of 2	ON	NA	Event	CI
V54X1026E1	STBD RMS Aft Pos Mech Stowed Ind 1	1	ON	NA	Event	CI
V54X1027E1	STBD RMS Aft Pos Mech Stowed Ind 2	of 2	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) One of two measurements acceptable for confirmed instrumentation failure and dual motor function capability is verified. (5)

(3) One of two measurements acceptable for confirmed instrumentation failure and dual motor function capability is verified. (6)

(4) Mission dependent: This SSID is effective on missions with Orbiter Boom Sensor System (OBSS) installed and with required mission use. Reference Appendix H, SSID MEL-13, for mission specific requirements.

PREPLANNED CONTINGENCY PROCEDURE:

(5) The following troubleshooting steps require access to an aft flight deck panel. If access to aft panel is not available then Preplanned Contingency Procedure (PCP) cannot be completed. LCC violation confirmed, No Go for launch.
Failure type: Shoulder Deploy indication ON/should be OFF.
A. Leave AC power ON and issue Manipulator Positioning Mechanism (MPM) deploy switch command (Power Drive Unit (PDU) is isolated from AC power by Payload Bay (PLB) Mechanical Power Switches and Payload Bay Mechanical Mid-Motor Control Assembly Bus Enable relays). Monitor Motor Control Assembly (MCA) operational status.
B. If the MCA operational status inverts, the relay has activated (MCA does not see the indication ON), the failure is confirmed instrumentation loss. Motor function is not lost (still have dual motor deploy capability), LCC violation cleared, continue countdown.
C. If MCA operational status does not invert, the deploy indication is inhibiting the relay, and dual motor deploy capability is lost. LCC violation confirmed, No Go for launch.

(6) The following troubleshooting steps require access to an aft flight deck panel. If access to aft panel is not available then PCP cannot be completed. LCC violation confirmed, No Go for launch.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

Failure type: Shoulder Stowed indication OFF/should be ON.

A. Leave AC power ON and issue stow switch command. Monitor MCA operational status.
B. If the MCA operational status does not invert, the stowed indication is still inhibiting the relay in the MCA, the failure is confirmed instrumentation loss. Connector integrity is good, dual motor function maintained and drive mechanism position is verified. Drive mechanism position is also confirmed by the redundant limit switch, LCC violation cleared, continue countdown.
C. If the MCA operational status does invert, turn ON PLB mechanical power and monitor AC current (five seconds max).
D. If the limit switch is picked up, LCC violation cleared, continue countdown.
E. If the limit switch is not picked up but the other limit switch is ON (CONF POSN) and there is AC power draw on all three phases (connector integrity), LCC violation cleared, continue countdown.
F. If there is no AC power draw, LCC violation confirmed, No Go for launch. There may be a demated connector and dual motor stow capability is lost.

NOTES:

(7) Measurements available in OI.
(8) Preplanned Contingency Troubleshooting for Forward and Aft mechanism stow indication anomaly is not required as the associated limit switches are not on the PDU AC connector (located at Shoulder). Therefore these indications do not affect connector integrity associated with OBSS deploy/stow mechanism PDU functionallity.

REDLINE DERIVATION: CRITICALITY: 1R

(9) a. SSID Intent Summary - The intent of this LCC is to ensure the OBSS is properly stowed for launch and that the Starboard (STBD) MPMs will adequately support the mission. This includes dual motor deploy and stow capability and at least one of two position indications for each function.

b. Voting Logic - One of two position indications for Shoulder, Forward and Aft mechanisms are acceptable for launch. For the Forward and Aft mechanisms only one stow indicator is required to ensure acceptable position for worst case loading scenario. For Shoulder mechanism which is the Power Drive Unit (PDU)location, dual motor functional capability must be verified for initial deploy or stow indication anomaly to ensure PDU connector integrity.

c. Minimum and Maximum Redline Development - Each indicator is either ON or OFF. The stow indicators are all required to be ON while the Shoulder deploy indicators are all required to be OFF.

d. Time Effectivity - The OBSS Deploy/Stow System is configured prior to launch count down and is committed to launch prior to Go For GLS Start

REDLINE DERIVATION: (Continued)

(T-9 minutes).

e. Requirements - For the starboard OBSS there are three MPMs; shoulder, forward and aft. The shoulder MPM has two stow and two deploy indicators. One of two deploy and one of two stow indicators are acceptable if instrumentation failure is confirmed and if dual motor function for the PDU is verified. The forward and aft MPMs each have two stow indicators. One of two indicators is acceptable for launch.

f. Preplanned Contingency Procedures - For a failure of the shoulder deploy or stow indicators, the stow or deploy commands may be issued to verify MCA operational (op) status and dual motor function. The PDU is electrically isolated via the PLB Mechanical Power Switches and Payload Bay Mechanical Mid-Motor Control Assembly Bus Enable relays. MCA op status response will verify instrumentation failure. For confirmed loss of stow indication the PLB Mechanical Power Switch will be taken to on to drive the PDU for five seconds max to try and re-gain the limit switch or verify three phase PDU operation. A preplanned procedure is not required for the loss of one of two forward or aft MPM stow indicators as these are position indicator limit switches only not affecting functionality. Preplanned contingency procedures are not workable after crew module close out due to inability of flight crew to access the appropriate aft flight deck panels.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Failure type: Indication ON/should be OFF. Presence of faulty shoulder deploy indications results in loss of dual motor capability for deploying the STBD MPMs. Failure of both indications for shoulder deploy results in loss of capability to deploy the STBD MPMs.
(11) Failure type: Indication OFF/should be ON. STBD MPMs that are improperly stowed for launch and ascent may result in MPM/OBSS structural contact and damage.

CAUSES OF EXCEEDING REDLINE:

(12) Failure type: Indication ON/should be OFF. Instrumentation failure or limit switch failure.
(13) Failure type: Indication OFF/should be ON. Instrumentation failure, open circuit or improperly positioned STBD MPM pedestals.

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SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: Mechanical

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LCC VIOLATION CALL: OBSS Retention Latch Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V54X1070E1	STBD RMS Fwd Retnn Lch-Rel Ind 1	(2)	OFF	NA	Event	CI
V54X1071E1	STBD RMS Fwd Retnn Lch-Rel Ind 2	(2)	OFF	NA	Event	CI
V54X1060E1	STBD RMS Fwd Retnn Lch-Lch Ind 1	(3)	ON	NA	Event	CI
V54X1061E1	STBD RMS Fwd Retnn Lch-Lch Ind 2	(3)	ON	NA	Event	CI
V54X1072E1	STBD RMS Mid Retnn Lch-Rel Ind 1	(2)	OFF	NA	Event	CI
V54X1073E1	STBD RMS Mid Retnn Lch-Rel Ind 2	(2)	OFF	NA	Event	CI
V54X1062E1	STBD RMS Mid Retnn Lch-Lch Ind 1	(3)	ON	NA	Event	CI
V54X1063E1	STBD RMS Mid Retnn Lch-Lch Ind 2	(3)	ON	NA	Event	CI
V54X1074E1	STBD RMS Aft Retnn Lch-Rel Ind 1	(2)	OFF	NA	Event	CI
V54X1075E1	STBD RMS Aft Retnn Lch-Rel Ind 2	(2)	OFF	NA	Event	CI
V54X1064E1	STBD RMS Aft Retnn Lch-Lch Ind 1	(3)	ON	NA	Event	CI
V54X1065E1	STBD RMS Aft Retnn Lch-Lch Ind 2	(3)	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) One of two measurements acceptable for confirmed instrumentation failure and dual motor function capability is verified. (5)

(3) One of two measurements acceptable for confirmed instrumentation failure and dual motor function capability is verified. (6)

(4) Mission dependent: This SSID is effective on missions with the Orbiter Boom Sensor System (OBSS) installed and mandatory for mission success. See Appendix H, SSID MEL-13, for mission specific requirements.

PREPLANNED CONTINGENCY PROCEDURE:

(5) The following troubleshooting steps require access to an aft flight deck panel. If access to aft panel is not available then Preplanned Contingency Procedure (PCP) cannot be completed. LCC violation confirmed, No Go for launch.
Failure type: Latch - Release indication ON/should be OFF.
A. Leave AC power ON, issue STBD Manipulator Retention Latch (MRL) release switch command (Power Drive Unit (PDU) is isolated from AC power by Payload Bay (PLB) Mechanical Power Switches and Payload Bay Mechanical Mid-Motor Control Assembly Bus Enable relays). Monitor Motor Control Assembly (MCA) operational status.
B. If the MCA operational status inverts, the relay has activated (MCA does not see the indication ON), the failure is confirmed instrumentation loss. Motor function is not lost (still have dual motor release capability), LCC violation cleared, continue countdown.
C. If MCA operational status does not invert, the latch indication is still inhibiting the relay and dual motor release capability is lost. LCC violation confirmed, No Go for launch.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

(6) The following troubleshooting steps require access to an aft flight deck panel. If access to aft panel is not available then PCP cannot be completed. LCC violation confirmed, No Go for launch.
Failure type: Latch - Latch indication OFF/should be ON.
A. Leave AC power ON and issue STBD MRL latch switch command. Monitor MCA operational status.
B. If the MCA operational status does not invert, the latched indication is still inhibiting the relay in the MCA, the failure is confirmed instrumentation loss. Connector integrity is good and latch position is verified. Latch position is also confirmed by the redundant limit switch, LCC violation cleared, continue countdown.
C. If the MCA operational status does invert, turn ON PLB mechanical power and monitor AC current (five seconds max).
D. If the limit switch is picked up, LCC violation cleared, continue countdown.
E. If the limit switch is not picked up but the other limit switch is ON (CONF POSN) and there is AC power draw on all three phases (connector integrity verified) LCC violation cleared, continue countdown.
F. If there is no AC power draw, LCC violation confirmed, No Go for launch. There may be a demated connector and dual motor latching capability is lost.

NOTES:

(7) Measurements available in OI.
(8) Release/latch indications are not on PDU AC connectors; therefore, indications do not verify connector integrity.

REDLINE DERIVATION: CRITICALITY: 1R

(9) a. SSID Intent Summary - The intent of this LCC is to ensure the OBSS is properly latched for launch and ascent and that dual motor latch and release capability is maintained.

b. Voting Logic - One of two Latch and one of two Release position indications for the Shoulder, Mid and Aft Latches are acceptable as long as dual motor function for each PDU can be verified.

c. Minimum and Maximum Redline Development - Each indicator is either ON or OFF. The latch indicators are all required to be ON while the release indicators are all required to be OFF.

d. Time Effectivity - The OBSS Retention Latches are configured prior to launch count down and are committed to launch prior to Go For GLS Start (T-9 minutes).

e. Requirements - For the starboard OBSS there are three retention latches; shoulder, mid and aft. Each retention latch has two latch and two release position indicators. One of two latch and one of two release indicators are acceptable if instrumentation failure is confirmed and if dual motor function for the PDU is verified.

REDLINE DERIVATION: (Continued)

f. Preplanned Contingency Procedures - For a failure of a Retention Latch - Release indication, the release command may be issued to verify MCA operational status and dual motor function. The PDU is electrically isolated via the PLB Mechanical Power Switches and Payload Bay Mechanical Mid-Motor Control Assembly Bus Enable relays. MCA op status response will verify instrumentation failure.

For a failure of a Retention Latch - Latch indication, the latch command may be issued. If the MCA operational status does not invert, instrumentation failure is confirmed because the relay is being inhibited by the latched indication in the MCA. If the MCA operational status does invert, instrumentation failure can still be confirmed by taking the PLB Mechanical Power Switch to ON and monitoring the latched limit switch and AC current draw. If the limit switch activates or if the alternate limit switch is already ON and 3-phase AC current draw is verified, then instrumentation failure is confirmed. Preplanned contingency procedures are not workable after crew module close out due to inability of flight crew to access the appropriate aft flight deck panels.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Failure type: Indication ON/should be OFF. Failure of both release indications on the same OBSS retention latch may result in the inability to release the OBSS.
(11) Failure type: Indication OFF/should be ON. OBSS retention latches improperly configured for launch and ascent may allow the OBSS to become unrestrained causing structural damage.

CAUSES OF EXCEEDING REDLINE:

(12) Failure type: Indication ON/should be OFF. Instrumentation failure or limit switch failure.
(13) Failure type: Indication OFF/should be ON. Instrumentation failure, open circuit or improperly positioned retention latch.

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SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: Mechanical

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SSIDs AFM-21 thru AFM-29 Reserved

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LCC VIOLATION CALL: Orbiter Vent Door Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V59X3055X	L Fwd Vents 1&2 Open 1	(2,3,4	OFF	NA	Event	CI
V59X3065X	L Fwd Vents 1&2 Open 2	(2,3,4	OFF	NA	Event	CI
V59X3105X	L Fwd Vents 1&2 Purge Ind 1	(2,6)	ON	NA	Event	CI
V59X3115X	L Fwd Vents 1&2 Purge Ind 2	(2,6)	ON	NA	Event	CI
V59X3005X	L Fwd Vents 1&2 Closed 1	(2,5)	OFF	NA	Event	CI
V59X3015X	L Fwd Vents 1&2 Closed 2	(2,5)	OFF	NA	Event	CI
V59X4055X	R Fwd Vents 1&2 Open 1	(2,3,4	OFF	NA	Event	CI
V59X4065X	R Fwd Vents 1&2 Open 2	(2,3,4	OFF	NA	Event	CI
V59X4105X	R Fwd Vents 1&2 Purge Ind 1	(2,6)	ON	NA	Event	CI
V59X4115X	R Fwd Vents 1&2 Purge Ind 2	(2,6)	ON	NA	Event	CI
V59X4005X	R Fwd Vents 1&2 Closed 1	(2,5)	OFF	NA	Event	CI
V59X4015X	R Fwd Vents 1&2 Closed 2	(2,5)	OFF	NA	Event	CI
V59X3255X	L PB Vent 3 Open 1	(4)	OFF	NA	Event	CI
V59X3265X	L PB Vent 3 Open 2	(4)	OFF	NA	Event	CI
V59X3205X	L PB Vent 3 Closed 1	(6)	ON	NA	Event	CI
V59X3215X	L PB Vent 3 Closed 2	(6)	ON	NA	Event	CI
V59X4255X	R PB Vent 3 Open 1	(4)	OFF	NA	Event	CI
V59X4265X	R PB Vent 3 Open 2	(4)	OFF	NA	Event	CI
V59X4205X	R PB Vent 3 Closed 1	(6)	ON	NA	Event	CI
V59X4215X	R PB Vent 3 Closed 2	(6)	ON	NA	Event	CI
V59X3455X	L PB Vent 5 Open 1	(4)	OFF	NA	Event	CI
V59X3465X	L PB Vent 5 Open 2	(4)	OFF	NA	Event	CI
V59X3405X	L PB Vent 5 Closed 1	(6)	ON	NA	Event	CI
V59X3415X	L PB Vent 5 Closed 2	(6)	ON	NA	Event	CI
V59X4455X	R PB Vent 5 Open 1	(4)	OFF	NA	Event	CI
V59X4465X	R PB Vent 5 Open 2	(4)	OFF	NA	Event	CI
V59X4405X	R PB Vent 5 Closed 1	(6)	ON	NA	Event	CI
V59X4415X	R PB Vent 5 Closed 2	(6)	ON	NA	Event	CI
V59X3555X	L PB Vent 6 Open 1	(4)	OFF	NA	Event	CI
V59X3565X	L PB Vent 6 Open 2	(4)	OFF	NA	Event	CI
V59X3505X	L PB Vent 6 Closed 1	(6)	ON	NA	Event	CI
V59X3515X	L PB Vent 6 Closed 2	(6)	ON	NA	Event	CI
V59X4555X	R PB Vent 6 Open 1	(4)	OFF	NA	Event	CI
V59X4565X	R PB Vent 6 Open 2	(4)	OFF	NA	Event	CI
V59X4505X	R PB Vent 6 Closed 1	(6)	ON	NA	Event	CI
V59X4515X	R PB Vent 6 Closed 2	(6)	ON	NA	Event	CI

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V59X3855X	L Aft Vents 8&9 Open 1	(2,3,4	OFF	NA	Event	CI
V59X3865X	L Aft Vents 8&9 Open 2	(2,3,4	OFF	NA	Event	CI
V59X3905X	L Aft Vents 8&9 Purge Ind 1	(2,6)	ON	NA	Event	CI
V59X3915X	L Aft Vents 8&9 Purge Ind 2	(2,6)	ON	NA	Event	CI
V59X3805X	L Aft Vents 8&9 Closed 1	(2,5)	OFF	NA	Event	CI
V59X3815X	L Aft Vents 8&9 Closed 2	(2,5)	OFF	NA	Event	CI
V59X4855X	R Aft Vents 8&9 Open 1	(2,3,4	OFF	NA	Event	CI
V59X4865X	R Aft Vents 8&9 Open 2	(2,3,4	OFF	NA	Event	CI
V59X4905X	R Aft Vents 8&9 Purge Ind 1	(2,6)	ON	NA	Event	CI
V59X4915X	R Aft Vents 8&9 Purge Ind 2	(2,6)	ON	NA	Event	CI
V59X4805X	R Aft Vents 8&9 Closed 1	(2,5)	OFF	NA	Event	CI
V59X4815X	R Aft Vents 8&9 Closed 2	(2,5)	OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) Under certain circumstances, vent doors #1 & #2 or #8 & #9 may be temporarily moved to either the OPEN or CLOSED positions during the launch countdown. If so, the appropriate position indications (OPEN or CLOSED) shall be ON, and the PURGE indications shall be OFF until the affected vent doors are returned to the PURGE position.

(3) If both OPEN indications on the same vent door are failed OFF, the associated bit in the LPS Orbiter Vent Doors Override Word (V99J8836C) for each failed indication must be set to ON with the vehicle in a G9 configuration.

PREPLANNED CONTINGENCY PROCEDURE:

(4) Failure type: OPEN Indication ON but should be OFF:

A. Issue only one OPEN command for the motor associated with the failed indication (two commands are required to drive the motor). Monitor the associated MCA operational status.

B. If the associated MCA operational status inverts, the relay has activated (MCA is not receiving the ON indication), and the failure is in the instrumentation circuit. Motor function is not lost (dual-motor capability still exists). LCC violation cleared, continue countdown.

C. If the MCA operational status does not invert, the relay is being inhibited by the ON indication, and the limit switch is considered failed ON. Dual-motor vent door opening capability is lost for that actuator.

D. For Fwd or Aft vent doors, if the affected actuator still has

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

single-motor opening capability, and the actuator on the opposite side has dual-motor opening capability, LCC violation cleared, continue countdown. Otherwise, insufficient redundancy exists to open vent doors for that compartment. LCC violation confirmed, No Go for launch.

E. For midbody vent doors, if either of the following can be verified, LCC violation cleared, continue countdown:

1. LH and RH vent door 3 actuators both have single-motor open capability, and all other midbody vent door actuators have dual-motor open capability.
2. A total of three midbody vent door actuators have single-motor open capability, and no more than one of them is a vent door 3 actuator.

Otherwise, insufficient redundancy exists to open midbody vent doors. LCC violation confirmed, No Go for launch.

(5) Failure type: CLOSED Indication ON but should be OFF:

A. Issue only one CLOSE command for the motor associated with the failed indication (two commands are required to drive the motor). Monitor the associated MCA operational status.

B. If the associated MCA operational status inverts, the relay has activated (MCA is not receiving the ON indication), and the failure is in the instrumentation circuit. Motor function is not lost (dual-motor capability still exists). LCC violation cleared, continue countdown.

C. If MCA operational status does not invert, the relay is being inhibited by the ON indication, and the limit switch is considered failed ON. Dual-motor vent door closing capability for entry is lost for that actuator. LCC violation confirmed, No Go for launch.

(6) Failure type: Indication OFF but should be ON:

A. Issue only one drive command to the associated motor in the direction of the failed indication (two commands are required to drive the motor). Monitor the associated MCA operational status.

B. If the associated MCA operational status does not invert, the relay is being inhibited by the ON indication, and the failure is in the instrumentation circuit. Connector integrity, dual-motor capability, and proper vent door position are verified. LCC violation cleared, continue countdown.

C. If the associated MCA operational status inverts, the relay has activated (MCA is not receiving the ON indication). The failure is a vent door out of position, a limit switch failed OFF, or a demated connector.

D. Cycle the vent door(s) using dual motors between OPEN and CLOSED

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

positions. Verify that the total travel time between OPEN and CLOSED is 5 seconds or less. Verify AC current draw on all three phases on both motors.

E. If both of the conditions in step D. are verified, dual-motor capability confirmed. LCC violation cleared, continue countdown.

F. If either of the conditions in step D. are not verified, demated connector exists, and dual-motor capability is lost. LCC violation confirmed, No Go for launch.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(7) a. SSID Intent Summary - The vent doors are driven by actuators with two redundant motors. Vent doors 1 and 2 are driven by a common actuator on each side of the vehicle, and vent doors 8 and 9 are also driven by a common actuator on each side of the vehicle. Limit switches for each motor indicate each possible position of the vent door (i.e. OPEN, PURGE, CLOSED). When an actuator is commanded to drive to a particular position, activation of the associated limit switch causes the Motor Control Assembly (MCA) to isolate electrical current from the associated motor. Consequently, the associated limit switch must be OFF for a particular motor to function in a particular direction. A failed ON limit switch will inhibit motor operation in the direction of the failed switch. A failed OFF limit switch indication could be the result of a demated connector, which would then result in loss of motor function in both directions. All vent doors must be closed for re-entry to protect against thermal damage. Therefore, this SSID ensures dual-motor close capability. For atmospheric venting, certain combinations of vent doors failed closed are acceptable. For vent doors 1/2 and 8/9, either the LH or RH side can be failed closed. For midbody vents, if both left and right vent doors 3 are failed closed, then all other midbody doors are required to be open. If at least one vent door 3 retains open capability, then a total of 3 midbody doors can be failed closed. This SSID ensures one level of redundancy to open vent doors above the maximum allowable failures described above. In addition, single motor capability to open all vent doors for ascent is an RSLS requirement and is ensured by this SSID. This SSID also ensures that the vent doors are in the proper configuration during the launch countdown prior to RSLS start.

b. Voting Logic - N/A

c. Minimum and/or Maximum Redline Development - When limit switches fail ON and should be OFF, motor redundancy on the affected vent doors is lost. Launch with more than one OPEN limit switch failed ON for the Forward vent doors, more than one OPEN limit switch failed ON for the Aft Vent doors, or 3 of 6 midbody (4 of 6 if both Left and Right Vent

REDLINE DERIVATION: (Continued)

Doors 3 are affected) OPEN limit switches failed ON does not provide an adequate level of redundancy for venting operations. Launching with any CLOSED limit switches failed ON does not provide an adequate level of redundancy for thermal protection during entry.

d. Time Period - Monitoring of the OPEN/PURGE/CLOSED limit switch indications begins at the start of ET Cryo Tanking, when venting operations are necessary. Monitoring continues until T-9 minutes. Failure of the limit switches between T-9 minutes and final RSLS open postion check is considered unlikely and an acceptable risk, as the vent doors are not operated in that time period.

e. Requirements - Vent doors #1 & #2 may be temporarily moved to the OPEN position during GN2 purge operations to preclude low O2 concentrations in the White Room. Vent doors #8 & #9 may be temporarily moved to the OPEN position during ET/Orbiter Plate Gap Delta Pressure Transducer testing. Additionally, for weather protection, vent doors #1 & #2 and/or #8 & #9 may be temporarily moved to the CLOSED position. In these cases, alternate limit switch indications are used to verify the health of the vent door actuators. Although failed-off limit switches are acceptable for flight, RSLS requires at least one OPEN indication to be ON at each vent door location. If both OPEN indications on the same actuator are failed OFF, but the doors are confirmed to be open, ON indications will be artificially provided to the RSLS to avoid a launch scrub.

f. Preplanned Contingency Procedures - In the case of Limit Switches failed ON, instrumentation failure can be confirmed by verifying that the operational status function designator inverts when set to ON in the direction of a failed indicator. In the case of Limit Switches failed OFF, instrumentation failure can be confirmed by verifying that the operation status function designator does not invert when set to ON in the direction of a failed indicator. Limit switches failed OFF do not cause a loss of redundancy by inhibiting motor operation, and protection against demated connectors which would cause a loss of motor operation can be achieved by cycling the vent doors and verifying that the motors operate through AC current levels during cycling.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) One or more vent doors fail to open prelaunch. This is a RSLS violation that the RSLS software may not identify. (Two faulty open indicators failed on.)
(9) All vent doors open prelaunch, but RSLS goes into hold if both open indicators fail OFF. Use of the Vent Door Override Word would prevent this failure.
(10) Insufficient redundancy to prevent catastrophic thermal damage due to entry with a vent door failed open or structural failure due to insufficient venting with vent doors failed closed.
(11) Reference Integrated Hazard Report IMEO-01 (Cause G).

CAUSES OF EXCEEDING REDLINE:

(12) Failure type: Indication ON but should be OFF.
A. Instrumentation failure.
B. Limit switch failed closed.
(13) Failure type: Indication OFF but should be ON.
A. Instrumentation failure.
B. Improperly positioned vent door.
C. Limit switch failed open.
D. Demated connector.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 15-1	SHEET 1-4	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-930099	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: Mechanical

SECTION 30

ENVIRONMENTAL CONTROL AND LIFE SUPPORT

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SECTION 30: ENVIRONMENTAL CONTROL AND LIFE SUPPORT

SSID No.	Description/Violation Call	Page
ECL-01	Orbiter Cabin Vent Valve Anomaly	30-01.1
ECL-02	Orbiter Nitrogen Supply System Anomaly	30-02.1
ECL-03	Orbiter Nitrogen System Valve Anomaly	30-03.1
ECL-04	Orbiter Cabin Pressure Anomaly	30-04.1
ECL-05	Orbiter Cabin/Airlock Pressure Anomaly	30-05.1
ECL-06	Orbiter Cabin Partial Pressure of Oxygen Anomaly	30-06.1
ECL-07	Orbiter Cabin Fan Anomaly	30-07.1
ECL-08	Orbiter Water Coolant Loop Leakage Indication	30-08.1
ECL-09	Water Coolant Loop Anomaly	30-09.1
ECL-10	Orbiter Avionics Bay Cooling Anomaly	30-10.1
ECL-11	Orbiter IMU Fan Anomaly	30-11.1
ECL-12	SSIDs ECL-12 Through ECL-19 Reserved	30-12.1
ECL-20	Orbiter Potable Water Quantity Anomaly	30-20.1
ECL-21	Orbiter Waste Water Quantity Anomaly	30-21.1
ECL-22	Orbiter Waste Water Dump Nozzle Temperature Anomaly	30-22.1
ECL-23	Orbiter Supply Water Dump Nozzle Temperature Anomaly	30-23.1
ECL-24	SSIDs ECL-24 Through ECL-29 Reserved	30-24.1
ECL-30	Orbiter Crew Cabin Smoke Detector Concentration Measurement Failure	30-30.1
ECL-31	Orbiter Crew Cabin Smoke Detector Alarm Indication	30-31.1
ECL-32	Orbiter Avionics Bay Smoke Detector Concentration Measurement Failure	30-32.1

SECTION 30: ENVIRONMENTAL CONTROL AND LIFE SUPPORT (CONTINUED)

SSID No.	Description/Violation Call	Page
ECL-33	Orbiter Avionics Bay Smoke Detector Alarm Indication	30-33.1
ECL-34	Orbiter Avionics Bay Fire Bottle Empty Indication	30-34.1
ECL-35	SSIDs ECL-35 Through ECL-39 Reserved	30-35.1
ECL-40	Freon Flow Rate Anomaly	30-40.1
ECL-41	Orbiter Freon Coolant Loop Pressure/Quantity Anomaly	30-41.1
ECL-42	Orbiter Ammonia System Tank Temperature/ Pressure Anomaly	30-42.1
ECL-43	Orbiter Freon Coolant Loop Evaporator Out Temperature Anomaly	30-43.1
ECL-44	Orbiter Flash Evaporator Water Accumulator Temperature Anomaly	30-44.1
ECL-45	Orbiter Flash Evaporator Water Accumulator Anomaly	30-45.1
ECL-46	Orbiter Flash Evaporator Topping Duct Temperature Anomaly	30-46.1
ECL-47	Orbiter Flash Evaporator Hi Load Duct Temperature Anomaly	30-47.1
ECL-48	Orbiter Flash Evaporator Water Feedline Temperature Anomaly	30-48.1
ECL-FG01	Figure 30-01 NH3 Tank Quantity versus Pressure and Temperature	30-FG01.1

LCC VIOLATION CALL: Orbiter Cabin Vent Valve Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V61X2005E	Cabin Vent Isol-Close	(2)	ON	NA	Event	DI
V61X2045E	Cabin Vent-Close	(2)	ON	NA	Event	DI

TIME PERIOD:

(1) Verify at completion of 2 psid Cabin Pressure Integrity Check (Approximately T-20 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown. (4)
(3) Both valves must be operational and are required closed for flight.

PREPLANNED CONTINGENCY PROCEDURE:

(4) One or both valve close indication(s) OFF:
- A. Request the crew to report the talkback position (Pnl L2): If CLOSED, LCC violation cleared, continue countdown.
- B. If the talkback indicates OPEN or barberpole, request the crew to verify that the circuit breakers are closed (Pnl 014:D) and cycle the valve OPEN, then CLOSED.
- C. If the valve close indication(s) are ON and the talkback indicates ON, LCC violation cleared, continue countdown.
- D. If the valve close indication(s) are OFF and the talkback indicates OFF, repeat the 2 psid Cabin Pressure Integrity Check (requires approximately 1.5 hours).
- E. If the 2 psid Cabin Pressure Integrity Check is successful, the problem is instrumentation failure. LCC violation cleared, continue countdown.
- F. If the 2 psid Cabin Pressure Integrity Check is unsuccessful, the problem is a valve failed open. LCC violation confirmed, No Go for launch.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(5) The redline verifies that both valves are closed following the 2 psid Cabin Pressure Integrity Check.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) The next valve failure vents the cabin pressure to vacuum.

CAUSES OF EXCEEDING REDLINE:

(7) Valve in the wrong position.
(8) Instrumentation failure.
(9) Valve failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 6.1	SHEET 21	ZONE N&L-7
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-960099	SHEET 6	ZONE 4&6M

ELEMENT: Orbiter SUBSYSTEM: ARS/ARPCS

LCC VIOLATION CALL: Orbiter Nitrogen Supply System Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V61P2301A	Sys 1 N2 Supply Press	1 of	(2)	NA	psia	CI
V61P2309A	Sys 2 N2 Supply Press	2	(2)	NA	psia	CI
V61T2406A	Sys 1 N2 Tank 1 Temp	(4)	20(3)	150(3)	deg F	CI
V61T2407A	Sys 1 N2 Tank 2 Temp	(4)	20(3)	150(3)	deg F	CI
V61T2408A	Sys 2 N2 Tank 1 Temp	(4)	20(3)	150(3)	deg F	CI
V61T2409A	Sys 2 N2 Tank 2 Temp	(4)	20(3)	150(3)	deg F	CI
V61T2422A	Sys 2 N2 Tank 3 Temp	(4)	20(3)	150(3)	deg F	CI
V61T2423A	Sys 2 N2 Tank 4 Temp	(4)	20(3)	150(3)	deg F	CI
V61T2424A	Sys 1 N2 Tank 3 Temp	(4)	20(3)	150(3)	deg F	CI
V61T2425A	Sys 1 N2 Tank 4 Temp	(4)	20(3)	150(3)	deg F	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) No leaks. (6)
(3) Redlines are for detecting instrumentation failure only.
(4) A minimum of one temperature measurement is required.
(5) Redlines apply to installed tanks only.

PREPLANNED CONTINGENCY PROCEDURE:

(6) A pressure change of three data bits, exclusive of usage and temperature changes, indicates leakage. For a confirmed leak, LCC violation confirmed, No Go for launch.

NOTES:

(7) The number of measurements is vehicle and mission specific. Each vehicle has at least four measurements.
(8) Pressure and temperature measurements are used on-orbit for quantity calculations (not available in BFS) and for leak detection. Individual measurements are not displayed onboard.
(9) Loss of all measurements in one system may indicate tank rupture.

REDLINE DERIVATION: CRITICALITY: 1R

(10) Functional measurements are required to provide leak detection capability and to ensure atmosphere revitalization capability.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Loss of onboard quantity measurement (unable to detect small leaks on-orbit)

CONSEQUENCES OF EXCEEDING REDLINE: (Continued)

(12) Insufficient nitrogen for planned mission and contingency use resulting in early mission termination.

CAUSES OF EXCEEDING REDLINE:

(13) Instrumentation failure.
(14) Leak.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	psia								
V61P2301A	14.07	11.82	3531						
V61P2309A	14.07	11.82	3531						
UNITS-->	deg.F								
V61T2406A	0.99	-73.9	174.5						
V61T2407A	0.99	-73.9	174.5						
V61T2408A	0.99	-73.9	174.5						
V61T2409A	0.99	-73.9	174.5						
V61T2422A	0.99	-73.9	174.5						
V61T2423A	0.99	-73.9	174.5						
V61T2424A	0.99	-73.9	174.5						
V61T2425A	0.99	-73.9	174.5						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 6.1	SHEET 2	ZONE W3&7
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-960099	SHEET 7	ZONE 22B&D,
	DWG NO	SHEET	ZONE 23

ELEMENT: Orbiter SUBSYSTEM: ARS/ARPCS

LCC VIOLATION CALL: Orbiter Nitrogen System Valve Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V61X2321E	N2 Sys 1 Reg Inlet-Open		ON (2)	NA	Event	CI
V61X2323E	N2 Sys 1 Supply-Open		ON (2)	NA	Event	CI
V61X2328E	N2 Sys 2 Reg Inlet-Open		ON (2)	NA	Event	CI
V61X2319E	N2 Sys 2 Supply-Open		ON (2)	NA	Event	CI
V61X2372E	O2/N2 Cntlr Vlv-Sys 1 Open		(3)	NA	Event	CI
V61X2377E	O2/N2 Cntlr Vlv-Sys 2 Open		(3)	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) Two nitrogen supply systems are required. (4)
(3) The selected Pressure Control System should be ON; the other system should be OFF. (5)

PREPLANNED CONTINGENCY PROCEDURE:

(4) If one or more N2 Supply/Regulator Inlet valve OPEN indications are OFF, request the crew to report valve talkback position (Pnl L2).
A. If talkback indicates OPEN, LCC violation cleared, continue countdown.
B. If talkback indicates CLOSED or BARBERPOLE, verify that circuit breakers are CLOSED (Pnl 015:D and/or 014:D) and cycle valve CLOSED, then OPEN.
1. If valve talkback indicates OPEN, LCC violation cleared, continue countdown.
2. If N2 Supply Valve talkback indicates CLOSED or BARBERPOLE, close both N2 Supply Valves. If N2 Regulator Inlet Valve indicates CLOSED or BARBERPOLE, close both N2 Regulator Inlet Valves.
Move O2/N2 Control Valve System 1 and System 2 (Pnl L2) to CLOSE.
a. Open H2O Alternate Pressure Valve (Pnl L1) until N2 Regulator Pressure (V61P2310A, 2410A) drops by 30 psid minimum.*
*(Minimize venting beyond 30 psid to limit repress time. Do not allow System 1/2 N2/H2O Tank Pressures (V61P2307A, 2311A) to drop below 5 psig.)
Close H2O Alternate Pressure Valve.
b. Open suspect Regulator Inlet Valve or N2 Supply Valve of affected system.
c. Monitor N2 Regulator Press (System 1 or 2) to determine that it returns to 200 psia nominal.
d. If successful, reopen remaining N2 Regulator Inlet Valves and N2 Supply Valves and move O2/N2 Control Valves to the launch configuration, LCC violation cleared, continue countdown. Otherwise, LCC violation confirmed, No Go for launch.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

(5) If active O2/N2 Controller Valve Open indication indicates OFF, request the crew to report switch position (Pnl L2).
   A. If switch position is CLOSE or AUTO:
      1. Verify valve circuit breakers are CLOSED (Pnl 014:D and 015:D) and cycle affected valve CLOSE, then OPEN (Pnl L2).
      2. If O2/N2 Controller Valve Open indication on affected valve indicates ON, LCC violation cleared, continue countdown.
      3. If O2/N2 Controller Valve Open indication on affected valve indicates OFF, go to Step (5) B.1.
   B. If switch position is OPEN:
      1. Close both N2 Regulator Inlet Valves (Pnl L2).
         Open H2O Alternate Pressure Valve (Pnl L1) until Cabin Regulator Inlet Pressure (V61P2104A/2204A) drops by 30 psid minimum.*
         *(Minimize venting beyond 30 psid to limit repress time. Do not allow System 1/2 N2/H2O Tank Pressures (V61P2307A, 2311A) to drop below 5 psig.)
         Close H2O Alternate Pressure Valve, open Regulator Inlet Valve in affected system, monitor Cabin Regulator Inlet Pressure (Sys 1 or Sys 2) to determine that it returns to 200 psia nominal.
      2. If successful, reopen remaining N2 Regulator Inlet Valve, LCC violation cleared, continue countdown.
      3. If unsuccessful, LCC violation confirmed, No Go for launch.

NOTES:

(6) Normally, O2/N2 Control System 1 is configured on.
(7) Limiting venting of GN2 to approximately 30 psid will limit repress time for the potable water tanks, thus assuring the required 25 psia for FES operations at MECO.

REDLINE DERIVATION: CRITICALITY: 1R

(8) Redline ensures capability to supply N2 to the Cabin during a contingency situation.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Loss of one N2 supply valve: Loss of access to 1/2 of required N2 (unable to support planned contingencies).
(10) Loss of one N2 regulator inlet valve: Subsequent failure of alternate N2 Regulator Inlet Valve or N2 Regulator will result in loss of access to N2 supply for normal or contingency operations.
(11) Loss of one O2/N2 controller valve: Subsequent failure of alternate O2/N2 controller valve will result in loss of access to N2 supply for normal or contingency operations.

CAUSES OF EXCEEDING REDLINE:

(12) Valve in wrong position.
(13) Instrumentation failure.
(14) Valve failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 6.1	SHEET 2	ZONE T4&6
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-960099	SHEET 7	ZONE 13,15,
	DWG NO	SHEET	ZONE 17

ELEMENT: Orbiter SUBSYSTEM: ARS/ARPCS

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LCC VIOLATION CALL: Orbiter Cabin Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V61R2401A	Cabin Press Rate of Change Ind	(2)	-0.015	0.020 (3)	psi/min	CI
V61P2405A	Cabin Press	(4)	NA	(4)	psia	BU

TIME PERIOD:

(1) From final closure for launch of Cabin Vent Valves (approximately T-20 minutes) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Cabin Press Rate of Change Ind (V61R2401A) redline violation is acceptable if instrumentation failure is confirmed. (5,6)
(3) Maximum redline violations are acceptable during suit pressurization by the crew. The maximum redline of 0.020 psi/min may be exceeded after visor closure because of O2 flow into the crew module from the suits.
(4) No requirement unless the Cabin Press Rate of Change Ind measurement is lost. Cabin Press (V61P2405A) must be functional if Cabin Press Rate of Change Ind measurement is lost. A rate increase in Cabin Press above 0.020 psi/min not caused by a thermal transient, suit pressurization, or O2 flow from crew visors is unacceptable. (5,6,7)

PREPLANNED CONTINGENCY PROCEDURE:

(5) Either a step function increase of Cabin Press Rate of Change Ind (V61R2401A) to OSH (approximately +0.45 psi/min, equivalent to 0 vdc transducer output) or a decrease of Cabin Press Rate of Change Ind (V61R2401A) to below the minimum redline limit (-0.015 psi/min) indicates instrumentation failure. For either condition, check Cabin Press measurement (ref. S0007.500 - "Orbiter Cabin Pressure Anomaly SSID ECL-04").
    A. If Cabin Press measurement is still functional and reading an expected value based on current vehicle configuration, LCC violation cleared, continue countdown.
    B. If Cabin Press measurement (V61P2405A) is non-functional (reference ECL-05), LCC violation confirmed, No Go for launch.
(6) For Cabin Press Rate of Change Ind maximum redline violation but not OSH (OSH is approximately 0.45 psi/min), then,
    A. If Cabin Press measurement (V61P2405A) is non-functional (reference ECL-05), then dp/dt and backup dp/dt are not available, LCC violation confirmed, No Go for launch.
    B. If Cabin Press measurement (V61P2405A) has not failed, then, monitor Cabin Press for increase, and if available utilize BFS calculated backup dp/dt (V980004C1 - available following transition to OPS 101) to evaluate cabin pressure rate of change. (ref. S0007.500 - "Orbiter Cabin Pressure Anomaly (SSID ECL-04)"). Allow sufficient

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

time, based on indicated dp/dt, to see an increase of 2-bits (0.16 psi) in Cabin Press, or to see a corresponding change in BFS calculated backup dp/dt.

1. If no corresponding increase in Cabin Press (and calculated dp/dt if available), instrumentation failure confirmed, LCC violation cleared, continue countdown.
2. If the Cabin Press (and BFS calculated backup dp/dt, if available) has a corresponding increase, monitor Cabin Temperature (V61T2552A) and Cabin Hx Out-Air Temp(V61T2635A).
   a. If the Cabin Temperature and Cabin Hx Out-Air Temp have increased, violation may be caused by a thermal transient. With nominal starting conditions of approximately 14.7 psia and 70-80 deg F in the crew cabin, a cabin temperature increase of approximately 3 deg F will result in a bit change (0.08 psi) in cabin pressure. Monitor until the Cabin Press Rate of Change is within limits, LCC violation cleared, continue countdown.
   b. If there is no temperature correlation, and the Cabin Press Rate of Change Ind is positive, the violation is caused by a leak into the cabin. LCC violation confirmed, No Go for launch. Perform one of the following:
      1. If the N2 tank pressure is decreasing, close both GN2 supply valves.
      2. If the PPO2 level is increasing, close both GO2 supply valves.

(7) If Cabin Press Rate of Change Ind measurement is lost, and Cabin Press (or BFS calculated dp/dt) indicate above 0.020 psi/min, then determine if the increase is caused by a thermal transient or a leak into the cabin and respond accordingly per (6.B.2a, 2b).

NOTES:

(8) Minimum redline is for the detection of instrumentation failure only.
(9) Cabin Press (V61P2405A) is used by the BFS for Cabin Pressure Rate of Change calculation (V98R0004C1).
(10) Because of expected cabin pressure excursions, this redline should not be automated.
(11) The hardware C&W limits for Cabin Press vary for each vehicle based on the actual crack pressure of the relief valves, and the unique transducer calibration curve. The target value for the hardware C&W are as follows:

Minimum: A value as close to but not greater than 13.8 psi to prevent receiving a hardware C&W alarm annunciation prior to the software alarm. 13.8 psia is the backup C&W software limit.

Maximum: A value less than or equal to the target value without being below the backup C&W software limit of 15.35 psia. If this value is unattainable, the closest value above the target value will be chosen. This prevents receiving a hardware C&W alarm annunciation prior to the software alarm. The target value is the actual positive pressure relief valve crack pressure minus the 0.3 psi pressure increase allowance during the crew visor down period extending from approximately T-2 minutes until as late as MECO.

NOTES: (Continued)

Because the voltage input increment for the hardware C&W system is 0.05 vdc (corresponds to 0.2 psi increments for Cabin Press), the actual hardware C&W values may vary from the target values as shown in the MEASUREMENT INFORMATION TABLE.

REDLINE DERIVATION: CRITICALITY: 1R

(12) a. SSID Intent Summary - Redline ensures that the capability (instrumentation) exists to detect cabin pressure changes by the flight and ground crews during ascent and on-orbit, to determine if there is a cabin leak, or a leak into the cabin from the GO2 or GN2 system. The Cabin Pressure monitoring system is single fault tolerant. Loss of either Cabin Press Rate of Change Ind. or Cabin Press measurement results in zero fault tolerance for the ability to detect changes in Cabin Pressure.

b. Voting logic - N/A

c. Minimum and Maximum Redline Development - The minimum redline for the Cab Press Rate of Change (dp/dt) is for detection of instrumentation failure only. Negative dp/dt values indicate decreasing pressure in the cabin. However, during the time period effectivity of this LCC the crew cabin is not pressurized significantly above the ambient external pressure and therefore cannot experience any loss of pressure. The maximum redline for the Cab Press Rate of Change was chosen to detect a significant leak into the cabin from the GN2 or GO2 system. 0.020 psi/minute equates to a leak rate on the order of 20 lb/hr from the GO2 or GN2 system. Instrumentation error is not included because a unique calibration curve is derived for each Cabin Press Rate of Change and each Cabin pressure transducer based on test data (actual readings against a standard gage), thus minimizing transducer error.

d. Time Period - For the bulk of the countdown the cabin hatch is open, and the Cabin Press Rate of Change Ind value cannot be used to determine the integrity of the cabin. After the cabin is vented following the completion of the cabin 2 psid leak check, the upper limit is to detect leakage into the cabin from the ARPCS (Atmosphere Revitalization and Pressure Control System) and is monitored until T-31 seconds due to the criticality of the cabin environment and the requirement to verify the instrumentation is available to readily detect a cabin leak.

e. Requirements - Cabin pressure increases are expected if crew members flow oxygen to their suits for comfort as well as during the visor down GO2 flow that initiates at approximately T-2 minutes. Therefore, maximum redline violations are permitted during these functions. Loss of either the cabin pressure or the Cabin Press Rate of Change is acceptable. Cabin Press Rate of Change can determine cabin pressure changes real-time, however, if Cabin Press Rate of Change Ind is lost, the BFS calculates the cabin pressure rate of change based on the cabin

REDLINE DERIVATION: (Continued)

pressure changes during a 30 second window every 5 seconds. The BFS alert occurs if the cabin pressure decreases by 0.12 psi/minute (1 bit/20 seconds). Even with the loss of the Cabin Press Rate of Change Ind, if the Cabin Press measurement is still functional, the ground crew has visibility of the downlisted BFS calculated dp/dt (V98R0004C1) and it can be utilized to determine the appropriate action for loss of cabin pressure during ascent.

f. Preplanned Contingency Procedures - The preplanned contingency procedure is used to distinguish instrumentation failure from a confirmed leak into the cabin. As stated, the lower limit is for detection of instrumentation failure only because the cabin is not pressurized. Temperature measurements are utilized to determine if dp/dt values (or backup dp/dt values derived from Cabin Press) above the maximum redline were thermally induced, and therefore acceptable. For a possible leak into the cabin the GO2 or GN2 supply valves are closed to isolate the pressure source to prevent high cabin pressure or high O2 levels in the cabin.

CONSEQUENCES OF EXCEEDING REDLINE:

(13) Loss of ascent abort decision-making capability.
(14) Increasing cabin pressure (loss of consumables).
(15) Reference Orbiter Hazard Reports ORBI-406, ORBI-511.

CAUSES OF EXCEEDING REDLINE:

(16) EMI/instrumentation failure (both measurements).
(17) Thermal transient.
(18) Leak into cabin.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	psi/min								
FOR OV-103									
V61R2401A	-0.0039	-0.535	0.437					-0.12	
FOR OV-104									
V61R2401A	-0.0038	-0.534	0.439					-0.12	
FOR OV-105									
V61R2401A	-0.0039	-0.544	0.442					-0.12	
UNITS-->	psia								
FOR OV-103									
V61P2405A	0.080	-0.015	19.955	13.76	15.36	13.8	15.35		
FOR OV-104									
V61P2405A	0.080	-0.041	19.952	13.75	15.35	13.8	15.35		
FOR OV-105									
V61P2405A	0.080	0.008	20.029	13.62	15.42	13.8	15.35		

METER/DISPLAY RANGE - MSID: V61R2401A LOW: -0.5 HIGH: 0.4
V61P2405A LOW: 0 HIGH: 20

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 6.1 SHEET ZONE D6
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-960099 SHEET 11 ZONE 16-A

ELEMENT: Orbiter SUBSYSTEM: ARS/ARPCS

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LCC VIOLATION CALL: Orbiter Cabin/Airlock Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	OV103					
V61P2405A	Cabin Press	(2)	NA	15.4	psia	CI
V64P0101A	Airlock Diff Press No 1	(2)	NA	0.5	psid	CI
NA	OV104					
V61P2405A	Cabin Press	(2)	NA	15.5	psia	CI
V64P0101A	Airlock Diff Press No 1	(2)	NA	0.6	psid	CI
NA	OV105					
V61P2405A	Cabin Press	(2)	NA	15.4	psia	CI
V64P0101A	Airlock Diff Press No 1	(2)	NA	0.5	psid	CI

TIME PERIOD:

(1) From final closure for launch of Cabin Vent Valves (approximately T-20 minutes) to Go for GLS Start (T-9 Minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) Instrumentation requirements are mission unique:
For all missions, 1 of 2 measurements (V61P2405A or V64P0101A) is acceptable for confirmed instrumentation failure. However, for missions with planned 10.2 psia cabin pressure operations, if Cabin Press measurement is lost, the EMU Feedwater pressure sensor must have been verified to be accurate within +/- .24 psia. (3,4)

PREPLANNED CONTINGENCY PROCEDURE:

(3) For redline violation: See S0007.500 - "Orbiter Cabin/Airlock Pressure Anomaly (SSID ECL-05)".

A. If Cabin Press indicates OSL (approximately 0), or below expected values based on ambient conditions, instrumentation failure confirmed. For this condition, check Airlock Diff Press No 1 measurement.
   1. If Airlock Diff Press No 1 indicates expected value (typically 0 - 0.32 psi, when the cabin is vented, but will vary from vehicle to vehicle), then see "Failure of Cabin Press downlink measurement" for go/no go criteria. (4)
   2. If Airlock Diff Press No 1 does not indicate expected value (typically 0 - 0.32 psi, when the cabin is vented, but will vary from vehicle to vehicle), LCC violation confirmed, No Go for launch.

B. For Cabin Press indications above the maximum redline, check Airlock Diff Press No 1 measurement.
   1. If Airlock Diff Press No 1 is below the maximum redline limit and does not show an increase corresponding to the Cabin Press, then instrumentation failure confirmed, see "Failure of Cabin Press

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

downlink measurement" for go/no go criteria. (4)
2. If Airlock Diff Press No 1 does show a corresponding increase, see (3D).

C. For Airlock Diff Press No. 1 indications above the maximum redline, status Cabin Press measurement.
1. If Cabin Press is as expected (below maximum redline limit and does not show an increase corresponding to the increase in the Airlock Diff Press No 1), instrumentation failure confirmed, LCC violation cleared, continue countdown.
2. If Cabin Press does show a corresponding increase, see (3D).

D. If either Cabin Press or Airlock Diff Press No 1 is above the maximum redline, and the other parameter shows a corresponding increase, then monitor Cabin Temperature (V61T2552A), Cabin Hx Out-Air Temp (V61T2635A), and Cabin Press Rate of Change Ind (V61R2401A).
1. If the Cabin Temperature and Cabin Hx Out-Air Temp have increased, and Cabin Press Rate of Change Ind is positive, the violation is caused by a thermal transient. With nominal starting conditions of approximately 14.7 psia and 70-80 degF in the crew cabin, a cabin temperature increase of approximately 3 degF will result in a bit change (0.08 psi) in cabin pressure. Monitor until the pressure reading is within limits, LCC violation cleared, continue countdown.
2. If there is no temperature correlation, the Cabin Press Rate of Change Ind is positive, the violation is caused by a leak into the cabin. LCC violation confirmed, No Go for launch. Perform one of the following:
a. If the N2 tank pressure is decreasing, close both GN2 supply valves.
b. If the PPO2 level is increasing, close both GO2 supply valves.

(4) Failure of Cabin Press downlink measurement
A. If orbiter 10.2 psia operations are not planned, then LCC violation cleared, continue countdown.
B. If orbiter 10.2 psia operations are planned and EMU Feedwater Pressure Sensor has been verified to be accurate within +/- .24 psia, then LCC violation cleared, continue countdown.
C. If orbiter 10.2 psia operations are planned and EMU Feedwater Pressure Sensor was not verified to be accurate within +/- .24 psia, LCC violation confirmed, No Go for launch.

NOTES:

(5) The crew normally configures the ACES (Advanced Crew Escape Suit) at T-2 minutes which results in an increase in cabin pressure. To prevent violation of the redline, the crew is to be instructed to open their visors and close the O2 suit valves if a hold occurs and then to close their visors and open the O2 suit valves when the countdown resumes.

(6) 10.2 psia cabin pressure operations occur during EVA operations that originate from the orbiter airlock.

(7) EMU Feedwater Pressure Sensor data is not available during prelaunch but sensor verification data is available at the JSC Mission Evaluation Room ECLSS Console.

NOTES: (Continued)

(8) The hardware C&W limits for Cabin Press vary for each vehicle based on the actual crack pressure of the relief valves, and the unique transducer calibration curve. The target value for the hardware C&W are as follows:

Minimum: A value as close to but not greater than 13.8 psi to prevent receiving a hardware C&W alarm annunciation prior to the software alarm. 13.8 psia is the backup C&W software limit.

Maximum: A value less than or equal to the target value without being below the backup C&W software limit of 15.35 psia. If this value is unattainable, the closest value above the target value will be chosen. This prevents receiving a hardware C&W alarm annunciation prior to the software alarm. The target value is the the actual positive pressure relief valve crack pressure minus the 0.3 psi pressure increase allowance during the crew visor down period extending from approximately T-2 minutes until as late as MECO.

Because the voltage input increment for the hardware C&W system is 0.05 vdc (corresponds to 0.2 psi increments for Cabin Press), the actual hardware C&W values may vary from the target values as shown in the MEASUREMENT INFORMATION TABLE.

REDLINE DERIVATION: CRITICALITY: 1R

(9) a. SSID Intent Summary - The redline limits ensure that the cabin pressure will not reach the cabin positive pressure relief valve crack pressure as a result of a thermal effect, and the pressure increase from crew O2 usage during pre-launch/ascent visor down phase and verifies that a precise measurement (Cabin Press, or an acceptable EMU Feedwater Pressure Sensor) is available for planned orbiter 10.2 operations. The Cabin Pressure monitoring system is single fault tolerant. Loss of either Cabin press or Airlock Diff Press No. 1 meaurement results in zero fault tolerance for the ability to detect changes in Cabin Pressure.

b. Voting logic - N/A

c. Maximum Redline Development - The lower specification limit for the positive pressure relief valve crack pressure is 15.5 psia. However, the maximum redline for the Cabin Press is based on the lowest actual crack pressure (from ground testing) for the two positive pressure relief valves minus the pressure increase from visor closure (pre-launch) through the ascent phase, and includes holds post visor closure of up to 5 minutes. Instrumentation error is not included in the redline derivation for Cabin Press for the following reasons:
   1. A unique calibration curve is derived for each cabin pressure transducer based on test data (actual readings against a standard gage), which minimizes transducer error.
   2. The 0.3 psi cabin pressure increase allowed during the pre-ascent/ascent phase crew breathing with visors down is conservative.
   3. The crew cabin stretches during the first two minutes of ascent

REDLINE DERIVATION: (Continued)

causing the cabin pressure to decrease slightly.

4. Addition of the allowable transducer error (0.2 psi) would cause the upper limit to be too close to the maximum allowable cabin pressure (15.2 psia) following the 2 psid cabin integrity test, and would cause the Airlock Diff Press No 1 maximum limit to drop to a value that doesn't leave enough room for nominal variations in the pressure measurement output.

	Spec	OV103 (Actual)	OV104 (Actual)	OV105 (Actual)
Cracking pressure (psia)	15.5	15.7	15.8	15.7
O2 added pre-launch through ascent for 7 crewmen for 15 minutes (psi)	- .3	- .3	- .3	- .3
Redline (psia)	15.2	15.4	15.5	15.4

The maximum redline for the Airlock Diff Press No 1 is determined by the specific Cabin Press limit for each vehicle minus the maximum allowable payload bay purge pressure of 14.9 psia provided by the PVD purge. Although the tolerance for the Airlock Diff Press No 1 is +/- 1 psi at ambient, this measurement historically reads within 2 bits (0.32 psi) at ambient pressure. Inclusion of a transducer error of even 0.32 psi would result in a redline limit at the values typically observed during countdown. Therefore, based on historical data, transducer error is not considered in the development of the maximum redline limit for Airlock Diff Press No 1.

d. Time period - Prior to crew hatch closure for flight the cabin is open to atmosphere and cannot experience pressures above ambient. After the cabin is vented following the completion of the cabin 2 psid leak check, the upper limit protects against cracking a positive pressure relief valve. The time period effectivity expires at T-9 minutes, because the cabin pressure environment is stable following the 2 psid cabin leak check and subsequent cabin venting to atmospheric pressure.

e. Requirements - Either measurement can be utilized to determine the cabin pressure and protect against a crack of a positive pressure relief valve during ascent or on orbit when operating at 14.7 psia. Loss of the Cabin Press sensor during 14.7 psia operations is acceptable because the cabin regulator will maintain the pressure. However, the Cabin Press measurement is required for planned orbiter 10.2 psia operations because the cabin regulator is no longer maintaining the pressure, and the instrumentation is more critical. The Airlock Diff Press No 1 sensor is not as accurate as the Cabin Press, and therefore is not a suitable backup during 10.2 psia operations. However, the EMU Feedwater Pressure Sensor is referenced to ambient conditions and if this sensor was accurate within 0.24 psia during testing it is an acceptable backup to the Cabin Press sensor.

f. Preplanned Contingency Procedures - The preplanned contingency procedure

REDLINE DERIVATION: (Continued)

is used to distinguish instrumentation failure from an actual high pressure condition caused by either a thermal transient, or a confirmed leak into the cabin. In addition, an instrumentation failure is confirmed if the Cabin Press indicates less than 14.5 psi based on the defined minimum atmospheric pressure at sea level (Ref NASA Technical Memorandum 4511 Table 3.1). A high pressure could be caused by a leak into the cabin following the 2 psid cabin pressure integrity test. Therefore if both the Cabin Press and the Airlock Diff Press No 1 indicate high, Cabin Temperature (V61T2552A), Cabin Hx Out-Air Temp (V61T2635A), and Cabin Press Rate of Change Ind (V61R2401A) measurements are utilized to determine if indicated pressures (Cabin press and Airlock Diff Press No 1) above the maximum redline were thermally induced, and therefore acceptable. For a possible leak into the cabin the GO2 or GN2 supply valves are closed to isolate the pressure source to prevent high cabin pressure or high O2 levels in the cabin.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Relief valve actuation during ascent and on-orbit.
(11) Reference Orbiter Hazard Reports ORBI-162, ORBI-511, ORBI-259.

CAUSES OF EXCEEDING REDLINE:

(12) Instrumentation failure.
(13) Thermal transient.
(14) Leak into cabin.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
UNITS-->	psid								
V64P0101A	0.16	-20	20						
FOR OV-103									
V61P2405A	0.080	-0.015	19.955	13.76	15.36	13.8	15.35		
FOR OV-104									
V61P2405A	0.080	-0.041	19.952	13.75	15.35	13.8	15.35		
FOR OV-105									
V61P2405A	0.080	0.008	20.029	13.62	15.42	13.8	15.35		

METER/DISPLAY RANGE - MSID: V61P2405A LOW: 0 HIGH: 20

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 6.1/6.3 SHEET 1/1 ZONE F6/E7
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-960099 SHEET 11/29 ZONE 21-A/22

ELEMENT: Orbiter SUBSYSTEM: ARS/ARPCS

LCC VIOLATION CALL: Orbiter Cabin Partial Pressure of Oxygen Anomaly | EMERG COND: Yellow (7)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V61P2511A	O2 Partial Pressure-A	2 of 3	2.8(2)	3.4(2)	psia	CI
V61P2513A	O2 Partial Pressure-B		2.8(2)	3.4(2)	psia	CI
V61P2515A	O2 Partial Pressure-C		2.8(2)	3.4(2)	psia	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) Two O2 Partial Pressures must be within the redlines and within 0.15 psi of each other.
(3) Redline violations are acceptable during the 2 psid Cabin Pressure Integrity Check.

PREPLANNED CONTINGENCY PROCEDURE:

(4) For redline violations: Monitor Cabin Press (V61P2405A) and Cabin Temperature (V61T2552A).
   A. If Cabin Press is high, Cabin Temperature is high, and Cabin Press Rate Change Ind is positive; or if Cabin Press is low, Cabin Temperature is low, and Cabin Press Rate of Change Ind is negative, problem is caused by a thermal transient, LCC violation cleared, continue countdown.
   B. If Cabin Press is high, Cabin Press Rate of Change Indication is positive, and there is no temperature correlation, the problem is a leak into the cabin. Close both O2 Supply Valves and the Emergency O2 Supply Valve (if flown) on Panel L2, LCC violation confirmed, No Go for launch.
(5) If the PPO2 falls below 2.8 psi, request crew to close visors.

NOTES:

(6) SM minimum limit (1.9 psia) is not available in BFS.
(7) PPO2 greater than 3.4 psi is a flammability hazard. Less than 2.8 psi is below the physiological limit for crew health.

REDLINE DERIVATION: CRITICALITY: 1R

(8) Minimum redline development:

Metabolic minimum (psi)	2.45
O2 use during ascent (7 crew for 5 hours) (rev 3) (psi)	0.20
Instrumentation accuracy and uncertainty (psi)	0.075
Redline (psi)	2.8

REDLINE DERIVATION: (Continued)

(9) Maximum redline development:

Maximum permitted for flammability limits (psi)	3.80
O2 added during ascent with closed mask (15 minutes) (psi)	-0.30
Instrumentation accuracy (psi)	-0.075
Redline (psi)	3.4

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Insufficient O2 pressure for crew habitability.
(11) O2 enrichment leads to flammability problem.

CAUSES OF EXCEEDING REDLINE:

(12) Instrumentation failures, calibration drift.
(13) Thermal transient.
(14) Leak to cabin.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
UNITS-->	psia								
V61P2511A	0.02	0	5	2.7	3.6	2.7	3.6		
V61P2513A	0.02	0	5	2.7	3.6	2.7	3.6		
V61P2515A	0.02	0	5						

METER/DISPLAY RANGE - MSID: V61P2511A LOW: 0 HIGH: 5
V61P2513A LOW: 0 HIGH: 5

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 6.1 SHEET 1/2 ZONE F6/F5
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-960099 SHEET 12 ZONE 3-B&C/

ELEMENT: Orbiter SUBSYSTEM: ARS/ARPCS

LCC VIOLATION CALL: Orbiter Cabin Fan Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V61P2556A	Cabin Fan Delta Press	(2)	4.2	6.8	InH2O	CI
V61T2640A	Loop 1 H2O Pump Outlet Temp		(4)	NA	deg F	BU
V61T2740A	Loop 2 H2O Pump Outlet Temp		(4)	NA	deg F	BU

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown. (5)
(3) 2 of 2 cabin fans required for flight (only one is operating).
(4) No requirement unless V61P2556A Cabin Fan Delta Press is lost. If Cabin Fan Delta Press is lost, then the requirement is 1 of 2 Loop H2O Outlet Temp measurements with the valid measurement required on the active H2O loop. A loss of Cabin Fan Delta Press accompanied by a decrease in Loop H2O Outlet Temp is indicative of a Cabin Fan Failure. (6)

PREPLANNED CONTINGENCY PROCEDURE:

(5) A. If the Cabin Fan Delta Press (V61P2556A) is reading off scale high or off scale low, then monitor the active Water Coolant Loop (WCL) Loop H2O Pump Outlet Temp (ref S0007.500).
- If the active WCL Loop H2O Pump Outlet Temp does not have a corresponding decrease (nominal temperature decrease is 5 Deg F in 1 minute), then instrumentation failure is confirmed. LCC violation cleared, continue countdown.
- If the active WCL Loop H2O Pump Outlet Temp has a nominal decrease of 5 Deg F in one minute, then LCC violation confirmed, No Go for launch.

B. If the Cabin Fan Delta Press (V61P2556A) shifts, other than off scale low or high, then perform the following (ref. S0007.500).
- Verify that the Cabin Fan circuit breakers (Pnl L4:K) are closed.
- Turn the Cabin Fan Switch to OFF (Pnl L1).
- Wait until the active WCL Loop H2O Pump Outlet Temp drops 2-3 Deg F (45 seconds nominal).
- Turn the other Cabin Fan Switch to ON (Pnl L1).

1. If the Cabin Fan Delta Press retains the shift and the active WCL Loop H2O Pump Outlet Temp returns to normal, then instrumentation failure is confirmed. Return to the original Cabin Fan configuration (Pnl L1). LCC violation cleared, continue countdown.
2. If the Cabin Fan Delta Press retains the shift and the active WCL Loop H2O Pump Outlet Temp does not return to normal, then an air

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

flow problem is confirmed (high DP - restricted flow, low DP - duct leakage). LCC violation confirmed, No Go for launch.

3. If the Cabin Fan Delta Press is normal, then the problem is a Cabin Fan failure. LCC violation confirmed, No Go for launch.

(6) A Loop H2O Pump Outlet Temp (V61T2640A or V61T2740A) reading off scale low or off scale high is a confirmed instrumentation failure. If both the Cabin Fan Delta Press (V61P2556A) and the active WCL Loop H2O Pump Outlet Temp (V61T2640A or V61T2740A) are failed, then perform the following (ref. S0007.500).

- Reconfigure to the other H2O Coolant Loop.
- If the active WCL Loop H2O Pump Outlet Temp is normal, then LCC violation cleared, continue countdown otherwise LCC violation confirmed, No Go for launch.

NOTES:

(7) If both the Cabin Fan Delta Press and the active WCL Loop H2O Pump Outlet Temp are low, then the problem is an air flow leak. This condition can be confirmed by performing the following (ref. S0007.500).

- Turn the Cabin Fan OFF.
- Verify that the Cabin Fan Delta Press is zero.
- Turn the Cabin Fan back to ON.
- If the Cabin Fan Delta Press returns to the previous value, then the problem is a confirmed air flow leak.

(8) If the Cabin Fan Delta Press is high, the Cabin Hx Out-Air Temp (V61T2635A) is decreasing and the active WCL Loop H2O Pump Outlet Temp is decreasing, then the problem is an air flow restriction. This condition can be confirmed by performing the following (ref. S0007.500).

- Turn the Cabin Fan OFF
- Verify that the Cabin Fan Delta Press is zero.
- Turn the Cabin Fan back to ON.
- If the Cabin Fan Delta Press returns to the previous value, then the problem is a confirmed air flow restriction.

(9) The H2O Pump Outlet Temp for the active loop is the primary backup instrumentation for failure of the Cabin Fan Delta Press instrumentation.

REDLINE DERIVATION: CRITICALITY: 1R

(10) a. SSID Intent Summary - The functional measurements provide status of the Cabin Fan air circulation. Failing the Cabin Fan DP low limit may be the result of a fan failure or a leakage in the ducting system. Failing the high limit may be the result of a flow restriction. Any failure may lead to inadequate cooling of air cooled avionics and uncomfortable working conditions for the crew due to higher temperature, humidity and CO2 levels. Loss of one Cabin Fan is unacceptable because the next worse failure (loss of the other Cabin Fan) results in a complete loss of cooling to the cabin air cooled avionics. In addition, loss of both fans would ultimately result in the inability to control the cabin CO2 and humidity levels and a loss of the cabin circuit smoke detectors.

REDLINE DERIVATION: (Continued)

b. Voting Logic - NA

c. Minimum and Maximum Redline Development -

1. The maximum redline for the Cabin Fan Delta Press is based on the minimum flow rate requirement for the best performing fan plus half-scale instrumentation error (6.6 in. H2O + 0.2 in. H2O). The maximum worst case is the minimum flow condition (1400 lbs/hr.) with the maximum heat load.

2. The minimum redline for Cabin Fan Delta Press is based on the loss of one phase of AC power or a ruptured air duct. The maximum expected flow for an intact system is 1575 lbs/hr. and correlates to a fan delta pressure of 4.2 in. H2O.

   With a nominal Cabin Fan Delta Press measurement neither Loop Pump Outlet Temp is required because the fan delta pressure is the most direct method of determining the health of the cabin air system. However, in the event that the Cabin Fan Delta Press measurement fails, the Loop Pump Outlet Temp in the active loop is required to determine the health of the system. Loss of Cabin Fan Delta Press measurement and one WCL Loop Pump Outlet Temp is acceptable because the inactive loop (the one with the failed Loop Pump Outlet Temp) is only operated periodically during flight for short durations with the other loop always remaining active. In addition, AC phase currents can be monitored to determine the health of the cabin fan.

d. Time period - The Cabin Fan operates at all times during pre-launch, launch, and on-orbit. Due to the system criticality the Cabin Fan is monitored to T-31 seconds. Loss of both fans on orbit could lead to loss of crew/vehicle because the deorbit procedure for loss of both Cabin Fans is not fully certified because cabin temperatures may become too high and incapacitate the crew.

e. Requirements - The health of a Cabin Fan and the cabin ducting system is readily verified by the cabin fan delta pressure. However, for loss of the fan delta pressure, the fan function can be verified by the active WCL Loop H2O Pump Outlet Temp. Requirements allow for confirmed instrumentation failure resulting in the violation of the Cabin Fan Delta Press measurement, and provide the criteria for the use of the Loop Pump Outlet Temp as a backup measurement to verify the health of the fan. Both fans are required to maintain system redundancy. Confirmed instrumentation failure of one WCL Loop H2O Pump Outlet Temp measurement in addition to a failure of the Cabin Fan Delta Press measurement is acceptable due to the on-orbit AC bus current monitoring capability to determine Cabin Fan health.

f. Pre-Planned Contingency Procedures - These procedures provide a means to verify if the out-of-limits condition is caused by an instrumentation failure or a hardware failure. In the event of an instrumentation failure of both the Cabin Fan Delta Press and the

REDLINE DERIVATION: (Continued)

active WCL Loop H2O Pump Outlet Temp, the pre-planned procedures provide for the reconfigure to the alternate WCL so that the system health can be verified by a WCL that has a functional Loop H2O Pump Outlet Temp. The pre-planned contingency procedure is used to determine if the Cabin Fan has failed, or if there is a problem with the cabin air circuit ducting (leaking or blocked).

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Unacceptable loss of redundancy because the next worse failure is loss of the other Cabin Fan resulting in:
   a. Loss of cooling for crew and flight deck avionics (reduced crew performance and possible loss of cabin avionics) resulting in a possible loss of crew/vehicle.
   b. Loss of CO2 control, humidity control and cabin smoke detection.
(12) Loss of a single Cabin Fan in flight results in a Minimum Duration Flight (MDF).
(13) Reference Orbiter Hazard Reports ORBI-44 (cause C), ORBI-51 (cause N), ORBI-73 (causes C and D), ORBI-88 (causes A, B and C), and ORBI-321 (causes B and C).

CAUSES OF EXCEEDING REDLINE:

(14) Instrumentation failure.
(15) Air flow leak.
(16) Air flow restriction.
(17) Fan failure.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
UNITS-->	in.H2O								
V61P2556A	0.032	0	8	4.16	6.8	4.2	6.8		
UNITS-->	deg.F								
V61T2640A	0.36	32	122						
V61T2740A	0.36	32	122						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 6.2 SHEET 1 ZONE C6
DWG NO 7.4 SHEET 1 ZONE R5&7
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-960099 SHEET 12/24&2 ZONE 19B/18B

ELEMENT: Orbiter SUBSYSTEM: ARS/ARPCS

LCC VIOLATION CALL: Orbiter Water Coolant Loop Leakage Indication | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	OV-103 and OV-105					
V61P2600A	H2O Loop 1 Pump Outlet Press	(2)	20 (3)	30 (3)	psia	CI
			54 (4)	71 (4)	psia	CI
V61Q2610A	H2O Loop 1 Accum Quantity	(2)	40 (5)	55 (5)	%	CI
V61P2700A	H2O Loop 2 Pump Outlet Press	(2)	20 (3)	30 (3)	psia	CI
			56 (4)	73 (4)	psia	CI
V61Q2710A	H2O Loop 2 Accum Quantity	(2)	50 (5)	65 (5)	%	CI
NA	OV-104					
V61P2600A	H2O Loop 1 Pump Outlet Press	(2)	23 (3)	33 (3)	psia	CI
			57 (4)	74 (4)	psia	CI
V61Q2610A	H2O Loop 1 Accum Quantity	(2)	40 (5)	55 (5)	%	CI
V61P2700A	H2O Loop 2 Pump Outlet Press	(2)	20 (3)	30 (3)	psia	CI
			56 (4)	73 (4)	psia	CI
V61Q2710A	H2O Loop 2 Accum Quantity	(2)	50 (5)	65 (5)	%	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 measurements per Water Coolant Loop (WCL) is acceptable for confirmed instrumentation failure. (6)
(3) Redline when loop is inactive.
(4) Redline when loop is active.
(5) A differential of less than 5 percent between WCL 1 and WCL 2 accumulator quantities is unacceptable.

PREPLANNED CONTINGENCY PROCEDURE:

(6) Instrumentation failure is confirmed by a step change reading at the lower end or the upper end of the measurement range. An H2O Loop Accum Quantity measurement exhibiting erratic behavior is a confirmed instrumentation failure. LCC violation cleared, continue countdown.
(7) If failure can not be attributed to instrumentation failure, then LCC violation confirmed, No Go for launch.
- Perform the following safing to maintain/regain avionics cooling and to mitigate the potential for crew exposure to R-21 due to a Freon Coolant Loop (FCL) to WCL leak (ref S0007.500).
  a. Activate a pump in the alternate WCL.
  b. Deactivate the pump in the failed WCL unless a WCL to WCL leak is indicated. The following are indications of WCL to WCL leakage.
     1. WCL1 and WCL2 quantities converge.
     2. Prior to the activation of the alternate WCL, there is a decrease

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

of the H2O Loop Pump Outlet Press in the active loop accompanied by an increase of the H2O Loop Pump Outlet Press in the inactive loop.

3. Following the activation of the alternate WCL and prior to the deactivation of the failed WCL the H2O Loop Pump Outlet Press measurements on both loops converge. The rate of change will likely decrease and stop as the loops equalize in pressure.

NOTES:

(8) The various WCL leaks are manifest as follows.

a. Leak of GN2 pressurant: A decreasing H2O Loop Pump Outlet Press with the H2O Loop Accum Quantity remaining nominal. A minor increase in H2O Loop Accum Quantity may be evident when the pressure drops low enough to cause nominal entrained gas to come out of solution.

b. Leakage from an FCL to a WCL: An increase of the H2O Loop Pump Outlet Press and H2O Loop Accum Quantity and a decrease of an FCL Pump Inlet Press or Accumulator Quantity (Ref SSID ECL-41). The volume of the FCL accumulators are more than 30 times that of the WCL accumulators, so a decrease of the FCL accumulator quantity may not be readily apparent.

c. Leakage from one WCL to the other WCL: WCL1 and WCL2 H2O Loop Accum Quantities converge. A decrease of the active H20 Loop Pump Outlet Press and H2O Loop Accum Quantity and an increase of the inactive H2O Loop Pump Outlet Press and H2O Loop Accum Quantity.

d. Accumulator bellows leak: An increase of the H2O Loop Accum Quantity as the bellows moves toward its null position (100%), without a corresponding change in the H2O Loop Pump Outlet Press.

e. WCL external water leakage: A decrease of both the H2O Loop Pump Outlet Press and the H2O Loop Accum Quantity.

(9) H2O Loop 1 and 2 Pump Outlet Press are also used with Interchanger flow (Reference SSID ECL-09).

REDLINE DERIVATION: CRITICALITY: 1R

(10) a. SSID Intent Summary - The measurements provide means to detect various types of leakages in the 2 water coolant loops. A leak could be an accumulator GN2 leak, an inter-path leak between water loops, a Freon to Water inter-path leak, an internal leak at another WCL heat exchanger, or a water loop external leak. Any of these leakages could result in the loss of function of the WCL. Loss of a single WCL could result in overheating of water cooled avionics in the cabin until the other WCL is activated. Loss of one WCL is unacceptable, because the next worst failure (loss of other WCL) results in a complete loss of cooling to the cabin water cooled avionics, and eventual loss of cabin air cooled avionics due to loss of heat transfer from the cabin air to the WCL. Loss of one WCL results in the next PLS because the loss of the second loop requires a landing within four hours.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - OV-104 H2O Loop 1 Pump Outlet Press has a known bias of approximately 3 psi high and therefore the

REDLINE DERIVATION: (Continued)

minimum and maximum redlines are adjusted accordingly.

1. The Minimum Outlet Pressures are set to detect an accumulator GN2 leak.

   The minimum Outlet Pressure for an inactive loop (20 psia) is set approximately 3 psi and 5 psi below the nominal WCL1 and WCL2 accumulator pressures respectively. The lower limit will detect any GN2 leakage and protect against the SODB lower limit of 18 psia for pump activation to prevent pump cavitation.

   The minimum Outlet Pressure for an active loop is based on the minimum accumulator charge (at servicing) and the minimum pump delta pressure. This allows for variances in pump performance and flow configuration (allowable tolerances in interchanger flow rates due to bypass valve position) while maintaining the capability to readily detect a GN2 leak.

	WCL1	WCL2
OMRSD Minimum servicing pressure:	21 psia	23 psia
OMRSD Minimum pump delta pressure:	+ 33 psi	+ 33 psi
Minimum Redline limit:	54 psia	56 psia

2. The Maximum Outlet Pressures are set to detect a Freon-to-Water leak or a leakage between water loops, either of which would result in a functional loss of the WCL.

   The maximum Outlet Pressure for an inactive loop (30 psia) is set to readily detect inter-loop leakage (FCL to WCL or WCL to WCL) while allowing for nominal transducer bias and nominal changes (1 or 2 bits) during countdown.

   The maximum Outlet Pressure for an active loop is based on the maximum accumulator charge (at servicing) and the maximum pump delta pressure. This allows for variances in pump performance and flow configuration (allowable tolerances in interchanger flow rates due to bypass valve position) while maintaining the capability to readily detect inter-loop leakage.

	WCL1	WCL2
OMRSD Maximum servicing pressure:	25 psia	27 psia
OMRSD Maximum pump delta pressure:	+ 46 psi	+ 46 psi
Maximum Redline limit:	71 psia	73 psia

3. The Minimum Accumulator Quantities are set to detect a system external water leakage and accommodate minor quantity variations below the lower limit servicing requirement of 43% and 53% for WCL1

REDLINE DERIVATION: (Continued)

and WCL2 respectively.

4. The Maximum Accumulator Quantities are set to detect a FCL to WCL leakage, or an accumulator bellows leak while accommodating nominal thermal transients during countdown

d. Time period - Both Water Coolant Loops are configured and functionally stable during the LCC time period effectivity and the likelihood of a leak initiating after T-9 minutes on a system that has been monitored for leaks since loop servicing is very low.

e. Requirements - The Minimum difference in WCL1 and WCL2 quantities are set to detect leakage between the two loops. Water external leakage and internal (FCL to WCL or WCL to WCL) leakage can be detected by either the H2O Loop Pump Outlet Press or the H2O Loop Accum Quantity, and therefore the loss of either measurement is acceptable. Although, the loss of the H2O Loop Pump Outlet Press may inhibit the capability to detect a GN2 leak before the pressure is below the minimum permitted (18 psia) to start the pump without concern for pump cavitation the periodic in-flight operation (every 4 hours) of the backup loop (WCL1) can be used to determine the health of the GN2 accumulator charge. Given the low likelihood of a GN2 accumulator leak on a system that has been stable for months or years, permits launching without the measurement.

OV-104 H2O Loop 1 Pump Outlet Press has a known bias of approximately 3 psi high and therefore the minimum and maximum redlines are adjusted accordingly.

f. Preplanned Contingency Procedures - These procedures provide a means to verify if the out-of-limits condition is caused by an instrumentation failure or hardware failure. For all hardware failure modes (leakage) the procedure will direct the activation of a pump in the alternate WCL to maintain cooling. The pump in the failed loop will be deactivated unless the leakage is determined to be WCL to WCL interloop leakage. With both loops operating WCL to WCL interloop leakage will be minimized by reducing the pressure differential between the two loops. For all other leakage modes power down of the pump in the failed loop will help to prevent pump damage from cavitation, potentially decrease the leak rate, and prevent possible crew exposure to R-21 (FCL to WCL leak).

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Converging quantities: Leak between water coolant loops results in single water coolant loop configuration.
(12) Min press/quantity: Possible cavitation of water coolant loop pump, (overheat cabin equipment until other water coolant loop is activated) and loss of redundancy. Low pressure/quantity could be the result of an external water leak which would result in free water in the crew cabin.
(13) Max press/quantity: Top out accumulator bellows, and possible loss of water loop if thermal transients cause quantity/pressure to exceed accumulator design limits. Potential for crew exposure to R-21.

CONSEQUENCES OF EXCEEDING REDLINE: (Continued)

(14) Reference Orbiter Hazard Reports ORBI-117, ORBI-241, ORBI-276 and ORBI-321.

CAUSES OF EXCEEDING REDLINE:

(15) Instrumentation failure.
(16) External leak of accumulator N2 pressurant.
(17) Leak from an FCL in the midbody to the WCL via the interchanger.
(18) Leak between H2O loops.
(19) Accumulator bellows leak.
(20) Water loop external leak.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
UNITS-->	psia								
V61P2600A	0.6	0	150	19.5	79.5	19.5	79.5		
V61P2700A	0.6	0	150	45	81	45	81		
UNITS-->	pcnt								
V61Q2610A	0.51	-11.09	116.2						
V61Q2710A	0.51	-11.09	116.2						

METER/DISPLAY RANGE - MSID: V61P2n00A LOW: 0 HIGH: 150

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 7.4 SHEET 1 ZONE R,S&T
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-960102 SHEET 17/19 ZONE 16,17

ELEMENT: Orbiter SUBSYSTEM: ARS/ARPCS

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LCC VIOLATION CALL: Water Coolant Loop Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	OV-103 and OV-105					
V61P2600A	H2O Loop 1 pump outlet press	1	54	71	psia	CI
V61R2742A	H2O Loop 1 Interchanger Flow	of	649	NA	lb/hr	CI
V61P2605A	H2O Loop 1 Pump Delta Press	3	33	46	psid	CI
V61P2700A	H2O Loop 2 Pump Outlet Press	1	56	73	psia	CI
V61R2722A	H2O Loop 2 Interchanger Flow	of	649	NA	lb/hr	CI
V61P2705A	H2O Loop 2 Pump Delta Press	3	33	46	psid	CI
	OV-104					
V61P2600A	H2O Loop 1 Pump Outlet Press	1	57	74	psia	CI
V61R2742A	H2O Loop 1 Interchanger Flow	of	649	NA	lb/hr	CI
V61P2605A	H2O Loop 1 Pump Delta Press	3	33	46	psid	CI
V61P2700A	H2O Loop 2 Pump Outlet Press	1	56	73	psia	CI
V61R2722A	H2O Loop 2 Interchanger Flow	of	649	NA	lb/hr	CI
V61P2705A	H2O Loop 2 Pump Delta Press	3	33	46	psid	CI

TIME PERIOD:

(1) From Start of ET Cryo tanking (T-6 hours) to Go For SSME Start (T-10 seconds).

REQUIREMENTS: FIGURES/TABLES:

(2) Redline limits only apply to the active water coolant loop.

PREPLANNED CONTINGENCY PROCEDURE:

(3) For loss of the active water coolant loop, reconfigure cooling to the other Loop, LCC violation confirmed, No Go for launch.

NOTES:

(4) Both water coolant loops are required to be functional for launch with one of the two pumps in loop 1 operational. Only one water coolant loop is operating.

(5) Nominal prelaunch configuration: Water coolant loop 2 is active, loop 1 is not active and is not verified functional during the LCC timeframe.

REDLINE DERIVATION: CRITICALITY: 1R

(6) a. SSID Intent Summary - The measurements provide the means to detect anomalies in the active Water Coolant Loop such as a pump failure, or a flow blockage leading to inadequate vehicle cooling. Loss of the active water coolant loop pump (WCL2) results in loss of the WCL. Flow degradation due to blockage also results in loss of the WCL. Loss of

REDLINE DERIVATION: (Continued)

one WCL is unacceptable because the next worst failure (loss of other WCL) results in a complete loss of cooling to the cabin water cooled avionics, and eventual loss of cabin air cooled avionics due to loss of heat transfer from the cabin air to the WCL. Loss of one WCL will result in the next PLS because the loss of the second loop requires a landing within 4 hours.

b. Voting Logic - The intent of the requirement is to detect a WCL pump failure, performance problem, or loop flow anomaly due to blockage. A pump failure, performance problem or flow blockage will result in a change in all three measurements (H2O Loop - pump outlet press, pump delta press, interchanger flow). Therefore, a nominal value of one of the three measurements verifies WCL function.

c. Minimum and Maximum Redline Development - OV-104 H2O Loop 1 Pump Outlet Press has a known bias of approximately 3 psi high and therefore the minimum and maximum redlines are adjusted accordingly.

1. The minimum H2O Loop pump outlet press and H2O Loop pump delta press limits are set to detect pump failure or performance problems while allowing for acceptable pressure variances. Pressure variances are due to nominal differences in pump performance and acceptable loop flow configuration differences. Differences in the bypass valve configuration affect the loop pressures. The minimum H2O Loop pump delta pressure corresponds to the full flow configuration of approximately 1200 lbs/hr.

	WCL1	WCL2
OMRSD Minimum servicing press:	21 psia	23 psia
OMRSD/LCC Minimum pump delta press:	+ 33 psi	+ 33 psi
Minimum Redline limit:	54 psia	56 psia

2. The maximum H2O Loop pump outlet press and H2O Loop pump delta press limits are set to detect flow restriction (freezing or contamination) while allowing for acceptable pressure variances. Pressure variances are due to nominal differences in pump performance and acceptable loop flow configuration differences. Differences in the bypass valve configuration affect the loop pressures. The maximum H2O Loop pump delta pressure corresponds to the minimum flow configuration of approximately 850 lbs/hr.

	WCL1	WCL2
OMRSD Maximum servicing press:	25 psia	27 psia
OMRSD/LCC Maximum pump delta press:	+ 46 psi	+ 46 psi
Minimum Redline limit:	71 psia	73 psia

3. The minimum limit for H2O Loop interchanger flow is required to ensure adequate vehicle cooling. At a flow rate < 600 lb/hr,

REDLINE DERIVATION: (Continued)

avionics bay 2 coldplates cannot be maintained below their 130 deg F upper limit in a normal entry (five GPCs).

	Flow
Min. flow required	600
Instr accy	+49
R/L	649

d. Time period - The Water Coolant Loop 2 operates at all times during pre-launch, launch, and on-orbit. WCL1 is inactive at all times except during on-orbit periodic operations for thermal conditioning (approximately 6 minutes every 4 hours). Although both WCLs are functionally stable (only one loop is operating) during the LCC time period effectivity, the pressures and flow rate are monitored until T-10 seconds because a pump failure is readily detectable and the loss of a WCL leads to next PLS.

e. Requirements - The requirements are only applicable to the active WCL because the purpose of this requirement is to detect a pump failure or flow problems.

f. Preplanned Contingency Procedures - The procedures will direct the activation of the alternate WCL (normally WCL1) if the primary WCL fails. Although this is a No Go condition, the alternate loop activation is required to maintain vehicle cooling.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Reduced or no cooling provided to Orbiter cabin until water coolant loop flow recovery.
(8) Reference Orbiter Hazard Reports ORBI-117, ORBI-276 and ORBI-321.

CAUSES OF EXCEEDING REDLINE:

(9) Instrumentation failure.
(10) Flow restriction indicated by high delta pressure, low flowrate and increasing cabin heat exchanger air outlet temperature.
(11) Pump failure indicated by low delta pressure (low pump outlet pressure) and flowrate at low limit (300 lb/hr).
(12) Water loop leakage indicated by low pump outlet pressure with nominal flow.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	psia								
V61P2600A	0.6	0	150	19.5	79.5	19.5	79.5		
V61P2700A	0.6	0	150	45	81	45	81		
UNITS-->	psid								
V61P2605A	0.24	0	60						
V61P2705A	0.24	0	60						
UNITS-->	lb/hr								
V61R2722A	NL	4.5	1704						
V61R2742A	NL	4.5	1704						

METER/DISPLAY RANGE - MSID: V61P2600A LOW: 0 HIGH: 150
V61P2700A LOW: 0 HIGH: 150

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 7.4 SHEET 1 ZONE O&R6,5,
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-960099 SHEET 24/25 ZONE 10,20&2

ELEMENT: Orbiter SUBSYSTEM: ARS/ARPCS

LCC VIOLATION CALL: Orbiter Avionics Bay Cooling Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V61P2642A	Avionics Bay 1 Delta Press					
	OV-103	(2)	3.1 (4)	4.79(4)	InH2O	CI
	OV-104	(2)	2.51(4)	4.9 (4)	InH2O	CI
	OV-105	(2)	3.1 (4)	4.79(4)	InH2O	CI
V61T2645A	Avns Bay 1 Outlet Air Temp	(2)	(5)	125(11)	deg F	CI
V61T2615A	Loop 1 Avns Bay 1 Hx Outlet Temp	(7)	(6)	103 (6)	deg F	BU
V61T2624A	Loop 1 Avns Bay 1 H2O Outlet Temp	(7)	(6)	115 (6)	deg F	BU
V61T2616A	Loop 2 Avns Bay 1 Hx Outlet Temp	(7)	(6)	103 (6)	deg F	BU
V61T2625A	Loop 2 Avns Bay 1 H2O Outlet Temp	(7)	(6)	115 (6)	deg F	BU
V61P2647A	Avionics Bay 2 Delta Press					
	OV-103	(2)	2.51(4)	4.59(4)	InH2O	CI
	OV-104	(2)	2.4 (4)	4.79(4)	InH2O	CI
	OV-105	(2)	2.51(4)	4.59(4)	InH2O	CI
V61T2650A	Avns Bay 2 Outlet Air Temp	(2)	(5)	125(11)	deg F	CI
V61T2618A	Loop 1 Avns Bay 2 Hx Outlet Temp	(7)	(6)	103 (6)	deg F	BU
V61T2627A	Loop 1 Avns Bay 2 H2O Outlet Temp	(7)	(6)	115 (6)	deg F	BU
V61T2619A	Loop 2 Avns Bay 2 Hx Outlet Temp	(7)	(6)	103 (6)	deg F	BU
V61T2628A	Loop 2 Avns Bay 2 H2O Outlet Temp	(7)	(6)	115 (6)	deg F	BU
V61P2658A	Avionics Bay 3 Delta Press					
	OV-103 (standard avionics bay fan)	(2)	3.3 (4)	4.9 (4)	InH2O	CI
	OV-104 (standard avionics bay fan)	(2)	3.21(4)	5.0 (4)	InH2O	CI
	OV-105 (standard avionics bay fan)	(2)	3.3 (4)	5.0 (4)	InH2O	CI
	OV-103/4/5 (modified av bay fan)	(2)	6.1 (4)	7.7 (4)	InH2O	CI
V61T2661A	Avns Bay 3 Outlet Air Temp	(2)	(5)	125(11)	deg F	CI
V61T2621A	Loop 1 Avns Bay 3 Hx Outlet Temp	(7)	(6)	103 (6)	deg F	BU
V61T2630A	Loop 1 Avns Bay 3A H2O Outlet Temp	(7)	(6)	115 (6)	deg F	BU
V61T2622A	Loop 2 Avns Bay 3 Hx Outlet Temp	(7)	(6)	103 (6)	deg F	BU
V61T2631A	Loop 2 Avns Bay 3A H2O Outlet Temp	(7)	(6)	115 (6)	deg F	BU

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 measurements acceptable for confirmed instrumentation failure. (8)
(3) Loss of 1 standard avionics bay fan is acceptable (1 of 6 if all fans are standard, 1 of 4 if avionics bay 3A is equipped with modified fans). If installed in avionics bay 3A, both modified fans are required for launch.
(4) From the Start of ET Cryo Tanking (T-6 hours) to Go for GLS Start (T-9 minutes), any unexplained sustained changes in fan delta pressure exceeding +/- .2 inch of water (In H2O) not caused by transients in temperature and/or pressure require evaluation. (9),(10),(12)
(5) A decrease of 5 deg F or more in one minute indicates a loss of air flow. LCC violation confirmed, No Go for Launch. (9)
(6) A decrease of 10 deg F or more in one minute indicates a loss of air flow. LCC violation confirmed, No Go for Launch.
(7) No requirement unless either the Avionics Bay Delta Press or Avns Bay Outlet Air Temp is lost. If either of these measurements fail, the requirement is 1 of 2 measurements per active water loop only (Loop Avns Bay Hx Outlet Temp or Loop Avionics Bay H2O Outlet Temp).

PREPLANNED CONTINGENCY PROCEDURE:

(8) To confirm instrumentation failure, monitor backup parameters. If the values are normal, the problem is instrumentation failure. LCC violation cleared, continue countdown.
(9) If the Avionics Bay Delta Press decreases below the minimum redline limit and the corresponding water temperatures (Loop Avns Bay Hx Outlet Temp/Loop Avns Bay H2O Outlet Temp) and Avns Bay Outlet Air Temp are decreasing, switch to alternate AV Bay Fan (Panel L1) and perform troubleshooting (Reference S0007.500 "Avionics Bay Cooling Anomaly").
    1. If the Avionics Bay Delta Press and Avns Bay Hx Outlet Air Temp return to normal when the alternate fan is selected, fan failure is confirmed.
        - For the first failure of a standard avionics bay fan switch off the failed fan (Panel L1) and open the circuit breakers (Panel L4, three phases). LCC violation cleared, continue countdown.
        - For loss of a second standard avionics bay fan, or the first failure of a modified avionics bay 3A fan, LCC violation confirmed, No Go for Launch.
    2. If there is no change in the Avionics Bay Delta Press and Avns Bay Outlet Air Temp when the alternate fan is selected, the problem is an air flow leak. Power down air cooled equipment in the affected avionics bay. Manual inspection is required. LCC violation confirmed, No Go for Launch.
(10) If the Avionics Bay Delta Press and the Avns Bay Outlet Air Temp increase such that either exceeds the maximum redline limit, switch to alternate AV Bay Fan (Panel L1) and perform troubleshooting (Reference S0007.500 "Avionics Bay Cooling Anomaly").
    1. If there is no change Avionics bay Delta Press or Avns Bay Outlet Air Temp when the other fan is selected, the problem is an air flow restriction. Power down air cooled equipment in the affected avionics bay. Manual inspection is required. LCC violation confirmed, No Go for Launch.
    2. If the Avionics Bay Delta Press and Avns Bay Outlet Air Temp return to normal, the problem is restricted air flow in a single fan. The

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

restriction could move to the alternate fan. Manual inspection is required. LCC violation confirmed, No Go for Launch.

(11) If the Avns Bay Outlet Air Temp exceeds the maximum limit, switch to alternate AV Bay Fan (Panel L1) and perform troubleshooting (Reference S0007.500 "Avionics Bay Cooling Anomaly"). If there is no change in the H2O Loop Interchanger Flow, the Loop Avns Bay Hx Outlet Temp, and the Loop Avns Bay H2O Outlet Temp when the other fan is selected, the problem is an H2O loop flow restriction. Activate the other H2O loop. LCC violation confirmed, No Go for Launch.

(12) If the Avionics Bay Delta Press changes by more than 0.2 In H2O, monitor the corresponding water loop temperatures (Avns Bay Hx Outlet Temp/Avns Bay H2O Outlet Temp) and Avns Bay Outlet Air Temp for change/stabilization (10 minutes minimum). If the Delta Press stabilizes and can be explained by transient thermal conditions, LCC violation cleared, continue countdown.

NOTES:

(13) A Signal conditioner loss results in the loss of Avionics Bay Delta Press, Loop Avns Bay H2O Outlet Temp, and Avns Bay Outlet Air Temp measurements for that avionics bay.

(14) Fan dP values reflect the current avionics bay configuration. Avionics bay dP values are based on the flow analysis results presented in TS-TM-07-007, April 12, 2007. The analysis considers hardware additions and ducting modifications to accommodate ISS middeck cooled payloads.

REDLINE DERIVATION: CRITICALITY: 1R

(15) a. SSID Intent Summary - The SSID protects against the loss of cooling to the air cooled avionics located in Bays I, II, and IIIA. Both the standard and the modified Bay IIIA configurations are addressed. The avionics bay fan delta pressure is used to quickly determine the health of the operating avionics bay fan and the associated ducting. The redline limits in conjunction with the Avionics Bay Outlet Air Temp verify adequate air flow/air temperature to the av-bay air cooled equipment for proper cooling. The remaining two water temperatures are used as backup measurements to determine the health of the air circulation in the avionics bay.

b. Voting Logic - 1 of 2 measurements (Avionics Bay Delta Press or Avns Bay Outlet Air Temp) are acceptable for confirmed instrumentation failure- The delta pressure responds immediately to changes in air flow rates and the air temperature is the best indication of proper cooling of the avionics. However, loss of either measurement is acceptable because either of the corresponding water loop temperatures respond rapidly to significant changes in air flow.

Loss of one standard avionics bay fan - Although loss of one standard avionics bay fan in each of two different avionics bays will still support cooling requirements, loss of two fans may be evidence of a generic fan problem and is unacceptable unless proven not to be the case.

REDLINE DERIVATION: (Continued)

2 of 2 modified avionics bay 3A fans required - One modified fan is capable of supporting cooling in avionics bay 3A, however, to provide backup for unique 3A avionics, and station payloads both fans are required.

c. Redline Development- Prevents overheating of air and water cooled avionics.

1. Max Avns Bay Outlet Air Temp (deg F - spec limit) 130
   Instrumentation error (5%) -5

   Max Avns Bay Outlet Air Temp Redline (deg F) 125

   130 deg F prevents air cooled avionics from overheating and maintains the operating life of the avionics.

2. Max Avns Bay Hx Outlet Temp:
   Max Avns Bay Air Outlet temp (deg F - per spec) 130
   Max Avns Bay Air Inlet temp to maintain 130 deg F air out 95

   Max Avns Bay Hx Water Inlet temp to maintain 95 deg F air in 79
   Avns Bay Hx delta temp (water) at max heat load + 29
   Instrumentation error (5%) -4.5

   Derived max Avns Bay Hx Water Outlet Temp Redline (deg F) 103

   Temperature derivations are based on the minimum air flow (792lb/hr) and nominal water flow (234 lb/hr).

3. Max Avns Bay H20 Outlet Temp (deg F - spec limit) 120
   Instrumentation error (5%) -5

   Max Avns Bay H2O Outlet Temp Redline (deg F) 115

4. Avionics Bay Delta Pressure
   Minimum delta pressure (Standard) Av Bay fan (In. H2O) variable
   Minimum delta pressure (Modified) Av Bay fan (In. H2O) 6.1
   Max delta pressure (Standard) Av Bay fan (In. H2O) variable
   Max delta pressure (Modified) Av Bay fan (In. H2O) 7.7
   Max allowable change in Av Bay delta pressure (In. H2O) 0.2

Although fan delta pressure is used to readily detect fan failure, it is only a coarse representation of avionics bay cooling performance without associated temperature consideration as well. Therefore, measurement error for delta pressure will not be used to determine loss of an avionics bay fan.

The minimum fan delta pressure for the avionics bay is based on the lowest expected fan performance and highest allowable bay temperature (130 deg F). A delta pressure below the minimum is an indication of

REDLINE DERIVATION: (Continued)

either two-phase operation, or duct leakage. Values below the lower redline limit indicate inadequate flow to the avionics to support cooling.

The maximum fan delta pressure for the avionics bay is based on the highest fan performance operating during a cold start (70 deg F). A delta pressure above the maximum is an indication of a possible obstruction in the duct system. The redline limit corresponds to the delta pressure at the minimum acceptable flow to support General Purpose Computer (GPC) cooling.

Upper and lower Avionics Bay Delta Press limits were derived using the Thermal Hydraulic Analysis Program (THAP) to support minimum GPC cooling requirements. Limits are documented in Technical Memorandum TS-TM-07-007 (April 12, 2007).

The modified avionics bay fans (bay 3A only) support enhanced middeck cooling and have higher limits due to higher nominal flow, associated with the increased cooling requirements.

The +/- .2 inch of water fan delta pressure limit is designed to protect the fan surge region, duct dislodging and system air flow blockage.

d. Time Period - Powered on GPCs are limited to 5 minutes without air cooling. The end effectivity of T-31 seconds was chosen to monitor the health of the system without causing a cutoff due to instrumentation. The delta pressure limits and associated temperatures are primarily in place to detect the loss of air cooling. The 0.2 inch water Delta Press change evaluation is in place primarily to detect system configuration changes (leaking or blocked ducts). The T-9 minute ending effectivity for this change [Ref (4)] is due to the low likelihood of blockage or significant leakage occurring in a stable system coupled with the time required to evaluate such a change.

e. Requirements - The health of the avionics bay fans and the ducting system is readily verified by the fan delta pressure. The air outlet temperature limits protect the avionics from overheating with the GPCs being the limiting component. However, loss of either the fan delta pressure or air outlet temperature is acceptable with the use of the secondary temperatures from the active water coolant loop. The requirement also allows for the loss of one standard avionics bay fan because a subsequent fan failure in the same avionics bay in-flight can be managed by replacing one of the failed fans with an operational fan from another avionics bay. For the modified fan configuration in avionics bay 3A, both fans are required, because loss of a second fan in-flight leaves avionics bay 3A without a fan capable of supporting cooling.

f. Pre-Planned Contingency Procedures - These procedures provide a means to determine if the out-of-limits condition is caused by an instrumentation failure or a hardware failure. If the fan fails, a

REDLINE DERIVATION: (Continued)

backup fan is configured for launch and the failed fan circuit is isolated (breakers opened). For a failed primary measurement (delta pressure or air outlet temp) the alternate primary measurement is used in conjunction with at least one of the backup measurements (water coolant loop temperatures) to confirm proper cooling.

The pre-planned contingency procedure is also used to detect a ducting problem (leaking or blocked) and thus confirms the LCC violation.

CONSEQUENCES OF EXCEEDING REDLINE:

(16) Reduced or no cooling of air-cooled avionics (overheat equipment).
(17) Reference Orbiter Hazard Report ORBI-276.

CAUSES OF EXCEEDING REDLINE:

(18) Instrumentation failure.
(19) Air flow leak.
(20) Air flow restriction.
(21) Water flow restriction.
(22) Fan failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	in.H2O								
(OV-103)									
V61P2642A	0.02	0	5					3.10	4.80
(OV-104)									
V61P2642A	0.02	0	5					2.50	4.90
(OV-105)									
V61P2642A	0.02	0	5					3.10	4.80
(OV-103)									
V61P2647A	0.02	0	5					2.50	4.60
(OV-104)									
V61P2647A	0.02	0	5					2.40	4.80
(OV-105)									
V61P2647A	0.02	0	5					2.50	4.60
(OV-103 - standard avionics bay fan)									
V61P2658A	0.032	0	8					3.30	4.90
(OV-104 standard avionics bay fan)									
V61P2658A	0.032	0	8					3.20	5.00
(OV-105 standard avionics bay fan)									
V61P2658A	0.032	0	8					3.30	5.00
(OV-103/4/5 Cabin Fan)									
V61P2658A	0.032	0	8					6.10	7.70
UNITS-->	deg. F								
V61T2615A	0.36	32	122						
V61T2616A	0.36	32	122						
V61T2618A	0.36	32	122						
V61T2619A	0.36	32	122						
V61T2621A	0.36	32	122						
V61T2622A	0.36	32	122						
V61T2645A	0.4	45	145		130		130		
V61T2650A	0.4	45	145		130		130		
V61T2661A	0.4	45	145		130		130		
V61T2624A	0.42	24.87	129.9						
V61T2625A	0.42	24.87	129.9						
V61T2627A	0.42	24.87	129.9						
V61T2628A	0.42	24.87	129.9						
V61T2630A	0.42	24.87	129.9						
V61T2631A	0.42	24.87	129.9						

METER/DISPLAY RANGE - MSID: V61T2645A LOW: 45 HIGH: 145
MSID: V61T2650A LOW: 45 HIGH: 145
MSID: V61T2661A LOW: 45 HIGH: 145

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 6.2	SHEET 1 & 2	ZONE R2,4,&7
	DWG NO 7.4	SHEET 1	ZONE BDFH4
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-960099	SHEET 15/17/2	ZONE 5,9&13F

ELEMENT: Orbiter SUBSYSTEM: ARS/ARPCS

LCC VIOLATION CALL: Orbiter IMU Fan Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V61P2869A	IMU Delta Press	(2)	3.7	4.95(3)	InH2O	CI
V61X2860E	ARS-IMU Fan A-Normal Speed	(5)	(4)	NA	Event	BU
V61X2861E	ARS-IMU Fan B-Normal Speed	(5)	(4)	NA	Event	BU
V61X2862E	ARS-IMU Fan C-Normal Speed	(5)	(4)	NA	Event	BU

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For APU Start (T-5 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) Inertial Measurement Unit (IMU) Delta Press violation is acceptable if instrumentation failure is confirmed. (6)
(3) Maximum redline violations are acceptable during the 2 psid cabin pressure integrity test.
(4) No requirement unless the IMU Delta Press measurement is lost. Measurement should be ON for active fan if IMU Delta Press measurement is lost. If IMU delta Press is lost, 2 Atmospheric Revitalization System-IMU (ARS-IMU) Fan-Normal Speed discretes on functional fans are acceptable as verified in Preplanned Contingency Procedure. (6)
(5) Loss of 1 of 3 IMU Fans is acceptable.

PREPLANNED CONTINGENCY PROCEDURE:

(6) For the IMU Delta Press reading out of limits:
  A. If the IMU Delta Press is reading zero or off scale low (OSL), deactivate the IMU fan (Panel L1), activate one of the other IMU fans (Panel L1), and monitor the IMU Delta Press.
    1. If the other IMU fan exhibits normal IMU Delta Press, the problem is an IMU fan failure. For the second IMU Fan failure, LCC violation confirmed, No Go for launch.
       For the first IMU fan failure:
       - Open circuit breakers (three phases) for the failed fan (Panel L4). LCC violation cleared, continue countdown.
    2. If the IMU Delta Press for the other IMU fan does not return to normal, the problem is an IMU Delta Press instrumentation failure.
       a. Close the Sig Cond IMU Fan circuit breaker (Panel L4:J).
       b. Confirm that the ARS-IMU Fan-Normal Speed discrete for the selected fan indicates ON.
       c. Deactivate selected fan (Panel L1), reactivate the previously operating IMU fan (Panel L1) and verify Normal Speed discrete indicates ON. The Sig Cond IMU Fan circuit breaker shall remain closed for launch. Instrumentation failure confirmed, LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

B. If the IMU Delta Press is reading out-of-limits other than zero or OSL, deactivate the IMU fan (Panel L1).
   1. If the IMU Delta Press goes to zero, activate another fan (Panel L1).
      a. If the reading returns to normal, the problem is an IMU fan failure. For the second IMU fan failure, LCC violation confirmed, No Go for Launch.
         For the first IMU fan failure:
         - Open circuit breakers (three phases) for the failed fan (Panel L4). LCC violation cleared, continue countdown.
      b. If the other fan exhibits out-of-limits IMU Delta Press, the problem is a leaking or blocked duct, LCC violation confirmed, No Go for launch.
   2. If the IMU Delta Press does not go to zero when the affected fan is off, the problem is a shifted or static IMU Delta Press measurement.
      a. Activate another IMU fan - (Panel L1).
      b. Close the Sig Cond IMU Fan circuit breaker (Panel L4:J).
      c. Confirm the ARS-IMU Fan-Normal Speed discrete for the selected fan indicates ON.
      d. Deactivate selected fan (Panel L1), reactivate the previously operating IMU fan (Panel L1) and verify Normal Speed discrete indicates ON. The Sig Cond IMU Fan circuit breaker shall remain closed for launch. Instrumentation failure confirmed, LCC violation cleared, continue countdown.

NOTES:

(7) Normally for ascent all non mandatory AC circuit breakers are configured to open to lower the risk of potential AC shorts. The Sig Cond IMU Fan circuit breaker (Panel L4:J) is configured to open to support ascent at approximately L-2 days. However, closure of the signal conditioner circuit breaker becomes mandatory and is acceptable if required to provide IMU fan function visibility.

REDLINE DERIVATION: CRITICALITY: 1R

(8) a. SSID Intent Summary - The IMU fan delta pressure is used to determine the health of the operating IMU fan and the IMU ducting. The redline limits verify adequate air flow to the IMU's for proper cooling. Only one of three IMU fans is required to provide adequate cooling to all three IMU's. Three functional IMU fans provide two fault tolerance for IMU cooling, but single fault tolerance maintains redundancy and is acceptable for launch, thus allowing for the loss of one IMU fan.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - The minimum limit (3.7 In. H2O) is based on maximum expected flow for an intact system (185 bm/hr). A delta pressure below the minimum indicates possible system leakage, which may lead to inadequate air flow for proper cooling.

The maximum limit (4.95 InH2O) is based on the minimum air flow rate

REDLINE DERIVATION: (Continued)

required for proper IMU cooling (144 lbm/hr). A delta pressure above the maximum indicates possible flow restriction, which may lead to inadequate air flow for proper cooling.

d. Time Period - The ending time effectivity of T-5 minutes was chosen because the IMU's can operate without cooling from T-5 minutes until the crew can reconfigure the fans on orbit. Per the flight rules (A18-501) for "MAXIMUM OFF TIME FOR COOLING EQUIPMENT" the IMU's can operate for up to 90 minutes without cooling. Although Malfunction Procedures and In-Flight Maintenance (IFM) procedure exist to repair leaking ducts, and clean filters for high fan delta pressure, the likelihood of a failure of this nature after T-5 minutes is extremely low. Additionally, IMU's can be cycled in-flight to prevent overheating.

e. Requirements - The health of an IMU fan and the IMU ducting system is readily verified by the IMU fan delta pressure. However, for loss of the fan delta pressure, the fan function can be verified by the ARS-IMU Fan-Normal Speed discrete backup measurement. Requirements allow for confirmed instrumentation failure resulting in the violation of the IMU Delta Press measurement, and provide criteria for the use of the backup Fan Normal Speed discrete measurements to verify the health of operational IMU fans. The requirement also protects for the loss of more than one IMU fan.

f. Pre-Planned Contingency Procedures - These procedures provide a means to verify if the out-of-limits condition is caused by an instrumentation failure or a hardware failure. If the IMU fan fails, a backup fan is configured for launch and the failed fan circuit is isolated (breakers opened). For a failed delta pressure measurement, normal speed discretes are verified for a backup fan and the primary fan (Fan B). The Signal Conditioner circuit breaker remains closed for launch to maintain visibility of the Normal Speed discrete.

The pre-planned contingency procedure is also used to detect a ducting problem (leaking or blocked) and thus confirms the LCC violation. A shift in the delta pressure measurement outside the redline limits, that indicates zero when the fans are off, may be caused by an instrumentation problem which cannot be isolated and leads to a conservative call of an LCC violation confirmation.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Reduced or no IMU cooling which could result in IMU overheating and failure.

CAUSES OF EXCEEDING REDLINE:

(10) Instrumentation failure.
(11) Air flow leak.
(12) Air flow restriction.
(13) Fan failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	In. H2O								
V61P2869A	0.028	0	7					3.7	4.95

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 6.2 SHEET 1 ZONE MNO-6&8
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-960099 SHEET 19 ZONE 3,12&
DWG NO SHEET ZONE 18C

ELEMENT: Orbiter SUBSYSTEM: ARS/ARPCS

SSIDs ECL-12 Through ECL-19 Reserved

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LCC VIOLATION CALL: Orbiter Potable Water Quantity Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V62Q0410A	Supply H2O Ptbl Tk A Quantity	(2)	NA	(4)	%	CI
V62Q0420A	Supply H2O Tk B Quantity	(3)	(5,8)	(6,8)	%	CI
V62Q0548A	Supply H2O Tk C Quantity	(3)	(5)	(6)	%	CI
V62Q0544A	Supply H2O Tk D Quantity	(3)	(5)	(6)	%	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) MISSION DEPENDENT: Tank A quantity measurement is required for missions for which the total water quantity requirement is more than 550 pounds. For other missions, confirmed instrumentation failure is acceptable. (7,9)
(3) 2 of 3 measurements are acceptable for confirmed instrumentation failure. (9)
(4) The maximum quantity for Supply H2O Potable Tk A for the times specified is as follows: (The limits apply when the count is resumed after holds.)

Time	Normal Repress (T+56 minutes)	Early Repress (T+15 minutes)
T-9 minutes	81.7%	90.1%
T-5 minutes	82.5%	90.9%
T-31 seconds	83.5%	91.9%

(5) No leakage. A change of three data bits indicates a possible leak, LCC violation confirmed, No Go for launch.
(6) An increase of three data bits indicates a possible fuel cell primary flow path problem and requires engineering evaluation, LCC violation confirmed, No Go for launch.

PREPLANNED CONTINGENCY PROCEDURE:

(7) If Tank A instrumentation fails, calculate water quantity.
(8) For loss of Tank B quantity instrumentation, close Tank C Inlet and Outlet valves and open the crossover valve.
(9) A tank quantity reading at the lower or upper end of the instrumentation range is a confirmed instrumentation failure.

NOTES:

(10) Tanks A & B and C & D are operated as two separate systems. These two sets of tanks are operated separately until "entry" day to assure deorbit capability at anytime.
(11) Tank D SM lower limit is set off-scale low and the upper limit is set off-scale high.
(12) Fuel cell generated water is stored in Tank A during prelaunch.

REDLINE DERIVATION: CRITICALITY: 1R

(13) Redline development: (Maximum load) Indicated quantity (%)

Tank Capacity	100.0
FCP Gen to lift-off + 56 minutes	-13.3
Measurement Uncertainty	-5.0
Max. Load at lift-off	81.7

Maximum limit protects the Tank A bellows and fuel cell relief valve.

(14) FCP generated water is based on an electrical load of 25kw, normal tank repress, and no holds after T-9 minutes.

CONSEQUENCES OF EXCEEDING REDLINE:

(15) Min: Loss of water management capability.

(16) Max: A. If Tank A fills before the N2 pressure valve is opened, Tank A bellows may be damaged and each FCP relief valve becomes a single point failure (FCP will "flood" if relief valve does not relieve).

B. Extended bellows may be ruptured even if relief valve does relieve or if the check valve between Tanks A and B fails.

CAUSES OF EXCEEDING REDLINE:

(17) Min: A. Leak.

B. Instrumentation failure.

(18) Max: A. Overfill (Tank A).

B. Clogged primary line from fuel cells (TK B,C,D).

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
UNITS-->	pcnt								
V62Q0410A	0.468	-11.1	105.8						
V62Q0420A	0.468	-11.1	105.8						
V62Q0548A	0.468	-11.1	105.8						
V62Q0544A	0.468	-11.1	105.8						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 6.4 SHEET 1 ZONE NPR-6,7

INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-960099 SHEET 33/34 ZONE 19B/6B,

DWG NO SHEET ZONE 1

ELEMENT: Orbiter SUBSYSTEM: W/WMS&SD/FS

LCC VIOLATION CALL: Orbiter Waste Water Quantity Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V62Q0540A	Waste H2O Tank 1 Quantity	(2)	(3)	(3)	%	CI
V62P0500A	Waste H2O Liquid Pressure	(2)	(4)	(4)	psig	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Start of Cabin Leak Check

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 measurements acceptable.
(3) A change of 3 data bits in quantity indicates a possible leak. Leak confirmation requires realtime engineering evaluation of overall system performance. For a confirmed leak, LCC violation confirmed, No Go for launch.
(4) After Supply Water Tank A depressurization and with a constant cabin pressure, a change of 3 data bits in liquid pressure indicates a possible leak. Leak confirmation requires realtime engineering evaluation of overall system performance. For a confirmed leak, LCC violation confirmed, No Go for launch.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(5) The Waste H2O Tank Quantity increasing and stabilizing at 60-70 percent is an indication of an internal (bellows) leak.
(6) With Supply Water Tank A pressurized and fuel cells running, an increase in waste tank liquid pressure may occur.

REDLINE DERIVATION: CRITICALITY: 2

(7) The redline ensures integrity of the waste water system and its capability to prevent waste water accumulation in the crew cabin.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Loss of waste water storage capability.

CAUSES OF EXCEEDING REDLINE:

(9) Instrumentation failure.
(10) External water leak.
(11) Internal leak (bellows leak).

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	pcnt								
V62Q0540A	0.468	-11.1	105.8						
UNITS-->	psig								
V62P0500A	0.16	0	40						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 6.5 SHEET 1 ZONE K4;N2
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-960099 SHEET 41 ZONE C12;C6

ELEMENT: Orbiter SUBSYSTEM: W/WMS&SD/FS

LCC VIOLATION CALL: Orbiter Waste Water Dump Nozzle Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V62T0520A	Waste H2O Dump Nozzle Temp A	1 of	(2)	(2)	deg F	DI
V62T0519A	Waste H2O Dump Nozzle Temp B	2	(2)	(2)	deg F	DI

TIME PERIOD:

(1) Verify at Go for GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) This redline is for instrumentation failure detection only. Temperatures should not be more than 20 degrees F above or below any of the other supply (ECL-23) and waste water dump nozzle temperatures.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 2

(3) The redline ensures waste water dump capability.

CONSEQUENCES OF EXCEEDING REDLINE:

(4) For loss of both measurements, waste water will not be dumped if RMS is unavailable to observe the waste water dump (per Flight Rules).
(5) Early flight termination for limited waste water storage capability.

CAUSES OF EXCEEDING REDLINE:

(6) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	deg.F								
V62T0519A	1.6	-2	398.0						
V62T0520A	1.6	-2	398.0						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 6.5	SHEET 1	ZONE E2&5
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-960099	SHEET 36	ZONE C2

ELEMENT: Orbiter SUBSYSTEM: W/WMS&SD/FS

LCC VIOLATION CALL: Orbiter Supply Water Dump Nozzle Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V62T0439A	Supply H2O Dump Nozzle Temp A	(2)	(3)	(3)	deg F	DI
V62T0440A	Supply H2O Dump Nozzle Temp B	(2)	(3)	(3)	deg F	DI

TIME PERIOD:

(1) Verify at Go for GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) Mission Dependent: 1 of 2 measurements is acceptable for flights with payload constraints that require the Flash Evaporator System (FES) be inhibited. There is no requirement on flights without payload constraints on FES operation. Reference Flight Definition and Requirements Document (FDRD) for missions with Payload constraints on FES operation.
(3) This redline is for instrumentation failure detection only. Temperatures should not be more than 20 degrees F above or below any of the other supply and waste water dump nozzle (ECL-22) temperatures.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(4) This redline ensures supply water dump capability.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Possible early flight termination for limited supply water storage capability.
(6) Contamination of the payload.

CAUSES OF EXCEEDING REDLINE:

(7) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	deg.F								
V62T0439A	1.6	-2	398.0						
V62T0440A	1.6	-2	398.0						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 6.4 SHEET 1 ZONE B1 & 4
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-960099 SHEET 33 ZONE A4

ELEMENT: Orbiter SUBSYSTEM: W/WMS&SD/FS

SSIDs ECL-24 Through ECL-29 Reserved

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LCC VIOLATION CALL: Orbiter Crew Cabin Smoke Detector Concentration Measurement Failure | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V62Q0595A	Smoke Detr Concn Rtn Air-Cab Hx	(2)	-1000	NA	ug/m3	CI
V62Q0590A	Smoke Det Concn Left-Flight Deck	(2)	-1000	NA	ug/m3	CI
V62Q0591A	Smoke Det Concn Right-Flight Deck	(2)	-1000	NA	ug/m3	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) Either the Rtn Air-Cab Hx (V62Q0595A) measurement or both the Left-Flight Deck (V62Q0590A) and the Right-Flight Deck (V62Q0591A) measurements are acceptable.
(3) This LCC is for detection of instrumentation failure only. Violation of the minimum redline indicates instrumentation failure.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) Refer to LCC ECL-31 for positive alarm indication.

REDLINE DERIVATION: CRITICALITY: 1R

(5) A reading below the lower redline is indicative of instrumentation failure.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Loss of smoke detection capability.

CAUSES OF EXCEEDING REDLINE:

(7) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	ug/m3								
V62Q0595A	NL	10.46	13913		2000		2000		
V62Q0590A	NL	10.46	13913		2000		2000		
V62Q0591A	NL	10.46	13913		2000		2000		

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 5.1	SHEET 1	ZONE S6
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-960099	SHEET 68/69&7	ZONE 5C/4C

ELEMENT: Orbiter SUBSYSTEM: W/WMS&SD/FS

LCC VIOLATION CALL: Orbiter Crew Cabin Smoke Detector Alarm Indication | EMERG COND: Yellow (12)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V62X0596E	Smoke Det-Rtn Air To Cab Hx	(2)	OFF	NA (4)	Event	CI
V62X0606E	Smoke Detector-Left Flight Deck	(2)	OFF	NA (4)	Event	CI
V62X0607E	Smoke Detector-Right Flight Deck	(2)	OFF	NA (4)	Event	CI
V62Q0595A	Smoke Detr Concn Rtn Air-Cab Hx	(3)	N/A	2000	ug/m3	CI
V62Q0590A	Smoke Det Concn Left-Flight Deck	(3)	N/A	2000	ug/m3	CI
V62Q0591A	Smoke Det Concn Right-Flight Deck	(3)	N/A	2000	ug/m3	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Either the Rtn Air To Cab Hx (V62X0596E) measurement or both Left-Flight Deck (V62X0606E) and Right-Flight Deck (V62X0607E) measurements are acceptable for confirmed instrumentation failure. (6)
(3) Either the Rtn Air-Cab Hx (V62Q0595A) measurement or both the Left-Flight Deck (V62Q0590A) and the Right-Flight Deck (V62Q0591A) measurements are acceptable.
(4) For any detector alarm, LCC violation confirmed, No Go for launch.

PREPLANNED CONTINGENCY PROCEDURE:

(5) Discrete instrumentation failure is confirmed by verifying that the corresponding smoke concentration level is normal.
(6) If one sensor indicates Alarm (discrete = ON) and any system in the firing room indicates abnormal conditions in the cabin (i.e., black box failure, high temperatures, fan failures or power failure), then notify NTD immediately of confirmed smoke indication.
(7) If one sensor indicates Alarm (discrete = ON) and smoke concentration greater than 2000 micrograms per cubic meter, and a second sensor indicates Alarm (discrete = ON) or smoke concentration greater than 2000 micrograms per cubic meter, then notify NTD immediately of confirmed smoke indication.
(8) If one sensor indicates Alarm (discrete = ON) and smoke concentration greater than 2000 micrograms per cubic meter, and a second sensor indicates instrumentation failure (concentration = off-scale low), then notify NTD immediately of confirmed smoke indication.

NOTES:

(9) Refer to LCC ECL-30 for concentration lower limit indication.

REDLINE DERIVATION: CRITICALITY: 1R

(10) The "ON" event (and the C&W alarm) occurs if the rate of increase of the smoke concentration equals or exceeds 22 micrograms per cubic meter-second for 20 seconds or if the total concentration equals or exceeds 2000 micrograms per cubic meter. The redline is established to notify the crew and ground personnel of fire or smoke in the cabin.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Unacceptable smoke concentration or possible fire.
(12) A redline violation is a hazard to the crew because of smoke concentration or fire.

CAUSES OF EXCEEDING REDLINE:

(13) Instrumentation failure.
(14) Smoke concentration.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	Event								
V62X0596E				OFF					
V62X0606E				OFF					
V62X0607E				OFF					
UNITS-->	ug/m3								
V62Q0595A	NL	10.46	13913		2000		2000		
V62Q0590A	NL	10.46	13913		2000		2000		
V62Q0591A	NL	10.46	13913		2000		2000		

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 5.1 SHEET 1 ZONE R6,S6
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-960099 SHEET 68/69&7 ZONE 5C&7D/
DWG NO SHEET ZONE 4C&5E

ELEMENT: Orbiter SUBSYSTEM: W/WMS&SD/FS

LCC VIOLATION CALL: Orbiter Avionics Bay Smoke Detector Concentration Measurement Failure | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V62Q0618A	Smoke Detector Concn A-Av Bay 1	1 of	-1000	N/A	ug/m3	CI
V62Q0619A	Smoke Detector Concn B-Av Bay 1	2	-1000	N/A	ug/m3	CI
V62Q0608A	Smoke Detector Concn A-Av Bay 2	1 of	-1000	N/A	ug/m3	CI
V62Q0609A	Smoke Detector Concn B-Av Bay 2	2	-1000	N/A	ug/m3	CI
V62Q0628A	Smoke Detector Concn A-Av Bay 3	1 of	-1000	N/A	ug/m3	CI
V62Q0629A	Smoke Detector Concn B-Av Bay 3	2	-1000	N/A	ug/m3	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) This LCC is for detection of instrumentation failure only. Violation of the minimum limit indicates instrumentation failure.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) Redundant sensor may be monitored to confirm smoke/fire.
(4) Refer to LCC ECL-33 for positive alarm indication.

REDLINE DERIVATION: CRITICALITY: 1R

(5) Violation of the lower redline indicates instrumentation failure.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Loss of smoke detection capability.

CAUSES OF EXCEEDING REDLINE:

(7) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 0, 1, OR 2 FOR AV BAY 2, AV BAY 1, AND AV BAY 3 RESPECTIVELY									
UNITS-->	ug/m3								
V62Q06n8A	NL	10.46	13913		2000		2000		
V62Q06n9A	NL	10.46	13913		2000		2000		

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 5.1 SHEET 1 ZONE S2-S4
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-960099 SHEET 70/71 ZONE 3&12C
DWG NO SHEET /72 ZONE

ELEMENT: Orbiter SUBSYSTEM: W/WMS&SD/FS

LCC VIOLATION CALL: Orbiter Avionics Bay Smoke Detector Alarm Indication | EMERG COND: Yellow (11)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V62X0610E	Smoke Detector-A Av Bay-2	1 of	OFF (3)	NA (2)	Event	CI
V62X0611E	Smoke Detector-B Av Bay-2	2	OFF (3)	NA (2)	Event	CI
V62X0620E	Smoke Detector-A Av Bay-1	1 of	OFF (3)	NA (2)	Event	CI
V62X0621E	Smoke Detector-B Av Bay-1	2	OFF (3)	NA (2)	Event	CI
V62X0630E	Smoke Detector-A Av Bay 3	1 of	OFF (3)	NA (2)	Event	CI
V62X0631E	Smoke Detector-B Av Bay 3	2	OFF (3)	NA (2)	Event	CI
V62Q0618A	Smoke Detector Concn A-Av Bay 1	1 of	N/A	2000	ug/m3	CI
V62Q0619A	Smoke Detector Concn B-Av Bay 1	2	N/A	2000	ug/m3	CI
V62Q0608A	Smoke Detector Concn A-Av Bay 2	1 of	N/A	2000	ug/m3	CI
V62Q0609A	Smoke Detector Concn B-Av Bay 2	2	N/A	2000	ug/m3	CI
V62Q0628A	Smoke Detector Concn A-Av Bay 3	1 of	N/A	2000	ug/m3	CI
V62Q0629A	Smoke Detector Concn B-Av Bay 3	2	N/A	2000	ug/m3	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) For any detector alarm, LCC violation confirmed, No Go for launch.

PREPLANNED CONTINGENCY PROCEDURE:

(3) Discrete instrumentation failure is confirmed by verifying that the corresponding smoke concentration level is normal.
(4) If one sensor indicates Alarm (discrete = ON) and any system in the firing room indicates abnormal conditions in the same avionics bay (i.e., black box failure, high temperatures, fan failures or power failure), then discharge appropriate fire bottle immediately and notify NTD of confirmed smoke indication.
(5) If one sensor (A or B) indicates Alarm (discrete = ON) and smoke concentration greater than 2000 micrograms per cubic meter, and the other sensor (same bay) indicates Alarm (discrete = ON) or smoke concentration greater than 2000 micrograms per cubic meter, then discharge appropriate fire bottle immediately and notify NTD of confirmed smoke indication.
(6) If one sensor (A or B) indicates Alarm (discrete = ON) and smoke concentration greater than 2000 micrograms per cubic meter, and the other sensor (same bay) indicates instrumentation failure (concentration = off-scale low), then discharge appropriate fire bottle immediately and notify NTD of confirmed smoke indication.

NOTES:

(7) The redundant sensor may be monitored to confirm smoke/fire.
(8) Refer to LCC ECL-32 for concentration lower limit indication.

REDLINE DERIVATION: CRITICALITY: 1R

(9) The "ON" event (and the C&W alarm) occurs if the rate of increase of the smoke concentration equals or exceeds 22 micrograms per cubic meter-second for 20 seconds or if the total concentration equals or exceeds 2000 micrograms per cubic meter. The redline is established to notify the crew and ground personnel of fire or smoke in the cabin.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Unacceptable concentration of smoke or possible fire.
(11) Violation of this LCC is a hazard to the crew because of smoke concentration or fire.

CAUSES OF EXCEEDING REDLINE:

(12) Instrumentation failure.
(13) Smoke concentration.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, OR 3 FOR AV BAY 2, AV BAY 1, AND AV BAY 3 RESPECTIVELY									
UNITS-->	Event								
V62X06n0E				OFF					
V62X06n1E				OFF					
n = 0, 1, OR 2 FOR AV BAY 2, AV BAY 1, AND AV BAY 3 RESPECTIVELY									
UNITS-->	ug/m3								
V62Q06n8A	NL	10.46	13913		2000		2000		
V62Q06n9A	NL	10.46	13913		2000		2000		

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 5.1 SHEET 1 ZONE R2,3,4
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-960099 SHEET 70/71/7 ZONE 4&13E
DWG NO SHEET ZONE 3&12C

ELEMENT: Orbiter SUBSYSTEM: W/WMS&SD/FS

LCC VIOLATION CALL: Orbiter Avionics Bay Fire Bottle Empty Indication | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V62X0612E	Fire Bottle Av Bay 1 Full/Empty		OFF	NA	Event	CI
V62X0622E	Fire Bottle Av Bay 2 Full/Empty		OFF	NA	Event	CI
V62X0632E	Fire Bottle Av Bay 3 Full/Empty		OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) All three fire bottles are required for flight.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 1

(3) Empty Event "ON": Fire bottle or extinguisher internal pressure is at or below 60 + or - 1 psig. This indicates that the bottle has been activated or the freon has leaked out. The bottle pressure should remain at 200 psia 70 deg F until all liquid freon has been vaporized by freon outgassing.

CONSEQUENCES OF EXCEEDING REDLINE:

(4) "ON" event (empty bottle) indicates that no fire protection is available for that avionics bay during launch phase.
(5) Early mission termination because of halon in the cabin.

CAUSES OF EXCEEDING REDLINE:

(6) Bottle leakage.
(7) Pyrotechnic initiator activated.
(8) Loss of ground in pressure switch circuit.
(9) Smoke detector test circuit switch in A or B position.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 5.1 SHEET 1 ZONE K2,5&7
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-960102 SHEET 82/83/8 ZONE 10-D

ELEMENT: Orbiter SUBSYSTEM: W/WMS&SD/FS

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SSIDs ECL-35 Through ECL-39 Reserved

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LCC VIOLATION CALL: Freon Flow Rate Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V63R1100A	FCL 1 interchanger flow rate	2 of		NA	lb/hr	CI
V63R1103A	FCL 1 payload HX flow rate	3 M	SEE			CI
V63R1105A	FCL 1 coldplate network flow rate	(2)	REDLINE			CI
		(3)	DERIVA-			
			TION			
V63R1300A	FCL 2 interchanger flow rate	2 of		NA	lb/hr	CI
V63R1303A	FCL 2 payload HX flow rate	3 M				CI
V63R1305A	FCL 2 coldplate network flow rate	(2)				CI
		(3)				

TIME PERIOD:

(1) To Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 2 of 3 measurements in each loop required for flight. Payload heat exchanger flow rate measurements may be verified by placing the flow proportioning module (FPM) in the payload position.
(3) For loss of an interchanger flow rate measurement, utilize water interchanger (I/C) outlet temperature. 1 of 2 I/C measurements required for flight.
(4) Both freon loops required for flight.
(5) 3 of 4 pumps required for flight.

PREPLANNED CONTINGENCY PROCEDURE:

(6) If FCL-1 cold plate measurement lost, LCC violation confirmed, No Go for launch. If flow verified, LCC violation cleared, continue countdown.

NOTES:

(7) Symptom: Low flow, high temperatures at interfacing loops. Verify by monitoring WCL I/C HX outlet temperatures (V61T2724A/2744A).
(8) Symptom: Zero flow, all sensors.
(9) If redline violated: Verify freon pump circuit breakers (CB) (panel L4:M, N) closed. Ground or crew switch pump (panel L1) so ground can determine cause/action.

REDLINE DERIVATION: CRITICALITY: 1R

(10) Both freon loops required per flight rules.

	I/C Flow-lb/hr			P/L Flow-lb/hr (A)		
	I/C	P/L	C/P	I/C	P/L	C/P
Min. flow rate req.	2025	*	240			
Instr accuracy 5%	+125		+25			
Redline	2150	*	265	1450	1090	225

(A) Values are applicable only to the loop supplying payload cooling.
Minimum flow selection criteria:

a. At least 5% less than minimum flow with any combination of FPM flow control assembly (FCA) configuration.
b. Compatible with limits for other parallel flowpaths.
c. Minimum flow required is compatible with C&W limit.
d. Recognizes performance based on one freon coolant loop available for entry.

* Verify transducer is operable during countdown.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Minimum limit: Reduced cooling provided to Orbiter systems; IMMEDIATE POWER-DOWN may be required to minimize cabin equipment over-heating. Minimum flow rate maintains fail-safe posture with established powerdowns.

CAUSES OF EXCEEDING REDLINE:

(12)

Cause		Violation	Action Required
1. Instrumentation failure	*	Loss of 2 or more measurements, one loop	Scrub
	**	Loss of 2 I/C measurements	Scrub
2. Flow restriction (7)		Loss of one or two loops	Scrub
3. Pump failure (8)		Loss of one pump, one or two loops	Hold (9); Continue countdown
		Loss of two pumps	Scrub

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1 AND 3 FOR FCL 1 AND 2 RESPECTIVELY									
UNITS-->	lb/hr								
V63R1n00A	NL	732.0	2684	1186		1200			
V63R1n05A	1.98	-5.0	490						
OV-102									
V63R1103A	NL	190	1322						
OV-103									
V63R1103A	NL	214	1348						
OV-104									
V63R1103A	NL	177	1301						
OV-105									
V63R1103A	NL	172	1379						
OV-102									
V63R1303A	NL	148	1529						
OV-103									
V63R1303A	NL	181	1266						
OV-104									
V63R1303A	NL	173	1247						
OV-105									
V63R1303A	NL	178	1383						

METER/DISPLAY RANGE - MSID: V63R1n00A LOW: 0 HIGH: 2600

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 7.1/7.2 SHEET 1 ZONE D5,E3&
DWG NO SHEET ZONE J6
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-960102 SHEET 67/69 ZONE 3&13-A

ELEMENT: Orbiter SUBSYSTEM: ATCS

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LCC VIOLATION CALL: Orbiter Freon Coolant Loop Pressure/Quantity Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V63P1108A	FCL 1 Pump Inlet Press	(2)	92(3)	117(3)	psia	CI
V63Q1130A	FCL 1 Accumulator Quantity	(2)	23	39	%	CI
V63P1308A	FCL 2 Pump Inlet Press	(2)	77(3)	100(3)	psia	CI
V63Q1330A	FCL 2 Accumulator Quantity	(2)	23	39	%	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 measurements per loop acceptable for confirmed instrumentation failure. (6)
(3) The minimum acceptable delta pressure between loops is 5 psi.
(4) Changes of 2 bits or more must be evaluated. (5)

PREPLANNED CONTINGENCY PROCEDURE:

(5) If the FCL Pump Inlet Pressure and Accumulator Quantity are high or low in both loops, the problem results from an excessive heat load or environmental transient. If measurements return to acceptable range, LCC violation cleared, continue countdown.
(6) A measurement reading bottom of scale or top of scale, with the remaining measurement on the affected loop reading normal, is confirmed instrumentation failure.

NOTES:

(7) If the FCL Pump Inlet Pressure is decreasing with no change in Accumulator Quantity until boiling of freon occurs and the Accumulator Quantity increases, the problem is loss of the accumulator pressurant. Correlate FCL Pump Inlet Pressure change with appropriate Accumulator Quantity. (V63Q1130A or V63Q1330A).
(8) If an interfacing loop (H2O, hydraulics, or fuel cell coolant loop) pressure (H2O, V61P2605A/2705A; hydraulics, V58P0137A, 0237A, 0337A; fuel cell, V45P0147A, 0247A, 0347A) increases with corresponding Pump Inlet Pressure and Accumulator Quantity decrease, the problem is a freon loop leak to the interfacing loop.
(9) If the FCL Pump Inlet Pressure and Accumulator Quantity are decreasing and the cause can not be attributed to temperature transients or intersystem leakage, the problem is a freon leak overboard.
(10) For freon interloop leakage, the pump inlet pressures will converge.
(11) If the accumulator quantity increases with no corresponding increase in FCL pump inlet pressure, the problem is a leak across the accumulator bellows.

REDLINE DERIVATION: CRITICALITY: 1R

(12) The redline limit is based on accumulator preset envelope (same as OMRSD).
(13) The redline accommodates ground air purge temperature of 55 to 85 degrees F.
(14) The redline accommodates maximum fluid thermal transients during prelaunch, ascent, on-orbit, and entry phases with loss of one freon loop.

CONSEQUENCES OF EXCEEDING REDLINE:

(15) Minimum: Cavitation of the freon coolant loop (FCL) pump on-orbit (<35 psia), which reduces the cooling capability (power down for single FCL operation).
(16) Maximum: Damage to the accumulator bellows.
(17) A leak between the freon loops results in single FCL configuration. An external leak in one loop will drain fluid from both loops, resulting in loss of freon loop cooling, and subsequent overheating of the Orbiter systems.

CAUSES OF EXCEEDING REDLINE:

(18) Orbiter heat load transient. (5)
(19) Instrumentation failure. (6)
(20) Loss of accumulator N2 pressurant. (7)
(21) Intersystem coolant leak. (8)
(22) Overboard coolant leak. (9)
(23) Leak between freon loops. (10)
(24) Leak across accumulator bellows. (11)

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1 AND 3 FOR FCL 1 AND 2 RESPECTIVELY									
UNITS-->	psia								
V63P1n08A	2.0	0	500						
UNITS-->	pcnt								
V63Q1n30A	0.5	-11.3	114.3					12	

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 7.1/7.2 SHEET 1 ZONE E2
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-960099 SHEET 43/46 ZONE 15D&F

ELEMENT: Orbiter SUBSYSTEM: ATCS

LCC VIOLATION CALL: Orbiter Ammonia System Tank Temperature/ Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V63T1180A	NH3 Sys A Tank Temp	(2)	-50(4)	170(4)	deg F	CI
V63T1188A	NH3 Sys B Tank Temp	(2)	-50(4)	170(4)	deg F	CI
V63P1196A	NH3 Sys A Tank Press	(2)	5(3,4)	505(4)	psia	CI
V63P1197A	NH3 Sys B Tank Press	(2)	5(3,4)	505(4)	psia	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) 2 of 4 measurements are acceptable provided there is one measurement (pressure or temperature) on each tank and one of the measurements is pressure.
(3) No leakage. A pressure change of 4 data bits, exclusive of temperature changes, indicates leakage and must be evaluated. Reference Figure 30-01.
(4) Redline is for detecting instrumentation failure only.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(5) The ammonia boiler system (ABS) is required for abort cases including RTLS, TAL, and AOA; "loss of one freon loop"; or "hole-in-cabin" abort from orbit.
(6) In case of loss of one freon loop both ABS are required to preclude forced manual control since ABS A responds to freon loop #1 temperatures and ABS B responds to freon loop #2 temperatures. The LCC format allows loss of two measurements and still allows for reasonable visibility on both systems status.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Unable to support vehicle abort and/or post-landing activities.

CAUSES OF EXCEEDING REDLINE:

(8) Instrumentation failure.
(9) Leakage.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	deg.F								
V63T1180A	0.99	-73.9	174.5						
V63T1188A	0.99	-73.9	174.5						
UNITS-->	psia								
V63P1196A	2.4	0	600						
V63P1197A	2.4	0	600						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 7.1/7.2 SHEET 1 ZONE L6
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-960099 SHEET 61/62 ZONE 13B&C

ELEMENT: Orbiter SUBSYSTEM: ATCS

LCC VIOLATION CALL: Orbiter Freon Coolant Loop Evaporator Out Temperature Anomaly | EMERG COND: Yellow (10)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V63T1207A	FCL 1 Evap Out Temp		33	50	deg F	CI
V63T1407A	FCL 2 Evap Out Temp		33	50	deg F	CI

TIME PERIOD:

(1) From Crew Ingress (T-3 Hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 measurements acceptable for confirmed instrumentation failure. (4)
(3) Excursions above the maximum temperature limit for 5 minutes or less are acceptable. The following are constraints:
   A. From T-5 minutes to T-2 minutes - FCL Evap Out Temp may not exceed 70 degrees F.
   B. From T-2 minutes to Go For RSLS Start (T-31 seconds) - FCL Evap Out Temp above 50 degrees F requires a hold until temperature can be controlled to 50 degrees F or less.

PREPLANNED CONTINGENCY PROCEDURE:

(4) Instrumentation failure can be confirmed by verifying that FCL 1 Interchanger Inlet Temp (V63T1155A) and H2O Loop Intchgr Outlet Ln Temps (V61T2724A and V61T2744A) are reading within the expected range for conditions at time of failure.
(5) If FCL Evap Out Temp is greater that 50 degrees F, adjust ground cooling to control the temperature between 33 and 50 degrees F inclusive.
(6) If FCL Evap Out Temp falls below 33 degrees F, activate the second Orbiter Water Coolant Loop (WCL) and increase ground cooling temperatures. Monitor Orbiter WCL flow rates (V61R2742A and V61R2722A) for degradation indicating freezing in the interchanger. If temperature returns within limits, freezing is not indicated and the following constraints are not violated, return Orbiter WCLs to launch configuration, LCC violation cleared, continue countdown.
   A. If payload WCL is not present, excursions to 30 degrees F are allowed indefinitely if both Orbiter WCLs are flowing. Temperature may be below 30 degrees F for less than 90 seconds with both WCLs flowing.
   B. If a payload WCL is present, temperatures may be below 33 degrees F for less than 45 seconds.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(7) Redline Development:

	Min	Max
Control band limit	32	53
Instrumentation accuracy	+ 3	- 3
Environmental temp. effects	- 2	
Redline	33	50

Normal control band is 35 to 47 degrees F.

(8) Minimum: The redline prevents freezing of the water in the I/C HX and P/L HX (if serviced with water).

(9) Maximum:

A. The redline accommodates prelaunch/ascent thermal environment effects.

B. The redline maintains sufficient thermal capacitance to accommodate ascent "no cooling" period for Orbiter and payload cooling.

C. The redline is the maximum temperature allowable to ensure cabin avionics bay air temperature remains within limits.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Emergency Condition "Yellow" exists because loss of active cooling results in loss of cooling to the fuel cells. This is a hazardous condition.

(11) Minimum: Damage to the interchanger and/or P/L HX (H2O and/or freon leak).

(12) Maximum: Cabin avionics bay air temperature limits may be exceeded.

CAUSES OF EXCEEDING REDLINE:

(13) Instrumentation failure.

(14) Loss of temperature control by GSE or heat load or environment temperature transients.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	deg.F								
V63T1207A	0.42	24.9	129.9	32.2	115.2	32.0	115		
V63T1407A	0.42	24.9	129.9	32.2	115.2	32.0	115		

METER/DISPLAY RANGE - MSID: V63T1207A LOW: 25 HIGH: 130
V63T1407A LOW: 25 HIGH: 130

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 7.1/7.2 SHEET 1 ZONE I7
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-960099 SHEET 45/48 ZONE 4-C

ELEMENT: Orbiter SUBSYSTEM: ATCS

LCC VIOLATION CALL: Orbiter Flash Evaporator Water Accumulator Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V63T1750A	A Supply FES H2O Accum Temp	(2)	45	NA	deg F	CI
V63T1760A	B Supply FES H2O Accum Temp	(2)	45	NA	deg F	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 measurements is acceptable after one heater in each system has been verified functional during cryogenic loading.
(3) One heater string per feedline system is required.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(4) Redline is set to detect a failed heater system.
(5) Redline development:

Thermostat setting	55
Location delta	-6
Instrumentation error (5%)	-4
Redline limits	45 deg F

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Freezing of water in the FES H2O accumulator.

CAUSES OF EXCEEDING REDLINE:

(7) Control thermostat or heater failure.
(8) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	deg.F								
V63T1750A	0.42	24.9	129.9						
V63T1760A	0.42	24.9	129.9						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 7.3 SHEET 1 ZONE C2&4
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE 3-B

ELEMENT: Orbiter SUBSYSTEM: ATCS

LCC VIOLATION CALL: Orbiter Flash Evaporator Water Accumulator Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V63X1751E	A Supply FES H2O Accum-Norm	1 of	ON	NA	Event	CI
V63X1761E	B Supply FES H2O Accum-Norm	2	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) For loss of one measurement, reconfigure FES primary controller to feedwater system having "ON" indication, LCC violation cleared, continue countdown.

NOTES:

(3) Instrumentation failure cannot be distinguished from mechanical failure.

REDLINE DERIVATION: CRITICALITY: 2R

(4) OFF position indicates failure.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Accumulator loss results in erratic water supply pressure to the FES and may result in erratic "evaporator outlet" temperature.
(6) Icing in the FES core and subsequent shutdown may result.
(7) Inability to maintain long-duration operation of the FES.

CAUSES OF EXCEEDING REDLINE:

(8) Instrumentation failure.
(9) Loss of gas charge.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 7.3 SHEET 1 ZONE C1&3
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-960099 SHEET 54/55 ZONE 24F/4G

ELEMENT: Orbiter SUBSYSTEM: ATCS

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LCC VIOLATION CALL: Orbiter Flash Evaporator Topping Duct Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V63T1801A	Flash Evap Topping Duct Temp-Htr D	(2)	100(3)	300	deg F	CI
V63T1802A	Flash Evap Topping Duct Temp-Htr E	(2)	100(3)	300	deg F	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) Loss of the measurement is acceptable if both A and B heaters are functional. If either A or B heater is lost, instrumentation must be functional. 2 of 3 heaters (A, B, and C) is the minimum requirement. (4,5)
(3) Heaters are assumed functional if verified before instrumentation failure.

PREPLANNED CONTINGENCY PROCEDURE:

(4) For instrumentation failure, at T-5 minutes, Request the crew to position the Topping Evap Duct Heater switch (Panel L1) to the "A/B" position.
(5) For heater failure, switch to a functional heater.

NOTES:

(6) V63T1801A, Flash Evap Topping Duct Temp-Htr D, monitors the Forward heater. V63T1802A, Flash Evap Topping Duct Temp-Htr E, monitors the Aft heater.

REDLINE DERIVATION: CRITICALITY: 1R

(7) The minimum redline is based on a single heater string operation and the temperature variations in the prelaunch environment.
(8) The minimum redline ensures proper duct temperature at FES activation to prevent freezing of water carryover. The minimum redline also ensures that steam in the downstream duct does not freeze.
(9) The maximum redline protects against a failed-on heater. The maximum limit, 300 deg F, is based on the over-temperature thermostat limit and qualification test data.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Failure to meet the lower redline implies heater system failure which may result in freezing of water in the duct.
(11) Exceeding the upper redline will lead to overheating of the duct assembly and possible heater failure.

CAUSES OF EXCEEDING REDLINE:

(12) Thermostat failure.
(13) Failure of electrical heating element.
(14) Failure of LCA or PCA.
(15) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	deg.F								
V63T1801A	1.6	-2	398.0						
V63T1802A	1.6	-2	398.0						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 7.3 SHEET 1 ZONE K3&6
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-960099 SHEET 54 ZONE 4D&5F

ELEMENT: Orbiter SUBSYSTEM: ATCS

LCC VIOLATION CALL: Orbiter Flash Evaporator Hi Load Duct Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V63T1820A	Flash Evap Hi Load Duct Temp-Htr A	(2)	150 (4)	300	deg F	CI
V63T1821A	Flash Evap Hi Load Duct Temp-Htr B	(2)	150 (4)	300	deg F	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) Loss of the measurement is acceptable if both A and B heaters are functional. If either A or B heater is lost, the instrumentation must be functional. 2 of 3 heaters (A, B, and C) is the minimum requirement. (4,5)
(3) Heaters are assumed functional if verified after aft closeout.

PREPLANNED CONTINGENCY PROCEDURE:

(4) For instrumentation failure: at T-5 minutes, request the crew to position the Hi Load Evap Duct Heater switch (Panel L1) to the "A/B" position.
(5) For heater failure, switch to a functional heater.

NOTES:

(6) V63T1820A, Flash Evap Hi Load Duct Temp-Htr A, monitors the Inboard heater. V63T1821A, Flash Evap Hi Load Duct Temp-Htr B, monitors the Outboard heater.

REDLINE DERIVATION: CRITICALITY: 1R

(7) The minimum redline ensures proper duct temperature at FES activation to prevent freezing of water carryover.
(8) Redline development:

	Maximum
Normal control range	270 deg F
Instrumentation accuracy	+20 deg F
Sensor location	+10 deg F
Redline	300 deg F

(9) The minimum redline is based on a single heater string operation and temperature variations in the prelaunch environment.
(10) The maximum redline is based on the thermostat limit.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Exceeding the upper limit may lead to overheating of the duct assembly or possible heater failure.
(12) Failure to meet lower limit implies heater system failure which may result in freezing of water in the duct.

CAUSES OF EXCEEDING REDLINE:

(13) Thermostat failure.
(14) Failure of electrical heating element.
(15) Failure of LCA or PCA.
(16) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	deg.F								
V63T1820A	1.6	-2	398.0						
V63T1821A	1.6	-2	398.0						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 7.3 SHEET 1 ZONE M5,O4
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-960099 SHEET 54 ZONE 6-E&F

ELEMENT: Orbiter SUBSYSTEM: ATCS

LCC VIOLATION CALL: Orbiter Flash Evaporator Water Feedline Temperature Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	Water Supply A Feedline	(2)				
V63T1876A	Flash Evaporator H2O Fdln Temp 4-L		56	NA	deg F	CI
V63T1891A	A Supply FES Topping H2O Fdln Temp		56	NA	deg F	CI
V63T1892A	A Supply FES Accum H2O Fdln Temp		56	NA	deg F	CI
V63T1895A	A Supply FES Hi Load H2O Fdln Temp		56	NA	deg F	CI
	Water Supply B Feedline	(2)				
V63T1877A	Flash Evaporator H2O Fdln Temp 4-R		56	NA	deg F	CI
V63T1893A	B Supply FES Topping H2O Fdln Temp		56	NA	deg F	CI
V63T1894A	B Supply FES Accum H2O Fdln Temp		56	NA	deg F	CI
V63T1896A	B Supply FES Hi Load H2O Fdln Temp		56	NA	deg F	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, 1 of 2 heaters (String 1 or 2) in the affected zone is required. (4)
(3) 1 of 2 heaters in each zone is required. (5)

PREPLANNED CONTINGENCY PROCEDURE:

(4) An abrupt temperature change to off-scale (high or low) indicates instrumentation failure, LCC violation cleared, continue countdown.
(5) If temperature in a feedline zone cannot be maintained above 56 deg F, the heater is considered failed. Select other heater string (PNL L2), verify heater operation (temperature increase) in the affected zone, LCC violation cleared, continue countdown. If both heater strings contain different failed zones, switch between heater strings as needed to maintain temperatures above minimum redline.

NOTES:

(6) Each feedline (A and B) has two heater strings (String 1 and 2) wrapped around the line from the forward PLB bulkhead to the spray valves on the FES itself (located in the aft). Each heater string consists of eight segments: three in the midbody; four in the aft; and one accumulator body heater also in the aft. Each heater segment is controlled by its own thermostat, located on the same feedline zone, except that heater segments located on the hi load valve supply line (temperature MSIDs V63T189A and V63T1896A) and the accumulator line (temperature MSIDs V63T1892A and V63T1894A) are controlled by one thermostat (for each string) located on the accumulator line.

REDLINE DERIVATION: CRITICALITY: 1R

(7) Minimum redline protects against freezing in the FES feedlines from cryo-induced low temperatures in the aft.

(8) Redline development:

	Minimum
Thermostat setting	65
Location delta	-1
Instrumentation error (5%)	-8
Redline	56 deg F

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Failure to meet the lower redline may result in freezing of water and loss of FES redundancy.

CAUSES OF EXCEEDING REDLINE:

(10) Thermostat failure.
(11) Failure of electrical heater element.
(12) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	deg.F								
V63T1876A	0.64	-0.37	159.7						
V63T1877A	0.64	-0.37	159.7						
V63T1891A	0.64	-0.37	159.7						
V63T1893A	0.64	-0.37	159.7						
V63T1892A	0.64	-0.37	159.7						
V63T1894A	0.64	-0.37	159.7						
V63T1895A	1.0	-0.8	249.1						
V63T1896A	1.0	-0.8	249.1						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 7.3 SHEET 54 ZONE 7&8;9,1
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-960099 SHEET 55 ZONE 7&8A;10

ELEMENT: Orbiter SUBSYSTEM: ATCS

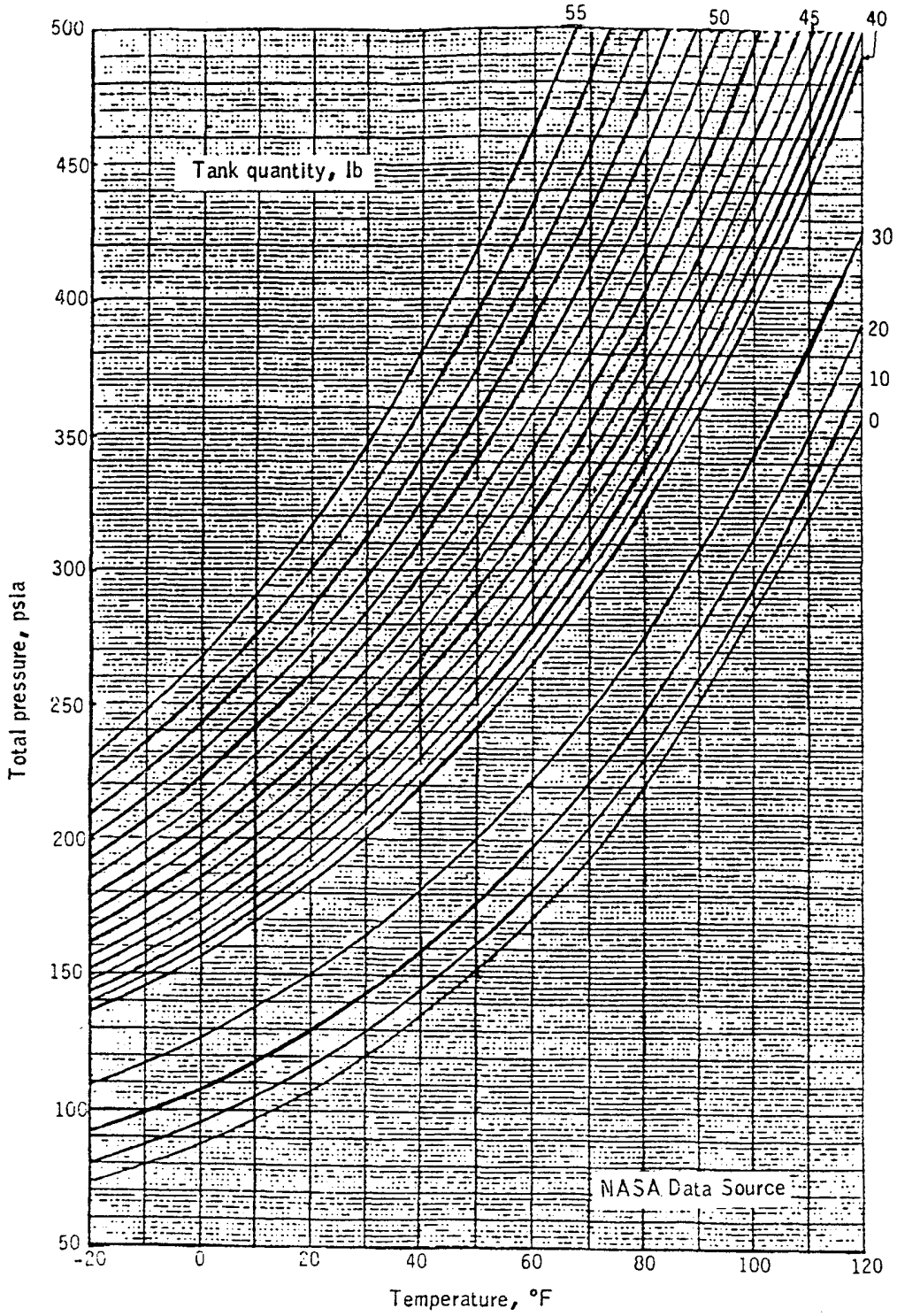

Figure 30-01 NH3 Tank Quantity versus Pressure and Temperature

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SECTION 31

DATA PROCESSING SYSTEM

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SECTION 31: DATA PROCESSING SYSTEM

SSID No.	Description/Violation Call	Page
DPS-01	PASS Multifunction CRT Display System Anomaly (REQUIREMENT DELETED)	31-01.1
DPS-01a	PASS Multifunction Electronic Display Subsystem (MEDS) Anomaly	31-01a.1
DPS-02	PASS GPC Fail Indicator	31-02.1
DPS-03	MDM BCE Bypass	31-03.1
DPS-04	MDM Guidance, Navigation and Control Initiation Bypass Anomaly	31-04.1
DPS-05	GPC BITE Indication	31-05.1
DPS-06	MMU Error (REQUIREMENT DELETED)	31-06.1
DPS-06a	SSMM Error	31-06a.1
DPS-07	Mass Memory Ready Discrete Anomaly	31-07.1
DPS-08	IPL Select Discrete Anomaly (REQUIREMENT DELETED)	31-08.1
DPS-09	PASS GPC Error	31-09.1
DPS-10	PASS Time Source Anomaly	31-10.1
DPS-11	PASS BFS Engage Discrete Anomaly.	31-11.1
DPS-12	IMU Data Bypass	31-12.1
DPS-13	IMU BCE String Bypass	31-13.1
DPS-14	Network Signal Processor Bus Control Element Bypass	31-14.1
DPS-15	Air Data Transducer Assembly BCE Bypass Anomaly	31-15.1
DPS-16	MTU BCE Bypass	31-16.1
DPS-17	Tactical Air Navigation/Radar Altimeter BCE Bypass	31-17.1

SECTION 31: DATA PROCESSING SYSTEM (CONTINUED)

SSID No.	Description/Violation Call	Page
DPS-18	Engine Interface Unit Mid Frequency Executive BCE Bypass	31-18.1
DPS-19	MDM BSR Anomaly	31-19.1
DPS-20	MDM Output Fault Summary Message	31-20.1
DPS-21	SUMWORD ICC Fault Summary Message	31-21.1
DPS-22	PASS I/O Error Log	31-22.1
DPS-23	DDU BITE Anomaly (REQUIREMENT DELETED)	31-23.1
DPS-24	DDU Power Supply Anomaly (REQUIREMENT DELETED)	31-24.1
DPS-25	This Requirement Moved To EPDC Section 26	31-25.1
DPS-26	GPC Soft Error Counter Anomaly	31-26.1
DPS-27	G3 Archive Load Status	31-27.1
DPS-28	GPS BCE Bypass Anomaly	31-28.1
DPS-29	PASS GPC Downlist Loss	31-29.1

PASS Multifunction CRT Display System Anomaly

(THIS REQUIREMENT HAS BEEN DELETED)

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LCC VIOLATION CALL: PASS Multifunction Electronic Display Subsystem (MEDS) Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	Fault Summary Messages (FSM)					
	(Down Listed PASS)					
FSM	I/O ERROR CRT x		(2,5,6)	NA	Error	CI
FSM	CRT BITE x		(2,5,6)	NA	Error	CI
	MEDS Status Word Errors					
V72M5650P	IDP1 MEDS Status Wd 1		(3,5)	NA	HEX	CI
V72M5720P	IDP2 MEDS Status Wd 1		(3,5)	NA	HEX	CI
V72M5810P	IDP3 MEDS Status Wd 1		(3,5)	NA	HEX	CI
V72M5910P	IDP4 MEDS Status Wd 1		(3,5,6)	NA	HEX	CI
V72M5670P	IDP1 MEDS Status Wd 2		(3,5)	NA	HEX	CI
V72M5740P	IDP2 MEDS Status Wd 2		(3,5)	NA	HEX	CI
V72M5830P	IDP3 MEDS Status Wd 2		(3,5)	NA	HEX	CI
V72M5930P	IDP4 MEDS Status Wd 2		(3,5,6)	NA	HEX	CI
V72M5680P	IDP1 MEDS Status Wd 3		(3,5)	NA	HEX	CI
V72M5750P	IDP2 MEDS Status Wd 3		(3,5)	NA	HEX	CI
V72M5840P	IDP3 MEDS Status Wd 3		(3,5)	NA	HEX	CI
V72M5940P	IDP4 MEDS Status Wd 3		(3,5,6)	NA	HEX	CI
	Crew indication of MEDS Anomaly		(4,5,6)	NA	NA	

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES: See Note 8

(2) No Fault Summary Message occurrence. (7)
(3) The following MEDS Status Word (SW) 1-3 reported conditions are redline violations (7):
   - MEDS Errors (SW1 Bits 5-7 = '001')
   - MEDS Operational Self Test (OST) and Power On Self Test (POST) Summary Built In Test (BIT) indications (SW1 Bits 5-7 = '010')
   - Display/Format Fill error (SW3 Bit 0 = '1')
   - Checksum Error (SW3 Bit 11 = '1').
(4) Crew is backup to the downlist and should notify the ground upon detection of any of the following MEDS anomalies (7):
   - MEDS FSM
   - "I/O ERROR CRT x" or "CRT BITE x" GPC FSM
   - "BIG X"
   - "Poll Fail"
   - Unexpected invalid indications (i.e., missing data or red outlined boxes)
   - Blank or unreadable MDU screen
   - Keyboard or edge key anomalies
   - Multiple IDPs responding to the same keyboard entry.

REQUIREMENTS: (Continued)

(5) The following minimum MEDS hardware is required to be functional: (6)
- 3 of 3 forward IDPs
- 3 of 3 forward CRT MDUs
- 5 of 6 forward non-CRT MDUs, if all ADCs and ADC ports are functional, or 6 of 6 otherwise
- 3 of 4 ADCs, if all MDUs and MDU ports are functional, or 4 of 4 otherwise
- 2 of 2 forward keyboards.

(6) IDP4 and aft MDU (CRT4, Aft Flight Deck (AFD)1) effectivities are mission unique. Reference MEL for current mission requirements.

PREPLANNED CONTINGENCY PROCEDURE:

(7) Evaluate MEDS anomaly per Figure DPS-01a.01, Flow Diagram for PASS MEDS Anomaly.

NOTES:

(8) The following Figure and Tables are included in this SSID: Figure DPS-01a.01, Tables DPS-01a.01, DPS-01a.02, DPS-01a.03, DPS-01a.04, DPS-01a.05.

(9) For "I/O ERROR CRT x" and "CRT BITE x" FSM, x = 1, 2, 3, 4 since crew may assign any CRT to PASS.

(10) "I/O ERROR CRT x" FSM will be annunciated on the first I/O error or checksum error encountered.

(11) "CRT BITE x" FSM will be annunciated upon GPC notification of any of the following IDP detected anomalies:
- Keyboard channel A fail
- Keyboard channel B fail
- Error Detection and Correction (EDAC) failure in Data Entry and Display (DED) card of IDP
- Keyboard Stack Underflow.

(12) Bit numbers used in this SSID are referenced from bit 0 being the leftmost bit, and bit 15 being the rightmost bit.

(13) MEDS Error event is indicated if SW1 Bits 5-7 = '001'. Specific error code will be reported in SW2 Bits 8-15, and the reporting LRU in SW3 (reference Table DPS-01a.05).

(14) MEDS OST/POST BIT event is indicated by the occurrence of a Summary BIT (SW1 Bits 5-7 = '010') followed by one or more Detailed BIT (SW1 Bits 5-7 = '100'). Specific BIT codes for each will be reported in SW2 Bits 0-15, and the reporting LRU in SW3 (reference Table DPS-01a.05).

REDLINE DERIVATION: CRITICALITY: 1

(15) a. SSID Intent Summary - The intent of this SSID is to ensure the MEDS system is functional and capable of supporting all critical flight and mission support operations. Launching with a latent MEDS system anomaly or reduced functionality may put the crew and vehicle at risk due to loss of critical display information required for the crew to fly the vehicle, maintain situational awareness, respond to contingencies, and enter keyboard commands to the GPCs. Refer to

REDLINE DERIVATION: (Continued)

paragraph (15)e5. for information on fault tolerance.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - Redline criteria is intended to detect the occurrence of MEDS error conditions that may indicate a loss of functionality, or aberrant behavior of a critical system component.

Monitored parameters consist of error codes, fault messages, and aberrant conditions observed by the crew. These parameters do not have quantifiable Max/Min redline limits. Violation of LCC exists upon the occurrence of any of the specified error conditions.

d. Time Period - The MEDS is operating in flight configuration throughout the terminal count period, and errors may be reported at any time through T-0. The chosen time period ensures continuous health monitoring from the start of tanking phase at T-6 hours until commitment for launch at T-31 seconds. Committing the system for flight at T-31 seconds enables monitoring for certain Crit 1/1 failure modes that are only detectable during preflight use of the system by the crew.

e. Requirements -

e1. Reference Measurement Description Table.

The parameters defined in the Measurement Description Table are intended to monitor the MEDS for anomalous conditions that may degrade system operability or fault tolerance. This includes monitoring for all of the following conditions.

- PASS GPC Fault Summary Messages:
  Required for detection of GPC/IDP interface issues.
- MEDS Status Word Indications:
  Required for detection of MEDS internal fault conditions and interface issues.
- Crew Detected Anomalies:
  Required to detect display anomalies and keyboard interface issues that may not be reported via the downlist.

e2. Reference Requirement (2).

PASS Fault Summary Messages are annunciated by the GPC upon detection of an error in receipt of response data from the IDP. GPC FSMs are reported in the downlist, and displayed onboard on the CRT message line, and Fault Summary Page. The occurrence of either of the following FSMs is a redline violation:

- I/O ERROR CRT x FSM - The GPC will report an "I/O Error CRT x" FSM upon the first occurrence of an I/O error in communication with the IDP. It will also report this error if a checksum error occurs

REDLINE DERIVATION: (Continued)

in the keystroke data returned in response to a poll request. Occurrence of this fault signifies a potential loss of keyboard data from the IDP, as well as a potential loss of GPC display data to the IDP.

- CRT BITE x FSM - The GPC will report a "CRT BITE x" FSM if the Critical Built In Test Equipment (BITE) bit in the IDP response header word is set. This bit is set by the IDP upon detection of certain internal critical faults that may compromise keystroke data integrity. Occurrence of this fault signifies a potential loss of keyboard data from the IDP.

e3. Reference Requirement (3).

IDP Status Words 1, 2 and 3 are downlisted digital patterns used to report MEDS status and error conditions. The SWs contain a mix of discrete error, BIT, and status indications, and submultiplexed error and edge key identification codes. The occurrence of any of the following Status Word reported error conditions is a redline violation:

- MEDS Errors

  MEDS errors signify the occurrence of certain IDP detected system abnormalities, and may indicate a loss of function of the IDP or one of its associated MDUs or ADCs. MEDS errors require evaluation to determine system effects.

- OST/POST BIT Summary Errors

  IDP Operational Self Test (OST) Built In Test (BIT)/Power On Self Test (POST) summary errors represent a roll up of fault indications detected internally by the IDP, MDU or ADC OST/POST routines. The occurrence of an OST/POST BIT summary indication will be accompanied by one or more detailed BIT fault codes that provide more specificity as to the source of the fault. It will also be accompanied by an LRU fail bit in SW3 that will remain set for as long as self test is detecting the anomalous condition.

  The occurrence of an OST/POST BIT failure signifies a possible loss of function of the associated Line Replaceable Unit (LRU). OST/POST BIT summary errors require evaluation in order to determine system effects. The associated detailed BIT and SW3 LRU fail indications are not required to be monitored for redline violation since they supplement the Summary BIT.

- Display Format Fill Error

  The occurrence of a Display Format Fill error is reported by the IDP via a bit in IDP status word 3 upon detection of any of the following DK bus message errors. Occurrence requires evaluation to determine system effects.

REDLINE DERIVATION: (Continued)

- o Word Error: The IDP Multiplexer Interface Adapter (MIA) has detected an incoming Manchester, bit count, or parity error.
- o Check Bit Error: The SEV check bit pattern on a data word received from the GPC was not '101'.
- o Address Miscompare: The address of a data word received by the IDP did not match the address of the preceding command word.
- o Message Timeout Error: The IDP did not receive all data words in the message within 36 ms of the command word.
- o Invalid Word Count: The number of display/format fill words received by the IDP does not match the word count sent by the GPC.
- o Invalid Address: The received display/format fill start or end address is outside the valid address range for the Display, Critical Format, and Message Line buffers.

- Checksum Error

  The occurrence of a Checksum error is reported by the IDP via a bit in IDP status word 3 if the Critical Format Buffer checksum value computed by the IDP does not match the checksum value sent by the GPC. Occurrence requires evaluation to determine system effects.

Certain other IDP Status Word 1-3 contents, such as MDU Command bits, Virtual Memory Load bits, Downlist Required bit, Non-Critical Error bit, spare bits, Edge Key data, Initialization Performed bit, and LRU ID bits, are information only and therefore, do not constitute redline violations.

e4. Reference Requirement (4).

Certain failure conditions may not appear in the downlist, and can only be detected and reported by the crew. Therefore, the crew is a backup to the ground for monitoring of system performance, and should report any anomalous conditions noted during operation of the MEDS:

- MEDS Fault Summary Messages, which appear on the MEDS message line of the MDU displays. These signify MEDS detected anomalies that may affect the crew's use of the system.
- "I/O ERROR CRT x" and "CRT x BITE" GPC Fault Summary Messages, which appear on the GPC FSM message line of the DPS displays. These signify GPC detected anomalies that may affect the crew's use of the system.
- Big X, which signifies that the active DPS display (Spec, Display, or Ops Display) is no longer being updated by the GPC.
- Poll Fail, which indicates the IDP is no longer receiving GPC polls for keystroke and status information.
- Unexpected invalid data indications, such as missing parameters or red-outlined data fields, which signifies that the IDP is not properly receiving the associated parameter.

REDLINE DERIVATION: (Continued)

- Display abnormalities, such as blank screen, malformed or unreadable characters, brightness issues, etc., which may affect readability of the display. Loss of display capabilities affects the crew's ability to monitor vehicle performance and respond to fault conditions.
- Keyboard anomalies, such as failed open/failed closed keys, or no response from the keyboard, which signify a loss of function from the associated keyboard, and impair the crew's ability to issue GPC commands and invoke DPS displays.
- MDU edge key anomalies, which affect the crew's ability to invoke MEDS displays and change MEDS configuration from the affected MDU.
- Multiple IDPs responding to the same keyboard entry, which presents a risk of unintended keyboard commands being executed by the GPC, with unpredictable results.

e5. Reference Requirement (5).

The minimum set of MEDS hardware specified is intended to provide Fail Operational/Fail Safe capability during flight by ensuring the minimum set of IDPs, MDUs, ADCs, and keyboards needed to fly and land the vehicle remain available following the worst case combination of two component or power bus failures. This is based on the crew's assessment that a minimum of one IDP, one forward keyboard, one CRT MDU and one other forward MDU are needed to successfully fly the vehicle. For proper operation, this remaining set of hardware must reside on the same hardware string.

Integrated Display Processors generate the critical display information for presentation on an MDU display. They also provide crew keystroke command data to the GPCs. Loss of an IDP also results in loss of a CRT MDU, loss of one port of several non-CRT MDUs and ADCs, and loss of one or two keyboard interfaces. All three forward IDPs must be functional at liftoff to meet the specified Fail Operational/Fail Safe criteria during flight.

Each IDP contains an internal Mass Storage Unit (MSU) used to store event logs and backup copies of IDP and MDU operating software. The MSU function is considered Crit 3 since the primary copy of IDP and MDU operating programs are stored in Electrically Erasable Programmable Read Only Memory (EEPROM). Therefore, loss of the MSU is not considered a constraint to launch.

Multifunction Display Units display the critical information provided by the IDPs to the crew. 3 of 3 forward CRT MDUs and 5 of 6 forward non-CRT MDUs must be functional at liftoff to ensure adequate visibility of critical flight information to the crew. Launching with all three forward CRT MDUs and 5 of 6 non-CRT MDUs functional ensures the system can still meet the minimum display requirements established by the crew following any combination of two failures of MDUs, IDPs, and power busses during flight. Loss of a single forward non-CRT MDU, or MDU port, is not a constraint to flight if all remaining IDPs, MDUs

REDLINE DERIVATION: (Continued)

and ADCs are operating nominally.

Analog to Digital Converters (ADCs) provide OMS, MPS, APU, Hydraulics, and Surface Position Indicator (SPI) subsystem measurement data to the IDPs for display on the MDUs. Three of four ADCs are required for flight. Loss of a single ADC, or ADC port, is not a constraint to launch as long as the remaining IDPs, MDUs and ADCs are operating nominally. This is acceptable because redundancy for most ADC parameters is provided on PASS or BFS GPC displays (GNC SYS SUMM 1/2, VERT SIT 1, MANEUVER for ADC1; SM SYS SUMM 2 for ADC2).

Keyboards provide the crew with GPC command capability. Both forward keyboards are required in order to provide command/control from both CDR and PLT flight stations, and meet FOFS safety criteria.

e6. Reference Requirement (6).

The aft MEDS components (IDP4, aft keyboard, CRT4, AFD1) may support mission operations, but are not critical for ascent/entry ops. Therefore, the requirements for these components are mission dependent, and are specified in the MEL.

f. Preplanned Contingency Procedure -

The intent of the Preplanned Contingency Procedure is to evaluate the occurrence of MEDS anomalies for their impact on the performance and redundancy of the system. The Figure DPS-01a.01 flowchart and accompanying notes and data tables are provided to facilitate this evaluation. Highlights of this evaluation are as follows:

- Acceptable Errors:
  The MEDS errors and OST/POST BIT indications identified in Tables DPS-01a.01 through DPS-01a.04 represent fault indications which have previously been evaluated and determined not to have an adverse impact on system performance or redundancy. In general, these errors relate to unused or non-critical functions of the LRU. Occurrence of these errors is therefore acceptable for flight. Note that the IDP/MDU OST/POST Summary BIT errors listed are only acceptable for flight if the Summary BIT occurs as a result of the specified Detailed BIT.

- MEDS Program Notes:
  MEDS program notes, such as User Notes and Ops Notes, document hardware/software behaviors that may be expected to occur under certain operational conditions. They generally represent explainable phenomena that do not adversely affect system performance or redundancy, as opposed to actual system failures. Some user action may be specified on the note to confirm the error signature or reset the error condition. Following completion of any required user response, errors that are deemed acceptable by a program note are not a constraint to launch.

REDLINE DERIVATION: (Continued)

- Keyboard/Keyboard Interface Errors:
  Two of two forward keyboards are required for flight. Therefore, any keyboard or keyboard I/F anomalies, such as failed open/closed keys, multiple IDPs responding to the same keyboard entry, or CRT BITE FSM, are not acceptable.

- Transient Errors:
  One-time transient errors do not adversely affect system performance or redundancy. Therefore, these errors are acceptable for launch, as long as MEDS operation is confirmed. For MDUs or ADCs, confirmation of a transient condition may require power cycle of the LRU to force a reset of the hardware.

- Single Non-CRT MDU or ADC Errors:
  Errors that are not resolved by the above criteria and are isolated to a single non-CRT MDU, MDU port, ADC, or ADC port are accepted based on system redundancy levels. Any MDU display or ADC data lost as a result of the anomaly may be recovered by port moding or re-arranging MDU displays as necessary. Determination of display and port configuration is left to crew preference.

  Errors isolated to IDPs, CRT MDUs, or keyboards violate redundancy requirements, and are not acceptable. Similarly, combinations of IDP, MDU and ADC faults that would individually be acceptable may result in violation of redundancy requirements, and therefore, are also not acceptable.

CONSEQUENCES OF EXCEEDING REDLINE:

(16) Launching with a failed or suspect display system may result in loss of crew and vehicle due to any of the following conditions:

- Inadequate displays to provide crew situational awareness during critical flight phases and contingency operations.
- Erroneous display information resulting in the crew taking inappropriate action.
- Erroneous output of keystroke data to the GPCs resulting in unintended issuance of keyboard commands.
- Non-universal I/O errors on a Display/Keyboard (DK) bus resulting in breakup of the redundant set.

CAUSES OF EXCEEDING REDLINE:

(17) Hardware anomaly in IDP/MDU/ADC.
(18) Software anomaly in IDP/MDU/ADC.
(19) MEDS 1553 bus anomaly.
(20) MEDS power cycle.
(21) GPC hardware anomaly (e.g., MIA, Bus Control Element (BCE)).
(22) GPC software anomaly.
(23) DK bus anomaly.

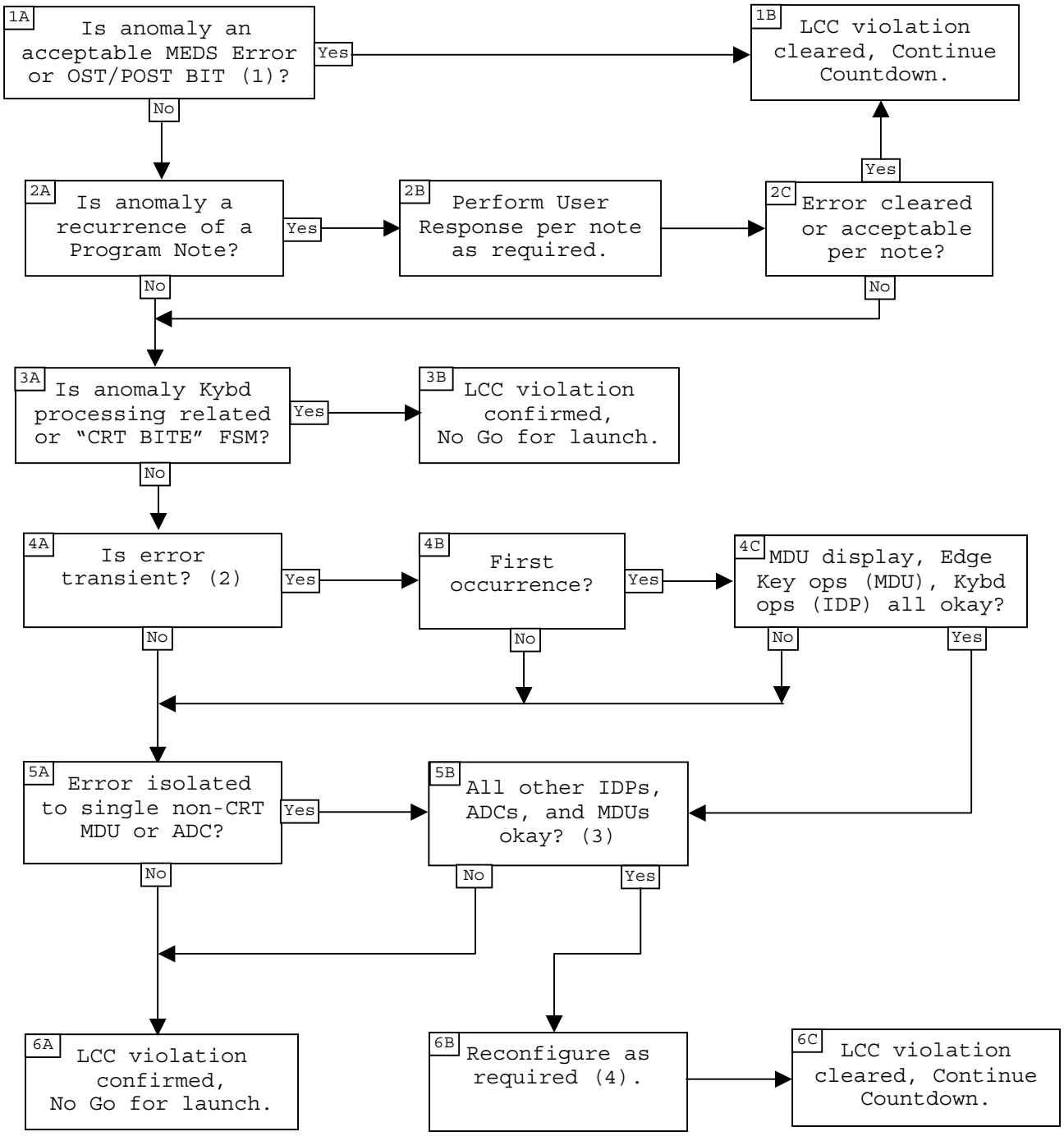
CAUSES OF EXCEEDING REDLINE: (Continued)

(24) MEDS input power circuit fault (e.g., RPC, power switch, circuit breaker, wiring).
(25) MDM, DSC, or transducer in OMS, MPS, APU or Hydraulics subsystem analog signal path.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 8.3	SHEET 1-3	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: DPS

SUPPORTING DATA:



(Numbers in parentheses refer to Supporting Notes on following page)

Figure DPS-01a.01 Flow Diagram For PASS MEDS Anomaly

SUPPORTING DATA:

Figure DPS-01a.01 Notes:

(1) The MEDS indications that have been deemed acceptable are as follows: (reference Table DPS-01a.05 to determine reporting LRU ID)

- MEDS errors specified in Table DPS-01a.01 are acceptable for flight.

- IDP OST/POST Summary BIT errors specified in Table DPS-01a.02 are acceptable for flight if they occur as a result of the associated Detailed BIT indications.

- MDU OST/POST Summary BIT errors defined in Table DPS-01a.03 are acceptable for flight if they occur as a result of the associated Detailed BIT indications.

- ADC OST/POST Summary BIT errors defined in Table DPS-01a.04 are acceptable for flight.

All other IDP/MDU/ADC OST/POST Summary BIT errors require evaluation.

(2) A transient error includes any of the following conditions:

- Single occurrence of an "I/O Error CRT x" FSM
- Single occurrence of a MEDS error*
- Single occurrence of a OST/POST BIT error that clears*
- Single occurrence of a crew reported display anomaly that clears*
- Single occurrence of a SW3 Display/Format Fill error or Checksum error that clears

* For MDUs and ADCs, an error condition that is cleared by power cycling the LRU is also considered a transient. If remaining hold time does not permit power cycle, the anomaly will be treated as hard failed.

(3) Only a single MEDS LRU anomaly is acceptable. Any transient or hard failed anomaly reported against any other IDP, MDU, ADC or MDU/ADC port, except for Excluded Errors, User Note conditions, or IDP/CRT 4 anomalies if excluded by the MEL, violates redundancy requirements.

(4) Crew may power off failed LRU and reconfigure displays, FC buses, and/or port mode MDUs as required to work around a single failed non-CRT MDU or ADC.

SUPPORTING DATA:

Table DPS-01a.01 Acceptable MEDS Errors*

ERROR CODE	MEDS ERROR DESCRIPTION
SW2 Hex^	
XX08	CST MM IN USE ERROR
XX11	DAS FOREGROUND EXTENDED
XX12	MSU SPIN-UP ERROR
XX4D	MSU I/O ERROR
XX50	OPERATOR REQUEST ERROR - MSU

* The MEDS Errors listed in this table are acceptable for flight. All other MEDS errors require evaluation.
^ XX = Don't Care

Table DPS-01a.02 Acceptable IDP BIT Errors*

OST/POST SUMMARY		DETAILED BIT	IDP SUMMARY/DETAILED BIT ERROR DESCRIPTION
SW2 Bit#	SW2 Hex	SW2 Hex	
08	0080	-	HDX Software Status
		F014	HDX SCSI Event Queue
		F015	HDX MSU Event Queue
15	0001	-	SCSI/MSU Fail
		F023	SCSI Failure 1
		F024	SCSI Failure 2
		F025	SCSI Failure 3
		F026	MSU Failure

* The IDP Summary BIT errors listed in this table are acceptable for flight if they occur as a result of the specified Detailed BIT indications. All other IDP Summary/Detailed BIT combinations require evaluation.

SUPPORTING DATA:

Table DPS-01a.03 Acceptable MDU BIT Errors*

OST/POST SUMMARY		DETAILED BIT	MDU SUMMARY/DETAILED BIT ERROR DESCRIPTION
SW2 Bit#	SW2 Hex	SW2 Hex	
01	4000	-	R3000 RAM Fail
		DD12	R3000 RAM Scrubber Fail
02	2000	-	EEPROM Fail
		DE03	EEPROM Write Fail
04	0800	-	Primary 1553B Fail
		DA12	Primary 1553B RAM Scrubber Fail
05	0400	-	Secondary 1553B Fail
		D712	Secondary 1553B RAM Scrubber Fail
07	0100	-	Spare (Unassigned)
		ALL	None defined - Disregard all
08	0080	-	Data Acquisition Fail
		DB04	Data Acquisition Backlight Sensor Fail
10	0020	-	GC RAM Fail
		D31A	GC CBIT Scrubber Fail
12	0008	-	Power Supply/Lamp Fail
		D905	Luminance Control Loop Fail
		DA05	Lamp Filament Fail
		DB05	Lamp TEC Fail
13	0004	-	Timer Fail
		DD07	Timer 1 Accuracy Fail
		DE07	Timer 1 Control Fail
		DF07	Timer 1 Interrupt Fail
14	0002	-	Miscellaneous Fail
		D503	UDI Interface Fail
15	0001	-	Overtemperature Sensor Fail
		D104	Ambient Temperature Sensor Fail
		D204	LCD Temperature Sensor Fail

* The MDU Summary BIT errors listed in this table are acceptable for flight if they occur as a result of the specified Detailed BIT indications. All other MDU Summary/Detailed BIT combinations require evaluation.

SUPPORTING DATA:

Table DPS-01a.04 Acceptable ADC BIT Errors*

OST/POST SUMMARY		ADC SUMMARY BIT ERROR DESCRIPTION
SW2 Bit#	SW2 Hex	
01	4000	Spare (Unassigned)
02	2000	Spare (Unassigned)
08	0080	Spare (Unassigned)
09	0040	Spare (Unassigned)
10	0020	Spare (Unassigned)

* The ADC Summary BIT errors listed in this table are acceptable for flight. All other ADC Summary BIT indications require evaluation.

Table DPS-01a.05 LRU ID Field Decode*

ID Field SW3 Binary	LRU Name	ID Field SW3 Binary	LRU Name
0001	IDP	0111	MFD1
0010	CRT	1000	MFD2
0011	CDR1	1001	AFD1
0100	CDR2	1010	ADC1
0101	PLT1	1011	ADC2
0110	PLT2	Other	Invalid

* LRU ID Field (SW3 Bits 12-15) identifies the LRU reporting status in SW2

LCC VIOLATION CALL: PASS GPC Fail Indicator | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V72X7011E	GPC 1 Fail Indicator		0	NA	Event	CI
V72X7012E	GPC 2 Fail Indicator		0	NA	Event	CI
V72X7013E	GPC 3 Fail Indicator		0	NA	Event	CI
V72X7014E	GPC 4 Fail Indicator		0	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to OPS 1 Transition (T-20 minutes)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) Reference Figure 31-02 Flow Diagram for GPC I-Fail for a preplanned contingency procedure which evaluates a fail indication. This flow diagram allows for continuation of count for instrumentation failures or GPC discrete failure only.

NOTES:

(3) From T-20 minutes to T-0, RSLS will initiate a hold due to M.E. data path failure, if a redundant set GPC fails.
(4) "0"=OFF (KSC), "0"=GO (MML); "1"=ON (KSC), "1"=NO GO (MML).

REDLINE DERIVATION: CRITICALITY: 1R

(5) These discretes, which are outputs from GPCs, indicate the GPCs assessment of its health. A valid fail indication means:
A. Two or more fail votes received from GPCs.
B. Internally detected BITE hardware Anomalies.
C. Software-detected fail-to-sync with two or more other GPCs.
D. Internally forced fail-to-sync because of discrepant transmitter enable mask.
E. Internally forced fail-to-sync because of unique input/output errors on critical busses.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Launch with a failed GPC.

CAUSES OF EXCEEDING REDLINE:

(7) Hardware or software anomalies within the redundant set GPC.
(8) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, 3, AND 4 FOR GPC 1, 2, 3, AND 4 RESPECTIVELY									
UNITS-->	Event								
V72X701nE				ON		ON			

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: DPS

SUPPORTING DATA:

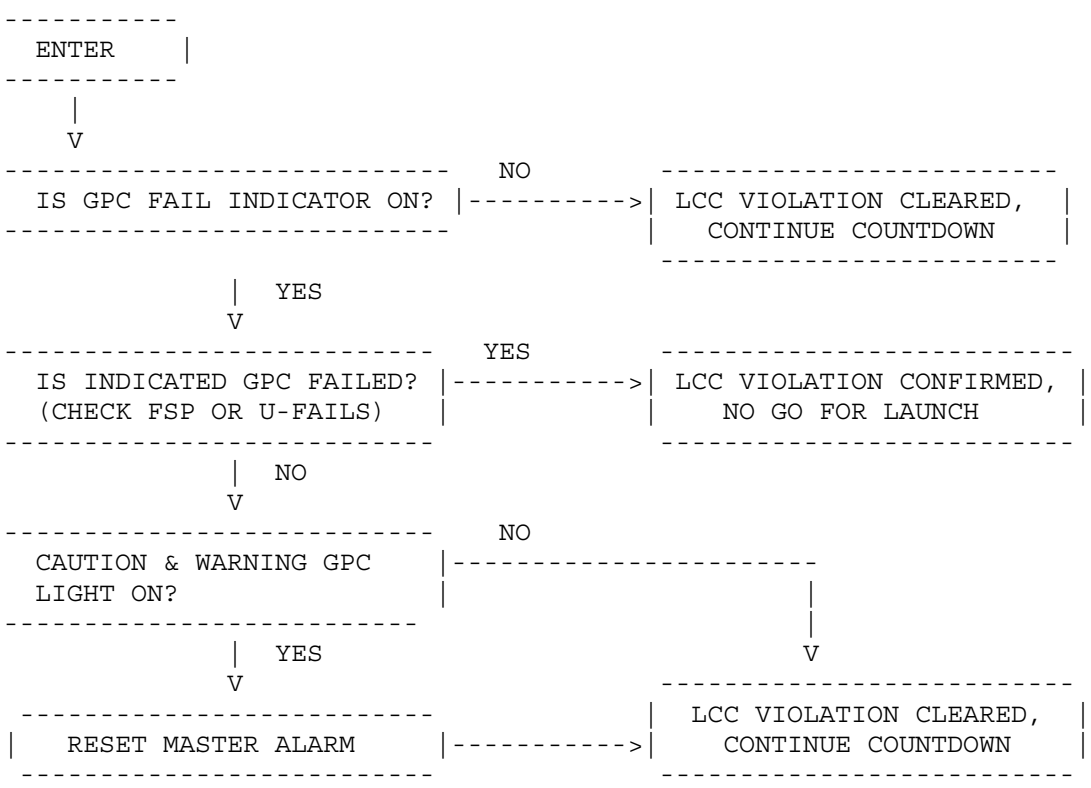


Figure 31-02 Flow Diagram for GPC I-FAIL

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LCC VIOLATION CALL: MDM BCE Bypass | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V91X2904X	FF1 MDM Return Word Bypass(HFE)	(2)	0 (5,6)	NA	Event	CI
V91X2905X	FF2 MDM Return Word Bypass(HFE)	(2)	0 (5,6)	NA	Event	CI
V91X2906X	FF3 MDM Return Word Bypass(HFE)	(2)	0 (5,6)	NA	Event	CI
V91X2907X	FF4 MDM Return Word Bypass(HFE)	(2)	0 (5,6)	NA	Event	CI
V91X2920X	FA1 MDM Return Word Bypass(HFE)	(2)	0 (5,6)	NA	Event	CI
V91X2921X	FA2 MDM Return Word Bypass(HFE)	(2)	0 (5,6)	NA	Event	CI
V91X2922X	FA3 MDM Return Word Bypass(HFE)	(2)	0 (5,6)	NA	Event	CI
V91X2923X	FA4 MDM Return Word Bypass(HFE)	(2)	0 (5,6)	NA	Event	CI
V91X2242X	FF1 Input PROM Seq 1,2 Bypass(MFE)	(2)	0 (6)	NA	Event	CI
V91X2243X	FF2 Input PROM Seq 1,2 Bypass(MFE)	(2)	0 (6)	NA	Event	CI
V91X2244X	FF3 Input PROM Seq 1,2 Bypass(MFE)	(2)	0 (6)	NA	Event	CI
V91X2245X	FF4 Input PROM Seq 1,2 Bypass(MFE)	(2)	0 (6)	NA	Event	CI
V91X2246X	FF1 Input PROM Seq 2,6 Bypass(HFE)	(2)	0 (6)	NA	Event	CI
V91X2247X	FF2 Input PROM Seq 2,6 Bypass(HFE)	(2)	0 (6)	NA	Event	CI
V91X2248X	FF3 Input PROM Seq 2,6 Bypass(HFE)	(2)	0 (6)	NA	Event	CI
V91X2249X	FF4 Input PROM Seq 2,6 Bypass(HFE)	(2)	0 (6)	NA	Event	CI
V91X2802X	FA1 Input PROM Seq 1,2 Bypass(MFE)	(2)	0 (6)	NA	Event	CI
V91X2803X	FA2 Input PROM Seq 1,2 Bypass(MFE)	(2)	0 (6)	NA	Event	CI
V91X2804X	FA3 Input PROM Seq 1,2 Bypass(MFE)	(2)	0 (6)	NA	Event	CI
V91X2805X	FA4 Input PROM Seq 1,2 Bypass(MFE)	(2)	0 (6)	NA	Event	CI
V91X2806X	FA1 Input PROM Seg3,10 Bypass(HFE)	(2)	0 (5,6)	NA	Event	CI
V91X2807X	FA2 Input PROM Seq3,10 Bypass(HFE)	(2)	0 (5,6)	NA	Event	CI
V91X2808X	FA3 Input PROM Seq3,10 Bypass(HFE)	(2)	0 (5,6)	NA	Event	CI
V91X2809X	FA4 Input PROM Seq3,10 Bypass(HFE)	(2)	0 (5,6)	NA	Event	CI
V91X2917X	FA2 Hydr Sys 3 Press C Bypass		0 (7)	NA	Event	CI
V91X2918X	FA3 OMS Chamber Press Left Bypass		0 (7)	NA	Event	CI
V91X2919X	FA4 OMS Chamber Press Right Bypass		0 (7)	NA	Event	CI
NA	PF 1 MDM Ret Word Bypass	(2)	(3,8)	NA	Event	CI
NA	PF 2 MDM Ret Word Bypass	(2)	(3,8)	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Loss of one port (19 of 20) is acceptable for launch. If more than one MDM sustains an "I/O Error" fault annunciation, LCC violation confirmed, No Go for launch.

(3) Not in downlist. Monitor PASS GPC I/O error log and Fault Summary Page (FSP). Violation will result in Fault Summary Message in G9 only. Not applicable in G1.

PREPLANNED CONTINGENCY PROCEDURE:

(4) Reference Figure 31-03, Flow Diagram For MDM Bypass, for a preplanned contingency procedure which evaluates MDM BYPASS Indication. This flow diagram allows for continuation of the launch countdown for port dependent failures at the MDM.

NOTES:

(5) RSLS monitors these starting at approximately T-15 seconds.
(6) Violation WILL result in fault summary message.
FF1(2,3,4) MDM Return Word Bypass: I/O Error FF1(2,3,4)
FA1(2,3,4) MDM Return Word Bypass: I/O Error FA1(2,3,4)
PF1(2) MDM Return Word Bypass: I/O Error PL1(2)
FF1(2,3,4) Input PROM Seq 1,2 Bypass: BCE String 1(2,3,4) A
FF1(2,3,4) Input PROM Seq 2,6 Bypass: BCE String 1(2,3,4) B
FA1(2,3,4) Input PROM Seq 1,2 Bypass: BCE String 1(2,3,4) C
FA1(2,3,4) Input PROM Seq 3,10 Bypass: BCE String 1(2,3,4) D
(7) Violation WILL NOT result in fault summary message.
(8) Required for payload bay door operation.
(9) "0"=OFF (KSC), "0"=OFF (MML); "1"=ON (KSC), "1"=ERROR (MML).

REDLINE DERIVATION: CRITICALITY:

(10) These discretes indicate the ability of a specific computer data bus port to acquire data from MDMs. A "1" in place of a "0" indicates that PASS has bypassed the associated element, resulting in loss of all data from the associated MDM or element.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Loss of system redundancy.
(12) Loss of FC/PL MDM.

CAUSES OF EXCEEDING REDLINE:

(13) Hardware anomaly in MDM, data bus, data bus coupler, or IOP BCE.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: DPS

SUPPORTING DATA:

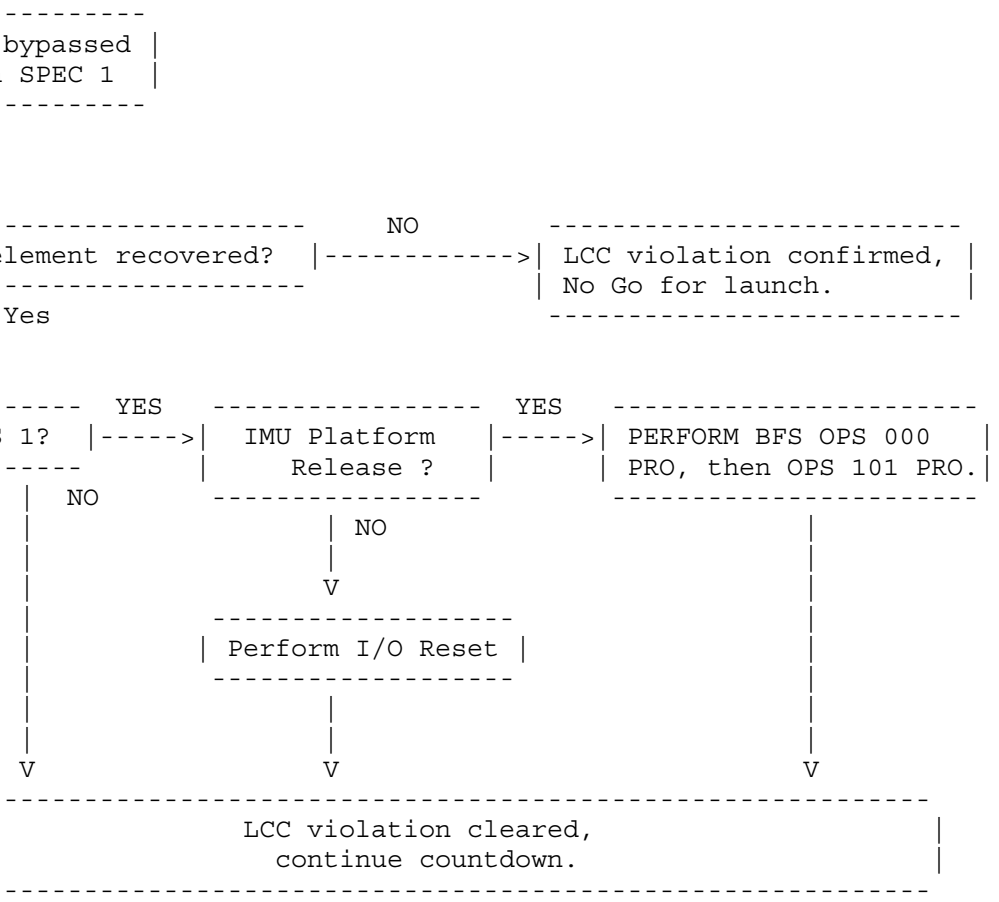

Figure 31-03 Flow Diagram For MDM Bypass

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LCC VIOLATION CALL: MDM Guidance, Navigation and Control Initiation Bypass Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V91X2892X	FA1 Bypass (GNC init)		0 (2)	NA	Event	DI
V91X2893X	FA2 Bypass (GNC init)		0 (2)	NA	Event	DI
V91X2894X	FA3 Bypass (GNC init)		0 (2)	NA	Event	DI
V91X2895X	FA4 Bypass (GNC init)		0 (2)	NA	Event	DI
V91X2896X	FF1 Bypass (GNC init)		0 (2)	NA	Event	DI
V91X2897X	FF2 Bypass (GNC init)		0 (2)	NA	Event	DI
V91X2898X	FF3 Bypass (GNC init)		0 (2)	NA	Event	DI
V91X2899X	FF4 Bypass (GNC init)		0 (2)	NA	Event	DI

TIME PERIOD:

(1) Snapshot at completion of OPS 1 Transition (T-19 minutes)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) Violation will not result in fault summary message.
(3) "0"=OFF (KSC), MML contains no designation for "0"; "1"=ON (KSC), "1"=ERROR (MML).

REDLINE DERIVATION: CRITICALITY: 1R

(4) PASS GPCs interrogate the flight critical MDMs upon entering G1 for a status of the current command outputs, and uses this data to initialize the OPS cyclic output buffer. A "1" in place of a "0" indicates that the associated MDM command outputs could not be read at OPS initialization, and therefore, the cyclic command output buffer for that MDM has not been properly initialized.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Potential loss of cyclic command outputs to affected MDM.
(6) Potential loss of flight critical MDM.

CAUSES OF EXCEEDING REDLINE:

(7) MDM hardware anomaly.
(8) GPC transmitter/receiver hardware anomaly.
(9) Data bus anomaly.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: DPS

LCC VIOLATION CALL: GPC BITE Indication | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA FSM	Fault Summary Message GPC BITE		(2)	NA	NA	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) No error occurrence.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) GPC BITE fault summary message annunciated for "Force Close" on any GPC process.

REDLINE DERIVATION: CRITICALITY: 1R

(4) Fault summary message: Violation implies that computer processing has stopped on some function. Only one GPC experiencing GPC BITE should generate a fail-to-sync. (Reference SSID DPS-02.)

(5) GPC BITE (1,2,3,4)

A. Possible causes/comment:
   1. Under no conditions would this error ever be expected.
   2. This error condition may or may not cause the GPC to fail redundant set sync.

B. Description:
   1. While performing normal GPC processing operations, PASS encountered a program or system interrupt which was generated due to an improper specification or use of instructions or data. One of the following errors caused this "BITE" condition:
      a. Illegal operation code - GPC attempted to execute a non-valid instruction.
      b. CPU address specification - CPU instruction attempted to access an out of range address.
      c. CPU protection violation - CPU instruction attempted to write to a store protected memory location.
      d. Privileged instruction - GPC attempted to execute a supervisory state instruction (e.g., insert store protect bits) while in an application state.

REDLINE DERIVATION: (Continued)

e. Instruction monitor - GPC attempted to execute information from unprotected storage.
f. I/O store protect violation - IOP instruction attempted to write to a store protected memory.
g. I/O address specification - IOP attempted to access data from an out of range address.

2. This problem indicates the possibility of a programming error, hardware error, or an invalid outside write to main memory. This error will cause a message to be written to PASS CRTs message line and fault summary pages. Upon receiving this error, the GPC will "Force Close" on the specific FCOS task it was running at that time and move on to the next FCOS highest priority task ready to run.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Launch with "Force Close" in GPC processing.
(7) Possible loss of redundant set.

CAUSES OF EXCEEDING REDLINE:

(8) "Generic" software problem.
(9) Hardware anomaly in GPC.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: DPS

MMU Error

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LCC VIOLATION CALL: SSMM Error | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	Fault Summary Message (Downlist)					
NA	I/O Error MMU1 (FSM)		NA	NA	Error	CI
NA	I/O Error MMU2 (FSM)		NA	NA	Error	CI

TIME PERIOD:

(1) During OPS 1 Transition (approximately T-20 minutes)

REQUIREMENTS: FIGURES/TABLES: Figure 31-04

(2) No Fault Summary Message (FSM). (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Evaluate the Solid State Mass Memory (SSMM) errors (ref Figure 31-04).

A. If a single transient SSMM error has occurred, and the SSMM is still able to complete an OPS transition, LCC violation cleared, continue countdown.

B. If multiple SSMM errors occur, LCC violation confirmed, No Go for launch.

NOTES:

(4) "I/O ERROR MMUx" Fault Summary Message will be annunciated on first error from the indicated SSMM.
(5) SSMM Status Registers A and B may be X0000 if the first SSMM read attempt fails. This is caused by the status register read performed on an overlay retry occurring before the SSMM status registers are downlisted.
(6) Upon initiation of the OPS 1 transition, the General Purpose Computer (GPC) will send a Status Register Read command and an OPS 3 Preposition command to both SSMM's. Following the G3 Archive load, an additional Status Register Read and an OPS 1 Preposition command will be sent to both SSMM's. An I/O error will result if the SSMM does not respond to a Status Register read, or if the unit does not return to the "READY" state within 70 seconds of a preposition command.
(7) "I/O ERROR MMUx" FSM annunciation will be suppressed for errors occurring within the 4.8 second interlock window of a prior "I/O Error MMUx" FSM annunciation against the same SSMM.

REDLINE DERIVATION: CRITICALITY: 2R

(8) a. SSID Intent Summary - The purpose of this requirement is to ensure two functional SSMM's are available for on orbit operations, including retrieval of on orbit GPC software and contingency recovery of Primary Avionics Software System (PASS) and/or Backup Flight Software (BFS) GPCs.

REDLINE DERIVATION: (Continued)

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - An "I/O ERROR MMUx" Fault Summary Message indicates that a data retrieval or transmission error has occurred with the SSMM during the GNC9 to GNC1 GPC OPS Transition, which includes the archiving of GNC3 entry software into upper core memory. The error signifies a potential loss of the associated SSMM.

   Only one SSMM is nominally accessed during the overlay read. If an I/O error is encountered, the GPC will annunciate an "I/O ERROR MMUx" FSM and perform an automatic retry of the overlay read from the same SSMM. If the retry also encounters an error, the GPC will automatically switch to the alternate SSMM and retry the overlay read. I/O errors occurring on the backup unit following the auto-switch will result in annunciation of an "I/O ERROR MMUx" FSM against that SSMM.

d. Time Period - Insight into the condition of the SSMM is only possible while the SSMM is being used to transfer data to the GPC. The last point in the count down where the SSMM's are used is the T-20 Minute GPC OPS 1 transition. Continuous monitoring of the down listed GPC FSM's during the OPS transition is required to ensure detection of errors encountered at any point during the SSMM access.

e. Requirements - An "I/O ERROR MMUx" FSM is annunciated by the GPC upon the first occurrence of an error. Monitoring of "I/O ERROR MMUx" FSM's for both SSMM's is required in order to detect any errors experienced with the non-prime SSMM during the Status Register read and preposition commands sent by the GPC prior to initiation of the overlay read. It also provides flexibility for use of either SSMM as the prime for the overlay read and allows detection of any errors logged against the "backup" SSMM should the GPC auto-switch to that unit during the transition.

f. Preplanned Contingency Procedure - The intent of the Preplanned Contingency Procedure is to discriminate between a one-time transient error and a loss of functionality of the SSMM. If the FSM resulted from a single I/O error logged against the prime SSMM, and the automatic retry performed by the GPC is successful, the error is considered to be a transient. Similarly, if the FSM resulted from a single I/O error logged against the backup SSMM, and a subsequent OPS transition is successfully performed from that SSMM, the error is considered to be a transient. One time transient errors are deemed acceptable for flight, since the SSMM is still able to perform its data retrieval function. A loss of SSMM functionality is evident if multiple errors occur.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) This event indicates a possible failure of a Solid State Mass Memory unit. Only one SSMM may be available for on-orbit operations. Loss of both SSMM's would result in an inability to acquire mission critical on-orbit

CONSEQUENCES OF EXCEEDING REDLINE: (Continued)

software and an inability to perform PASS/BFS GPC recovery contingency operations.

CAUSES OF EXCEEDING REDLINE:

(10) Any anomaly that occurs in receiving and transmitting data to GPCs:
A. Loss of power to SSMM.
B. Internal SSMM electronics failure.
C. GPC Bus Control Element (BCE) 18/19 transmitter/receiver failure (Multiplexer Interface Adapter).
D. GPC discrete input 06/07 receiver failure.
E. Mass Memory 1/2 data bus anomaly.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO		SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO		SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: DPS

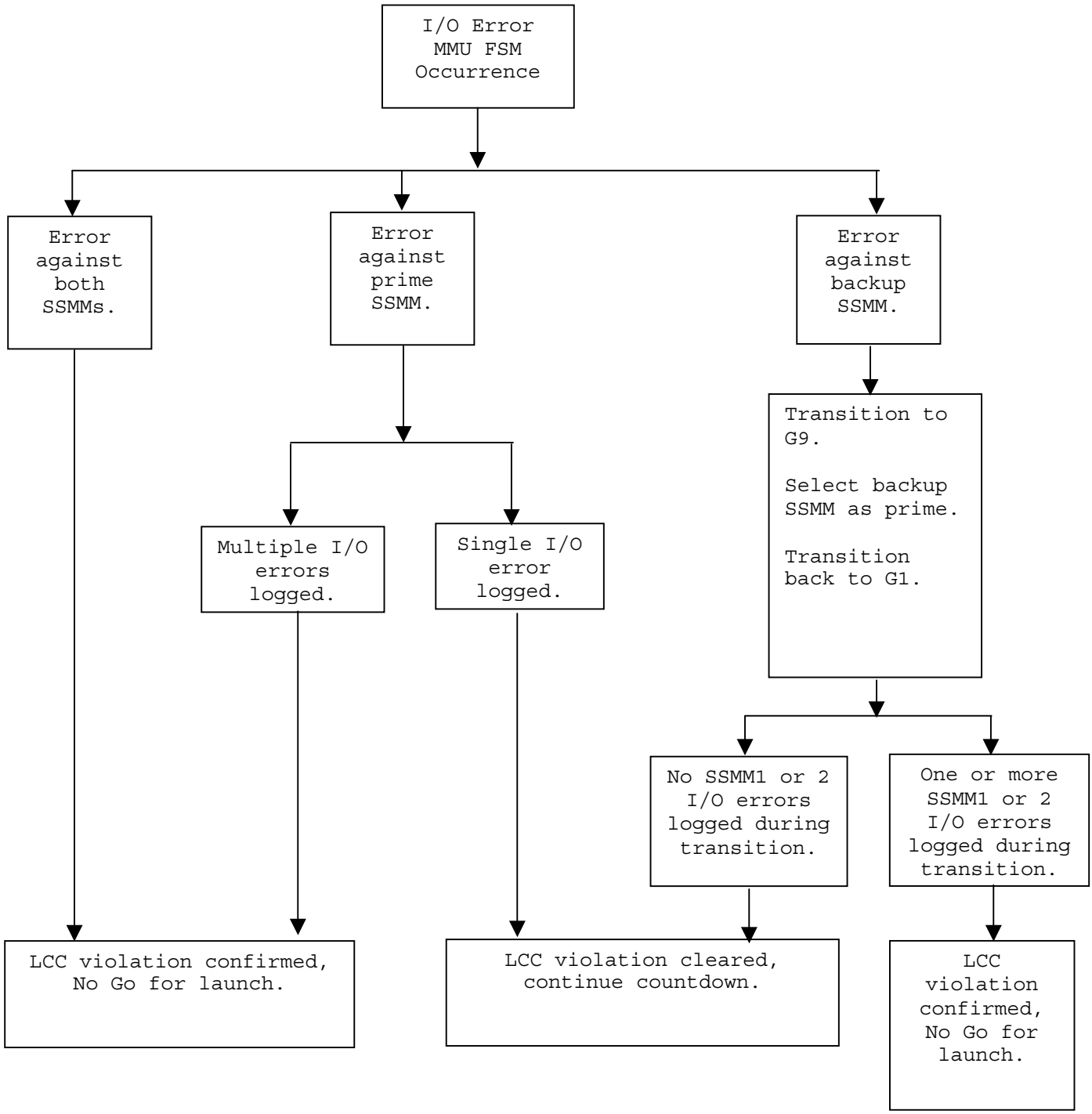

Figure 31-04 Flow Diagram for I/O Error MMU

LCC VIOLATION CALL: Mass Memory Ready Discrete Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V92X7368X	GPC1 MM1 Ready DI06	3 of 4	ON	NA	Event	CI
V92X7428X	GPC2 MM1 Ready DI06		ON	NA	Event	CI
V92X7488X	GPC3 MM1 Ready DI06		ON	NA	Event	CI
V92X7548X	GPC4 MM1 Ready DI06		ON	NA	Event	CI
V92X7369X	GPC1 MM2 Ready DI07	3 of 4	ON	NA	Event	CI
V92X7429X	GPC2 MM2 Ready DI07		ON	NA	Event	CI
V92X7489X	GPC3 MM2 Ready DI07		ON	NA	Event	CI
V92X7549X	GPC4 MM2 Ready DI07		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) An "OFF" in place of an "ON" indicates that the Mass Memory is busy or has lost power and is not available for transactions; however, the discretes are redundancy-managed in Primary Avionics System Software (PASS).
(3) Parent word V92M7361P GPC 1 Discrete Word A.
(4) Parent word V92M7421P GPC 2 Discrete Word A.
(5) Parent word V92M7481P GPC 3 Discrete Word A.
(6) Parent word V92M7541P GPC 4 Discrete Word A.
(7) "0"=OFF (KSC), "0"=OFF (MML); "1"=ON (KSC), "1"=ON (MML).

REDLINE DERIVATION: CRITICALITY: 2R

(8) These discretes indicate the availability of the respective Mass Memories. The discretes are redundancy-managed by software such that if three of four PASS GPCs detect a READY state ("ON"), the Mass Memory will be considered available for transactions (i.e., OPS transitions).

CONSEQUENCES OF EXCEEDING REDLINE:

(9) The affected Mass Memory may not be available for OPS transitions and other on-orbit operations.

CAUSES OF EXCEEDING REDLINE:

(10) Failed Mass Memory (1 or 2).
(11) Failed discrete input 06 (for MM 1) or discrete input 07 (for MM 2) at two or more of the four PASS GPCs.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: DPS

IPL Select Discrete Anomaly

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LCC VIOLATION CALL: PASS GPC Error | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V92Q6036C	GPC 1 Last GPC Err Count		(2)	NA	NA	CI
V92Q6046C	GPC 2 Last GPC Err Count		(2)	NA	NA	CI
V92Q6056C	GPC 3 Last GPC Err Count		(2)	NA	NA	CI
V92Q6066C	GPC 4 Last GPC Err Count		(2)	NA	NA	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES: Table 31-03

(2) No error occurrence. (3,4)
(3) Errors contained in Table 31-03, GPC Error Exclusions, are acceptable if they occur under the conditions described in the table or associated referenced documentation.

PREPLANNED CONTINGENCY PROCEDURE:

(4) All errors will be evaluated. If analysis determines errors occurred due to explainable phenomena documented in Space Shuttle Program approved documentation, and do not affect GPC or flight software functionality or system redundancy, LCC violation cleared, continue countdown.

NOTES:

(5) GPC error count will increment upon occurrence of a GPC error.

REDLINE DERIVATION: CRITICALITY: 1R

(6) a. SSID Intent Summary - The intent of this requirement is to detect the occurrence of GPC errors that may be symptomatic of a GPC hardware or PASS flight software anomaly. Such anomalies may affect the ability of the associated GPC or PASS software to safely fly the vehicle and complete mission objectives.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development -

Redline criteria is intended to detect the occurrence of GPC error conditions that may indicate a malfunctioning GPC, or aberrant behavior of the PASS flight software. All errors must be evaluated for potential causes and effects.

The occurrence of any GPC error will increment the GPC error counter. Each GPC error is defined by 6 halfwords logged in memory, and the last

REDLINE DERIVATION: (Continued)

five errors from the GPC as well as the last error from each GPC is maintained in the log. For simplicity, the redline criteria was selected to monitor only for a change in the error counter, which would signal the occurrence of a new error.

d. Time Period - The PASS redundant set is operating in flight configuration throughout the terminal count period, and errors may be reported at anytime through T-0. The chosen time period ensures continuous health monitoring from the start of tanking phase at T-6 hours until commitment for launch at T-10 seconds. Committing the system for flight at T-10 seconds allows monitoring for potential PASS software anomalies as late in the count as practical. If undetected, such anomalies may require manual engaging of the Backup Flight System (BFS) by the crew during ascent.

e. Requirements -

Since it is not possible to diagnose GPC error occurrences in advance, all errors must be evaluated for potential causes and effects. An exception is made for a few Program Note conditions that are benign in nature, and which may occur in the operating conditions in effect during countdown. These errors are excluded from the LCC to preclude an unnecessary hold.

f. Preplanned Contingency Procedure -

The intent of the Preplanned Contingency Procedure is to evaluate the occurrence of GPC errors for their potential impact on the performance and redundancy of the system.

Error conditions that result from a recurrence of a Program Note condition, and which do not affect system performance or redundancy, are acceptable for launch.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) PASS may not be operable for flight.
(8) Potential loss of GPC(s).

CAUSES OF EXCEEDING REDLINE:

(9) Hardware or software anomaly in GPC.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: DPS

SUPPORTING DATA:

Table 31-03 GPC Error Exclusions

Group/Code	Description	Conditions/Remarks
02/13	Cyclic Overrun	DR 46507, DR 47311, DR 50278, DR 54091
07/05	Downlist I/O Cycle Wrap	DR 25197, DR 47311, DR 55053, DR 55355, DR 105668
07/06	SRB Input I/O Cycle Wrap	DR 47311, DR 50278, DR 63450, DR 103002, DR 105668
07/08	LDB I/O Cycle Wrap	DR 47311
07/13	PMU OI/PL RAM Read I/O Cycle Wrap	DR 47311, DR 100572, DR 100702

NOTE: This table is intended to avoid unnecessary LCC holds for certain GPC errors when they occur under the described conditions or Discrepancy Reports (DR). These error occurrences have been evaluated and determined to be acceptable for flight, and are excluded due to likelihood of occurrence. This table is not intended to define all acceptable GPC errors.

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LCC VIOLATION CALL: PASS Time Source Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V91Q1710C	GPC 1 TMP Source (5)	(2)	(3)	NA	Binar	CI
V91Q1711C	GPC 2 TMP Source (5)	(2)	(3)	NA	Binar	CI
V91Q1712C	GPC 3 TMP Source (5)	(2)	(3)	NA	Binar	CI
V91Q1713C	GPC 4 TMP Source (5)	(2)	(3)	NA	Binar	CI
V91X1716X	GPC 1 Time Source GPC/MTU		1 (4)	NA	Event	CI
V91X1717X	GPC 2 Time Source GPC/MTU		1 (4)	NA	Event	CI
V91X1718X	GPC 3 Time Source GPC/MTU		1 (4)	NA	Event	CI
V91X1719X	GPC 4 Time Source GPC/MTU		1 (4)	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) At least two accumulators must be available for launch (i.e., Accumulator not bypassed. Reference DPS-16).
(3) 1 or 2. This number indicates the MTU accumulator time source, accumulator 1, 2, or 3.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) A "0" in place of a "1" indicates the GPC has faulted to internal time.
(5) TMP stands for Time Management Process.
(6) GPC TMP source can equal 1, 2, 3, or 4 when GPC/MTU time source is equal to zero (internal time).
(7) "0"=OFF (KSC), "0"=OFF (MML); "1"=ON (KSC), "1"=ON (MML).

REDLINE DERIVATION: CRITICALITY: 1R

(8) Above Function Designators (FDs) indicate PASS GMT/MET time source. If GMT is not received from the MTU, the software uses the GPC clock for updating the values of GMT and MET. The utilization of the GPC internal clock may result in inaccurate navigation calculations. MTU accumulators are covered by fault-down logic; faultdown order is accumulator 1 to accumulator 2 to accumulator 3 to GPC internal time. PASS will fault off an accumulator if the delta between the GPC time and the MTU accumulator is greater than 800 microseconds, or if the accumulator is commfaulted.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Increased PASS navigation inaccuracy.

CAUSES OF EXCEEDING REDLINE:

(10) Master Timing Unit, Multiplexer/Demultiplexer, or GPC hardware anomaly.
(11) Software anomaly.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO		SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO		SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: DPS

LCC VIOLATION CALL: PASS BFS Engage Discrete Anomaly. | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V92X7381X	GPC 1 BFS Engage 1 DI35	(2)	0	NA	Event	CI
V92X7382X	GPC 1 BFS Engage 2 DI36	(2)	0	NA	Event	CI
V92X7383X	GPC 1 BFS Engage 3 DI37	(2)	0	NA	Event	CI
V92X7441X	GPC 2 BFS Engage 1 DI35	(2)	0	NA	Event	CI
V92X7442X	GPC 2 BFS Engage 2 DI36	(2)	0	NA	Event	CI
V92X7443X	GPC 2 BFS Engage 3 DI37	(2)	0	NA	Event	CI
V92X7501X	GPC 3 BFS Engage 1 DI35	(2)	0	NA	Event	CI
V92X7502X	GPC 3 BFS Engage 2 DI36	(2)	0	NA	Event	CI
V92X7503X	GPC 3 BFS Engage 3 DI37	(2)	0	NA	Event	CI
V92X7561X	GPC 4 BFS Engage 1 DI35	(2)	0	NA	Event	CI
V92X7562X	GPC 4 BFS Engage 2 DI36	(2)	0	NA	Event	CI
V92X7563X	GPC 4 BFS Engage 3 DI37	(2)	0	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 11 of 12 required.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) "0"=OFF (KSC), "0"=OFF (MML); "1"=ON (KSC), "1"=ON (MML).

REDLINE DERIVATION: CRITICALITY: 1R

(4) For BFS engage, each PASS GPC requires 3 of 3 "BFS Engage Discretes" = 1 and "I/O terminate B" discrete = 1.
(5) The BFS Engage discrete inputs to the GPCs indicate the proper hardware configuration for BFS pre-engage. The loss of one discrete (i.e., 11 of 12 inputs still show "OFF") is acceptable for launch, and is most likely a failure of a single GPC hybrid discrete receiver. The failure of two or more discrete inputs (in any combination) is highly unlikely, and would seriously degrade confidence in the launch readiness of the BFS Engage system.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Potential loss of PASS GPC.
(7) Not able to load BFS in failed GPC.
(8) Launch with questionable BFC.
(9) Launch with PASS GPC(s) not fail-operational/fail-safe.

CAUSES OF EXCEEDING REDLINE:

(10) BFC hardware anomaly.
(11) GPC discrete receiver anomaly.
(12) BFS engage switch failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: DPS

LCC VIOLATION CALL: IMU Data Bypass | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V91X2924X	FF1 IMU Dscrs Bypass (IMU Input)		0 (3,4)	NA	Event	CI
V91X2925X	FF2 IMU Dscrs Bypass (IMU Input)		0 (3,4)	NA	Event	CI
V91X2926X	FF3 IMU Dscrs Bypass (IMU Input)		0 (3,4)	NA	Event	CI
V91X2911X	FF1 IMU Data Bypass (IMU Input)		0 (2)	NA	Event	CI
V91X2912X	FF2 IMU Data Bypass (IMU Input)		0 (2)	NA	Event	CI
V91X2913X	FF3 IMU Data Bypass (IMU Input)		0 (2)	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to OPS 1 Transition (T-20 minutes)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) Violation will result in fault summary message: BCE String 1 (2,3) IMU.
(3) Violation will not result in fault summary message.
(4) IMU discretes are discrete inputs to the MDM and should not be bypassed regardless of IMU operation.
(5) "0"=OFF (KSC), "0"=OFF (MML); "1"=ON (KSC), "1"=ERROR (MML).

REDLINE DERIVATION: CRITICALITY: 1R

(6) A "1" in place of a "0" indicates that PASS has bypassed the associated IMU, rendering its data unavailable for navigation calculations. Measurements only available in G9.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Loss of one IMU input to navigation software.
(8) Prelaunch criteria require three (3) operational IMUs to remain two-fault tolerant.

CAUSES OF EXCEEDING REDLINE:

(9) Hardware anomaly in IMU, MDM, or data bus.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: DPS

LCC VIOLATION CALL: IMU BCE String Bypass | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V91X2273X	FF1 IMU Bypass		0 (2,3)	NA	Event	CI
V91X2274X	FF2 IMU Bypass		0 (2,3)	NA	Event	CI
V91X2275X	FF3 IMU Bypass		0 (2,3)	NA	Event	CI

TIME PERIOD:

(1) From OPS 1 Transition (T-20 minutes) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) Violation will result in fault summary message.
FF1(2,3): BCE String 1(2,3) IMU.
(3) Only valid in OPS G1.
(4) "0"=OFF (KSC), "0"=OFF (MML); "1"=ON (KSC), "1"=ERROR (MML).

REDLINE DERIVATION: CRITICALITY: 1R

(5) A "1" in place of a "0" indicates that PASS has bypassed the associated IMU, rendering its data unavailable for navigation calculations.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Loss of one IMU input to navigation software.
(7) Prelaunch criteria require three (3) operational IMUs to remain two-fault tolerant.

CAUSES OF EXCEEDING REDLINE:

(8) Hardware anomaly in IMU, MDM, or data bus.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: DPS

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LCC VIOLATION CALL: Network Signal Processor Bus Control Element Bypass | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V91X2900X	FF1 NSP Discretes Bypass		0 (5,6)	NA	Event	CI
V91X2901X	FF3 NSP Discretes Bypass		0 (5,6)	NA	Event	CI
V91X2902X	FF1 NSP Data Bypass		0 (3,4)	NA	Event	CI
V91X2903X	FF3 NSP Data Bypass		0 (3,4)	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) To Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Two functional Network Signal Processors (NSP) are required.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) Nominally one of two bypasses will be set since two NSPs cannot be powered on simultaneously.
(4) Violation will result in fault summary message.
FF1(3) NSP Data Bypass: BCE String 1(3) NSP.
(5) Violation will not result in fault summary message.
(6) NSP discretes are discrete inputs to the MDM and should not be bypassed regardless of NSP operation.
(7) "0"=OFF (KSC), "0"=OFF (MML), "1"=ON (KSC), "1"=ERROR (MML).

REDLINE DERIVATION: CRITICALITY: 1R

(8) These discretes indicate the ability of the primary set to acquire data from the active NSP.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Loss of uplink command capability through affected NSP.

CAUSES OF EXCEEDING REDLINE:

(10) Hardware anomaly in NSP, MDM, or data bus.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: DPS

LCC VIOLATION CALL: Air Data Transducer Assembly BCE Bypass Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V91X2261X	FF1 ADTA Bypass		0	NA	Event	CI
V91X2262X	FF2 ADTA Bypass		0	NA	Event	CI
V91X2263X	FF3 ADTA Bypass		0	NA	Event	CI
V91X2264X	FF4 ADTA Bypass		0	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) Violation will result in fault summary message.
FF1(2,3,4): BCE String 1(2,3,4) ADTA.
(3) "0"=OFF (KSC), "0"=OFF (MML); "1"=ON (KSC), "1"=ERROR (MML).

REDLINE DERIVATION: CRITICALITY: 1R

(4) A "1" in place of a "0" indicates that PASS has bypassed the associated ADTA, rendering its data unavailable for GN&C calculations.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Loss of ADTA two-fault tolerance.

CAUSES OF EXCEEDING REDLINE:

(6) Hardware anomaly in ADTA, MDM, or data bus.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: DPS

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LCC VIOLATION CALL: MTU BCE Bypass | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V91X2277X	FF1 MTU Bypass		0 (3)	NA	Event	CI
V91X2278X	FF2 MTU Bypass		0 (3)	NA	Event	CI
V91X2279X	FF3 MTU Bypass		0 (3)	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) At least two (of 3) accumulators must be available for launch. (Reference DPS-10.)

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) Violation will result in fault summary message.
FF1(2,3): BCE String 1(2,3) MTU.
(4) "0"=OFF (KSC), "0"=OFF (MML); "1"=ON (KSC), "1"=ERROR (MML).

REDLINE DERIVATION: CRITICALITY: 1R

(5) A "1" in place of "0" indicates that PASS has bypassed the associated MTU, rendering its GMT and MET unavailable for navigation calculations.
(6) These discretes indicate the ability of the primary set to acquire GMT and MET from the MTU accumulators. If GMT is not received from the MTU, PASS will use the GPC internal clock for updating the values of GMT and MET. The utilization of the GPC internal clock may result in inaccurate navigation calculations.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Increased PASS navigation inaccuracy.

CAUSES OF EXCEEDING REDLINE:

(8) Hardware anomaly in MTU, MDM, or data bus.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: DPS

LCC VIOLATION CALL: Tactical Air Navigation/Radar Altimeter BCE Bypass | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V91X2253X	FF1 TACAN/RA Bypass	(2,3)	OFF	NA	Event	CI
V91X2254X	FF2 TACAN/RA Bypass	(2,3)	OFF	NA	Event	CI
V91X2255X	FF3 TACAN/RA Bypass	(2,3)	OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) For vehicles with TACAN installed:
TACAN/RA Bypass must be OFF for 3 of 3 MDMs. (4)

(3) For vehicles with Three String GPS installed:
FF3 TACAN/RA Bypass is not applicable. FF1 and FF2 TACAN/RA Bypasses must be OFF. TACAN/RA bypasses must be OFF to verify acceptable RA communication path. (4)

PREPLANNED CONTINGENCY PROCEDURE:

(4) For a single MDM TACAN/RA Bypass ON, notify Navaids Engineering of loss of communication with TACAN unit and Radar Altimeter unit if MDM FF1 or FF2. If loss of the TACAN does not violate CT-01, and loss of the RA does not violate CT-08, then LCC violation cleared, continue countdown.

NOTES:

(5) Violation will result in fault summary message.
FF1(2,3): BCE String 1(2,3) TAC.

(6) An isolated TACAN/RA data bypass would be caused by a failure in an MDM card, not by a failure of a TACAN or RA. By itself, the MDM bypass does not impact the DPS system as long as DPS-03 is not violated. The purpose of this requirement is to notify Navaids Engineering that the affected unit(s) are no longer communicating with the GPC.

(7) Reference SSID CT-01 for TACAN requirements.

(8) Reference SSID CT-08 for Radar Altimeter requirements.

REDLINE DERIVATION: CRITICALITY: 1R

(9) a. SSID Intent Summary - The intent of this LCC is to ensure navigational data provided by the TACAN and Radar Altimeter units are available to the PASS GNC flight software for determination of vehicle range, bearing, and altitude, and for display to the crew. Dual fault tolerance is required for updating the entry navigation state for EOM and single fault tolerance is required for intact abort.

b. Voting Logic - N/A

REDLINE DERIVATION: (Continued)

c. Minimum and/or Maximum Redline Development - The minimum redline value of OFF ensures the GPC is successfully acquiring data from the MDM TACAN/RA card. An ON in place of an OFF indicates that PASS has bypassed the associated TACAN/RA, rendering its TACAN data unavailable for navigation calculations, and its TACAN and RA data unavailable for display to the crew. There is no maximum redline value.

d. Time Period - Since PASS flight software interrogates the TACAN/RA MDM card for data at all times while in GNC OPS 1 or 9, the starting effectivity is T-6 Hours. An ending effectivity of T-31 seconds provides consistency with the TACAN and RA functional SSIDs (reference CT-01 and CT-08), which protects dual fault tolerance for determination of EOM entry navigation state until the system is committed for launch.

e. Requirements - Availability of TACAN/RA data for use by the PASS GNC software in determining Nav state and for display to the crew requires functioning TACAN/RA LRUs and valid data paths to the GPC. The LRUs functional requirements are addressed in SSIDs CT-01 (TACAN) and CT-08 (RA). The requirements in this SSID are intended to provide consistency with those functional SSIDs, and are partitioned to accommodate both TACAN and three string GPS equipped orbiters.

   TACAN equipped orbiters have three TACAN LRUs onboard, channelized to MDMs FF1, FF2, and FF3, and two RA LRUs, channelized to FF1 and FF2. Loss of more than one TACAN is a redline violation. Loss of only one of three TACANs requires evaluation via the Preplanned Contingency Procedure to determine if GPS or high speed C-Band Radar are available for use as a backup. Loss of both RAs is also a redline violation. Loss of one of two RAs requires evaluation via the Preplanned Contingency Procedure to determine if a viable backup source of altitude data is available using the MSBLS.

   Three string GPS equipped orbiters do not have TACANs, but still have the two RA LRUs channelized to FF1 and FF2. Since there is no RA data sourced through FF3, the FF3 TACAN/RA bypass is not applicable for three string GPS vehicles. Loss of both RAs is a redline violation. Loss of one of two RAs requires evaluation via the Preplanned Contingency Procedure to determine if a viable backup source of altitude data is available using the MSBLS.

f. Preplanned Contingency Procedure - A Preplanned Contingency Procedure is available to allow the Navaids systems engineer to evaluate loss of a single TACAN or RA data path per the criteria contained in functional SSIDs CT-01 and CT-08.

   For TACAN equipped orbiters, CT-01 specifies that loss of one of three TACANs is acceptable if GPS2 or high speed C-Band Radar can be utilized as a backup. CT-08 specifies that loss of one of two RAs is acceptable if three MSBLS units are available as a backup.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Loss of TACAN and RA system redundancy.
(11) Loss of TACAN input to navigation software.
(12) Loss of RA input to crew displays.
(13) Reference Orbiter Hazard Report ORBI 211.

CAUSES OF EXCEEDING REDLINE:

(14) Hardware anomaly in MDM, or data bus.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: DPS

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LCC VIOLATION CALL: Engine Interface Unit Mid Frequency Executive BCE Bypass | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V91X2928X	EIU1/P1 Data Bypass (MFE Input)		OFF	NA	Event	CI
V91X2931X	EIU2/P1 Data Bypass (MFE Input)		OFF	NA	Event	CI
V91X2934X	EIU3/P1 Data Bypass (MFE Input)		OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to OPS 1 Transition (T-20 minutes)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) Violation will not result in Fault Summary Message.
(3) From OPS 1 Transition (T-20 minutes) these redlines are monitored by the Redundant Set Launch Sequencer (RSLS) via the SSME Data Path Fail logic.

REDLINE DERIVATION: CRITICALITY: 1R

(4) An ON in place of an OFF indicates that PASS has bypassed the associated EIU Mid Frequency Executive (MFE) input, resulting in a loss of its data.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Loss of EIU data.
(6) Possible loss of GPC to EIU command capability on one or more ports.

CAUSES OF EXCEEDING REDLINE:

(7) Hardware anomaly in EIU, GPC or data bus.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: DPS

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LCC VIOLATION CALL: MDM BSR Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	FF1 Port 1&2 Bite Status Register		X0000	NA	HEX	DI
NA	FF2 Port 1&2 Bite Status Register		X0000	NA	HEX	DI
NA	FF3 Port 1&2 Bite Status Register		X0000	NA	HEX	DI
NA	FF4 Port 1&2 Bite Status Register		X0000	NA	HEX	DI
NA	FA1 Port 1&2 Bite Status Register		X0000	NA	HEX	DI
NA	FA2 Port 1&2 Bite Status Register		X0000	NA	HEX	DI
NA	FA3 Port 1&2 Bite Status Register		X0000	NA	HEX	DI
NA	FA4 Port 1&2 Bite Status Register		X0000	NA	HEX	DI
NA	PL1 Port 1&2 Bite Status Register		X0000	NA	HEX	DI
NA	PL2 Port 1&2 Bite Status Register		X0000	NA	HEX	DI

TIME PERIOD:

(1) Snapshot at T-45 minutes

REQUIREMENTS: FIGURES/TABLES:

(2) Any set bits in Bite Status Register (BSR) must be evaluated. If explainable and acceptable, LCC violation cleared, continue countdown.
(3) Loss of one port (19 of 20 remaining) is acceptable for launch. (Reference DPS-03.)

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) Performed at T-45 minutes because automated port moding can only be done in G-9.

REDLINE DERIVATION: CRITICALITY: 1R

(5) The BSR acts as an error accumulator for the MDMs error checking and performance monitoring bite circuitry. This BSR read verifies that no MDM detected hardware anomalies exist, and that the MDM is operating properly for the terminal count sequence.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Potential loss of MDM and associated functions.
(7) Potential loss of data bus.

CAUSES OF EXCEEDING REDLINE:

(8) Hardware anomaly in MDM, IOP transmitter, or data bus network.
(9) Incorrect commands to MDM.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: DPS

LCC VIOLATION CALL: MDM Output Fault Summary Message | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA FSM	Fault Summary Message MDM OUTPUT		(2)	NA	NA	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) No error occurrence.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) MDM OUTPUT PL1/PL2 not applicable in OPS 1. MDM OUTPUT for flight critical MDMs not applicable in G9.

REDLINE DERIVATION: CRITICALITY: 1R

(4) This MDM Fault Summary Message (FSM) indicates an error in either the commanding input/output processor (IOP) or the MDM. The IOP sends out an alternating pattern of ones and zeroes during each HFE input cycle (Flight Critical MDMs) and PF low rate cycle (PF MDMs). The MDM echoes this pattern back to the IOP where it is compared one time per major cycle (approximately once per second). Two consecutive miscompares of the same pattern are required to annunciate the MDM OUTPUT message. If MDM OUTPUT is annunciated only by one GPC for a flight critical MDM, then the failure is at the GPC rather than at the MDM.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) The faulted MDM may be receiving misdirected or altered GPC commands.

CAUSES OF EXCEEDING REDLINE:

(6) Hardware failure (GPC or MDM).

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: DPS

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LCC VIOLATION CALL: SUMWORD ICC Fault Summary Message | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	Fault Summary Message					
NA	SUMWORD ICCx		(2)	NA	NA	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) No error occurrence.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) SUMWORD ICCx fault summary message annunciated for ICC data pollution.
(4) "x"= 1, 2, 3, or 4 which designates the GPC number.

REDLINE DERIVATION: CRITICALITY: 1R

(5) Violation implies that computer processing may cause FTS with that GPC while operating redundantly with other GPCs. Anomaly annunciated when three consecutive miscompares are made on ICC data transferred parameters.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Possible fail-to-sync of the suspect GPC with the other GPCs in the redundant set.
(7) Possible loss of TAL capability due to inability to access G3 software.

CAUSES OF EXCEEDING REDLINE:

(8) Pollution of ICC data between redundant set.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: DPS

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LCC VIOLATION CALL: PASS I/O Error Log | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	PASS I/O Error Log - BCE Stat Reg					
NA	Bit 29: Illegal OP Code		(2)	NA	Event	CI
NA	Bit 28: Boundary Alignment Error		(2)	NA	Event	CI
NA	Bit 22: Self Test Error		(2)	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Occurrence of an I/O error with any of the indicated BCE Status Register bits set ON constitutes a redline violation. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Evaluate error. If error is explainable based on conditions present at the time, and can be determined to have no effect on flight, LCC violation cleared, continue countdown.

NOTES:

(4) Indicated Status Register bits applicable for Bus Control Element (BCE) 1-24 only.

REDLINE DERIVATION: CRITICALITY:

(5) A single occurrence of an I/O Error with any of the indicated BCE status register bits set ON, detected by all PASS GPCs, is indicative of a flight software problem. If detected by only one GPC, problem may be flight software or hardware.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Possible PASS system degradation.

CAUSES OF EXCEEDING REDLINE:

(7) Flight Software
(8) GPC Hardware

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: DPS

DDU BITE Anomaly

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DDU Power Supply Anomaly

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LCC VIOLATION CALL: GPC Soft Error Counter Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V92Q4375BX	GPC 1 Sft Err Cnt 0-128K		NA	(2)	Cnts	CI
V92Q4376BX	GPC 1 Sft Err Cnt 128-256K		NA	(2)	Cnts	CI
V92Q4377BX	GPC 2 Sft Err Cnt 0-128K		NA	(2)	Cnts	CI
V92Q4378BX	GPC 2 Sft Err Cnt 128-256K		NA	(2)	Cnts	CI
V92Q4379BX	GPC 3 Sft Err Cnt 0-128K		NA	(2)	Cnts	CI
V92Q4380BX	GPC 3 Sft Err Cnt 128-256K		NA	(2)	Cnts	CI
V92Q4381BX	GPC 4 Sft Err Cnt 0-128K		NA	(2)	Cnts	CI
V92Q4382BX	GPC 4 Sft Err Cnt 128-256K		NA	(2)	Cnts	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) More than two occurrences constitutes a redline violation.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) The left most eight bits of the parent word correspond to a soft error count in the lower 128K GPC memory and the right most eight bits of the parent word correspond to a soft error count in the upper 128K GPC memory.

(4) The following are parent words of the children words listed above:

V92M2909P GPC 1 Soft Error Counter;
V92M2910P GPC 2 Soft Error Counter;
V92M2911P GPC 3 Soft Error Counter;
V92M2912P GPC 4 Soft Error Counter.

REDLINE DERIVATION: CRITICALITY: 1R

(5) The AP101S GPCs have CMOS technology main memory. CMOS has demonstrated a vulnerability to bit toggles in space caused by a greater exposure to natural radiation. Thus the GPCs main memory utilizes an Error Detection and Correction (EDAC) design such that any GPC main memory read will be checked with a single bit error detect/correct and a multi-bit error detect functionality. A hardware process called "Scrub", which runs anytime the GPC is powered on, checks all memory every 1.7 seconds and corrects any single bit errors. A single bit error and a multi-bit error detected by Scrub increments the soft error counter. The failure of an entire 64K x 1 memory chip will result in the counter incrementing to 7F within two scrub cycles. A continuous incrementing counter is indicative of a single bit in memory hard-failed or a multi-bit error.

REDLINE DERIVATION: (Continued)

(6) Any single bit error detected during normal GPC software accesses is corrected before being sent to the CPU or IOP, but the memory location is not corrected nor is the soft error counter incremented. A multi-bit error detected during normal GPC accesses causes the GPC to halt (wait state).
(7) It is possible to have occurrences of single bit errors due to natural radiation while on the ground. Therefore, two occurrences of the soft error counter incrementing would most likely be attributed to natural radiation.
(8) Reset of the counter occurs during power On, IPL, GPC mode from Run to Standby, error log clear (OI-26 and subs), as well as certain GPC interrupts.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Launching with a GPC that may have some part(s) of memory that have failed, thus the GPC is more susceptible to failure due to natural radiation induced memory alterations. Launching with a GPC that has a multi-bit error will cause the GPC to fail when the GPC accesses that memory location.

CAUSES OF EXCEEDING REDLINE:

(10) GPC memory failure.
(11) Error correction circuitry failure.
(12) GPC hardware counter register failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: DPS

LCC VIOLATION CALL: G3 Archive Load Status | EMERG COND:

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V92J2010C	G3 Archive Status,GPC1		(2)	NA	Binar	DI
V92J2011C	G3 Archive Status,GPC2		(2)	NA	Binar	DI
V92J2012C	G3 Archive Status,GPC3		(2)	NA	Binar	DI
V92J2013C	G3 Archive Status,GPC4		(2)	NA	Binar	DI

TIME PERIOD:

(1) Snapshot at completion of OPS 1 Transition (T-19 min)

REQUIREMENTS: FIGURES/TABLES:

(2) 1, 2, or 3. This number indicates the MMU area from which the G3 archive load was retrieved.
(3) All GPCs must have a valid G3 archive load resident in upper memory.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) A "0" indicates that the GPC did not receive a valid G3 archive load into its upper page of memory.

REDLINE DERIVATION: CRITICALITY:

(5) The AP101-S GPCs upper page of memory (128K - 256K) is loaded with G3 software prelaunch to provide quick access to entry software in the event of a TAL abort. G3 software is first loaded into the lower page of GPC memory as part of the G9 to G1 transition. Upon successful loading of the G3 overlay into lower memory, the software is transferred to upper memory. The nominal G1 overlay is then completed.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Launching with a GPC that may have internal failures.

CAUSES OF EXCEEDING REDLINE:

(7) GPC internal failure.
(8) Transient GPC transmitter/receiver failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: DPS

LCC VIOLATION CALL: GPS BCE Bypass Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V91X0026X	FF1 GPS1 Bypass (GPS)	(2,3)	OFF	NA	Event	CI
V91X0027X	FF2 GPS2 Bypass (GPS)	(2,3)	OFF	NA	Event	CI
V91X0028X	FF3 GPS3 Bypass (GPS)	(2,3)	OFF	NA	Event	CI

TIME PERIOD:

(1) From GPS Activation (approximately T-4 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Applicable only for vehicles with Three String GPS installed.
(3) 3 of 3 GPS Bypasses must be OFF. (4)

PREPLANNED CONTINGENCY PROCEDURE:

(4) For a single GPS Bypass ON, notify Navaids Engineering of loss of communication with the GPS receiver. If loss of the GPS receiver does not violate CT-11, then LCC violation cleared, continue countdown.

NOTES:

(5) Violation will result in fault summary message.
FF1(2,3): BCE String 1(2,3) GPS.

REDLINE DERIVATION: CRITICALITY: 1R

(6) a. SSID Intent Summary - The intent of this LCC is to ensure navigational data provided by the GPS receivers are available to the PASS GNC flight software for determination of vehicle state vector and for display to the crew. Dual fault tolerance is required for updating the entry navigation state for EOM, and single fault tolerance is required for intact abort.

b. Voting Logic - N/A

c. Minimum and/or Maximum Redline Development - The minimum redline value of OFF ensures the GPC is successfully acquiring data from the associated GPS receiver. An ON in place of an OFF indicates that PASS has bypassed the associated GPS receiver, rendering its data unavailable for navigation calculations and display to the crew. There is no maximum redline value.

d. Time Period - A GPS bypass is possible at any time following initiation of GPS I/O. Therefore, the starting effectivity was chosen to coincide with GPS activation (approximately T-4 hours). An ending effectivity of T-31 seconds provides consistency with the GPS functional SSID

REDLINE DERIVATION: (Continued)

(reference CT-11), which protects dual fault tolerance for determination of EOM entry navigation state until the system is committed for launch.

e. Requirements - Availability of GPS data for use by PASS GNC software in determining Nav state and for display to the crew requires the GPS receivers to be functional, and the data paths to the GPC to be valid. The GPS functional requirements are addressed in SSID CT-11. The requirements in this SSID are intended to provide consistency with CT-11. This SSID is applicable only for vehicles with three string GPS installed.

   Three string GPS equipped orbiters have three GPS receivers onboard, channelized to MDMs FF1, FF2, and FF3. Loss of more than one GPS receiver is a redline violation. Loss of only one of three GPS receivers requires evaluation via the Preplanned Contingency Procedure to determine if a backup source of entry navigation data is available.

f. Preplanned Contingency Procedure - A Preplanned Contingency Procedure is available to allow the Navaids systems engineer to evaluate loss of a single GPS receiver data path per the criteria contained in functional SSID CT-11. CT-11 specifies that loss of one of three GPS receivers is acceptable if high-speed C-Band Radar can be utilized as a backup.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Loss of two-fault tolerance for updating Criticality 1 entry navigation state for EOM.
(8) Loss of single fault tolerance for updating Criticality 1 entry navigation state for intact abort.
(9) Reference Orbiter Hazard Report ORBI 211.

CAUSES OF EXCEEDING REDLINE:

(10) GPS receiver anomaly.
(11) MDM SIO card anomaly.
(12) Copper path anomaly in MDM to GPS receiver data bus.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: DPS

LCC VIOLATION CALL: PASS GPC Downlist Loss | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
SGPCAREA1	GPC FEP Area 1 Status	(2,3)	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to SRB Ignition (T-0).

REQUIREMENTS: FIGURES/TABLES: 31-29.1

(2) Not applicable if SSID LPS-18 is violated.
(3) No unexplained loss of PASS downlist. (4)

PREPLANNED CONTINGENCY PROCEDURE:

(4) Reference Figure 31-29.1 Flow Diagram for a Preplanned Contingency Procedure to evaluate PASS GPC downlist loss.

NOTES:

(5) Momentary dropouts of SGPCAREA1 are expected during certain events, such as OPS transition, downlink/downlist format changes, PCMMU switching, and GPC downlist memory dumps.
(6) The following PCMMU BITE bits may also be annunciated in conjunction with the loss of downlist (reference SSID INS-01):
- Bit 10 - Input Data Valid
- Bit 14 - No Response Computer Bus

REDLINE DERIVATION: CRITICALITY: 1S

(7) a. SSID Intent Summary

The intent of this SSID is to ensure PASS GPC downlist is valid through launch. It is primarily concerned with the integrity of the PASS GPC to PCMMU interface. Integrity of the PCMMU telemetry output and GPC Front End Processor (FEP) telemetry processing are covered by other SSIDs (INS-01, LPS-18).

PASS GPC downlist is required for the ground to maintain insight into the state of the vehicle, including detecting vehicle fault conditions and LCC violations, synchronizing onboard and ground countdown sequences, safing the vehicle in event of abort or scrub, and detecting and responding to emergency conditions. Loss of PASS downlist will impact the ground's ability to perform these vital functions.

Failure of a GPC/PCMMU data path may also affect the ability of the PASS GPC to acquire PCMMU data via RAM reads, and to perform Telemetry Format Loads, while in G9 or SM OPS. This may impact on-orbit capabilities for assignment of the SM GPC, or for reassignment of the BFS to a PASS GPC

REDLINE DERIVATION: (Continued)

slot in event of a BFS GPC failure. It may also affect post landing crew procedures for G9 operations. These issues can be worked around by selecting an alternate GPC for these functions.

PASS downlist fault tolerance is provided by four separate Redundant Set (RS) GPCs, and two PCMMUs. Each GPC has a dedicated Instrumentation/PCM (IP) bus to the PCMMUs; therefore, loss of a single GPC output circuit, IP bus, or PCMMU input circuit would not affect the ability of the remaining GPCs to send downlist telemetry or acquire PCMMU data. Only one PCMMU at a time may be active, and each GPC's IP bus is shared by the two PCMMUs. Loss of multiple GPC to PCMMU interfaces would most likely be a result of an internal PCMMU failure.

During a nominal count, a single PASS redundant set GPC, known as the "Prime" GPC, transmits PASS downlist data to PCMMU toggle buffer 1, which is then inserted into the GPC Area 1 window of the composite downlink. The remaining three RS GPCs continue to transmit downlist data to the PCMMU on their dedicated IP buses, but will use invalid PCMMU and toggle buffer addresses. Any of the PASS GPCs can be assigned the Prime downlist function via ITEM 44 on the GPC Memory Spec. The default assignment during countdown is GPC 1.

Downlist writes to the PCMMU are output only, and PASS GPCs do not acquire data from the PCMMU while in GNC flight OPS. Also, redundant set GPCs do not monitor PCMMU transactions originating from other GPCs. Therefore, loss of a single GPC's output, or the corresponding PCMMU input, would not be detected by the redundant set.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development

Redline criteria is intended to ensure PASS downlist data remains valid and accessible to the end users. The minimum value of 'ON' indicates the GPC FEP is successfully receiving and decommutating Area 1 downlist data. A change in the SGPCAREA1 discrete from ON to OFF indicates the GPC FEP is unable to lock up on PASS Area 1 downlist. This will result in the FEP terminating updates of PASS downlist data and LPS no longer having visibility into PASS downlisted MSIDs.

There is no maximum redline criteria.

d. Time Period

PASS GPC downlist is required beginning with the Start of ET Cryo Tanking (T-6 Hrs) down to T-0 in order to provide end users with PASS downlist measurement processing for critical MSIDs that have Launch Commit Criteria and/or OMRSD requirements effective between T-6 Hr and T-0. It is also required to properly synchronize the ground and onboard countdown sequences, perform post scrub/abort safing, and detect and respond to potential hazards and emergency conditions.

REDLINE DERIVATION: (Continued)

e. Requirements

e1. Reference Measurement Description Table

SGPCAREA1, GPC FEP Area 1 Status, is an LPS System Integrity Pseudo that provides a discrete indication of the validity of Area 1 (PASS) downlist. If the GPC FEP is successfully receiving and processing Area 1 downlist data, the state will be set to 'ON'. If Area 1 downlist data is either not being received, or not being processed, the state will be set to 'OFF'.

e2. Reference Requirement (2)

SSID LPS-18 covers the status of the GPC FEP. During countdown, the GPC FEP processes downlist from PASS in Area 1, and BFS in Area 2. Loss of the entire FEP would result in loss of both PASS and BFS downlists. This would not signify a problem with the PASS GPC to PCMMU interface this SSID is intended to protect. Instead, it would indicate either a problem with the FEP itself, or a problem with the PCMMU or LPS data paths common to both PASS and BFS downlists.

e3. Reference Requirement (3)

Certain operations that interrupt the normal telemetry stream, such as OPS transition, downlink/downlist format changes, PCMMU switching, and GPC downlist memory dumps, may cause momentary dropouts of SGPCAREA1. Occurrence of a downlist dropout due to any of these explainable causes does not constitute a redline violation since they are not the result of a hardware or software anomaly.

f. Preplanned Contingency Procedure

A Preplanned Contingency Procedure is provided via a flow diagram to evaluate a loss of downlist condition.

Since PASS downlist data is used by the LOX/LH2 ground software for control of ET pressurization, a loss of downlist after the start of ET pressurization presents a risk of excessively pressurizing the tank to the point of relief valve operation before valid downlist can be restored. Therefore, the requirement to perform immediate GLS safing for a loss of downlist after T-2M55S is imposed to ensure the pressurization process is terminated.

If BFS downlist is also affected, the problem does not lie with the PASS PCMMU I/F, but with the PCMMU, GPC FEP, or a data path common to both PASS and BFS downlists. In this case, the problem should be addressed by the applicable INS-01 or LPS-18 SSIDs.

If the problem is isolated to a single PASS GPC to PCMMU interface, system redundancy will be utilized to work around the problem and

REDLINE DERIVATION: (Continued)

restore the downlist function. This is accomplished by switching the Prime downlist GPC via ITEM 44 on the GPC Memory Specialist Function.

To maintain sufficient fault tolerance, the loss of only a single PASS GPC-PCMMU I/F is acceptable. Therefore, the PCP includes the requirement to ensure an alternate PASS GPC I/F has not previously been selected to work around another failure.

If the above conditions are met, and downlist is successfully restored by switching to an alternate GPC, the problem is isolated to a single GPC to PCMMU interface (GPC MIA transmitter, IP bus, or PCMMU MIA receiver). The failed telemetry path has been removed from the active loop by selection of an alternate Prime downlist GPC. Since there are three functional PASS GPC-PCMMU interfaces remaining, sufficient redundancy remains to safely fly the vehicle and complete the mission. The lost GPC-PCMMU I/F can be worked around on orbit by substituting an alternate GPC for the GNC or SM configurations, if required. Therefore, countdown may be resumed.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Loss of capability for the ground to monitor PASS downlist data from the vehicle, which may affect any/all of the following:

- Capability to detect and respond to LCC violations
- Capability to synchronize onboard and ground countdown sequences
- Capability to safe the vehicle in event of launch scrub/abort
- Capability to detect and respond to potentially safety critical emergency conditions
- Capability for reassignment of the BFS to the affected PASS GPC slot in event of a BFS GPC failure in flight

CAUSES OF EXCEEDING REDLINE:

(9) Hardware anomaly in Bus Control Element (BCE) 24 of downlisting GPC.
(10) Instrumentation/PCM (IP) data bus anomaly.
(11) PCMMU hardware anomaly.
(12) PASS software anomaly.
(13) GPC FEP anomaly.
(14) LPS data path anomaly.
(15) BFS Engage.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Launch and Landing SUBSYSTEM: DPS

SUPPORTING DATA:

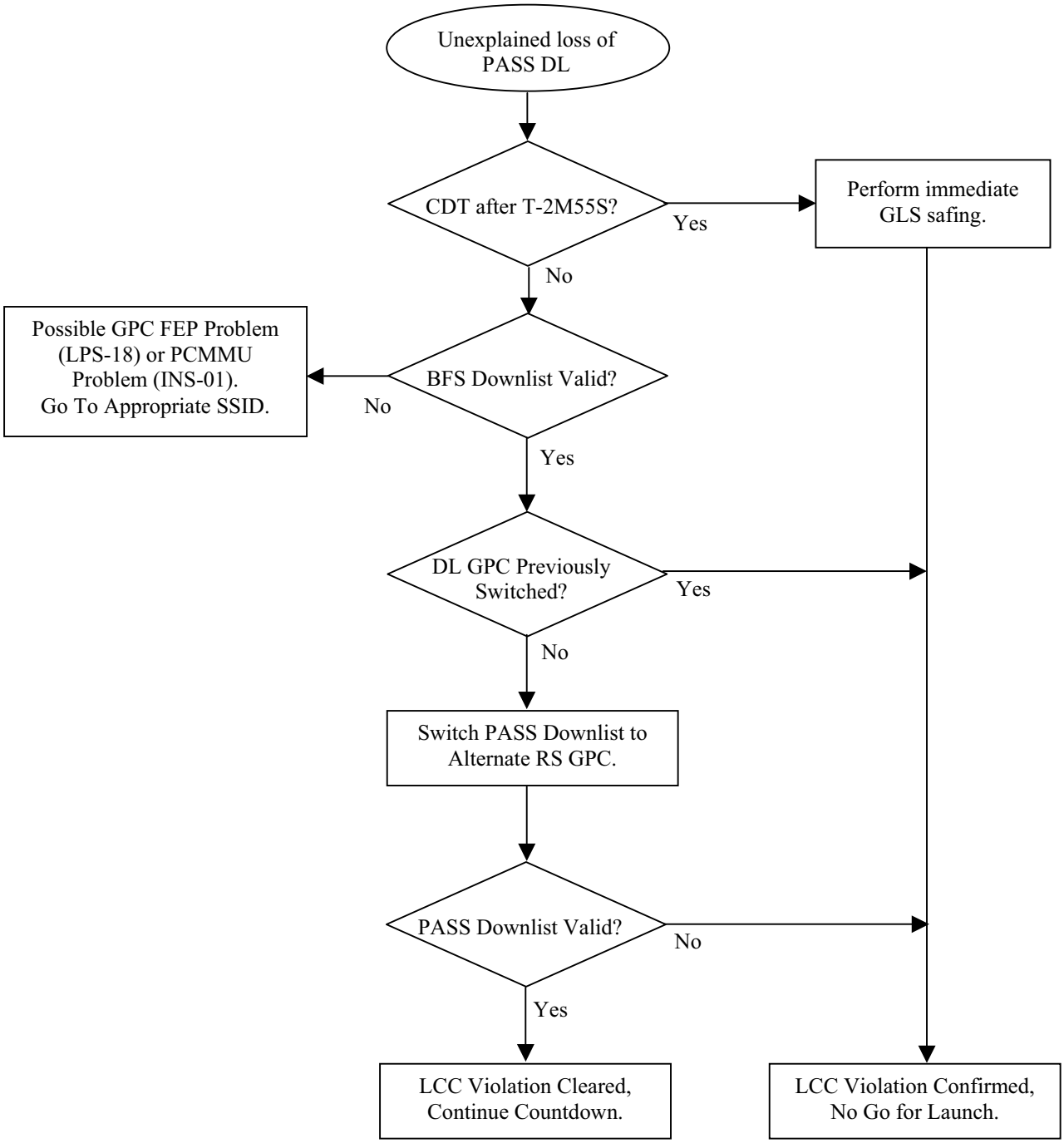

Figure 31-29.1 Flow Diagram for PASS GPC Downlist Loss

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SECTION 32

COMMUNICATIONS AND TRACKING

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SECTION 32: COMMUNICATIONS AND TRACKING

SSID No.	Description/Violation Call	Page
CT-01	Loss of TACAN Indication	32-01.1
CT-02	S-Band PM Transponder AGC Anomaly	32-02.1
CT-03	GCIL Active Anomaly	32-03.1
CT-04	Loss of Network Signal Processor Frame Sync Lock	32-04.1
CT-05	Voice Communication System Anomaly	32-05.1
CT-06	Improper TACAN Blanking Pulse (REQUIREMENT DELETED)	32-06.1
CT-07	TACAN Range/Bearing Operation Anomaly	32-07.1
CT-08	Radar Altimeter Ready Anomaly	32-08.1
CT-09	S-Band Phase Modulated Power Amplifier Anomaly	32-09.1
CT-10	Crew Communication System Anomaly	32-10.1
CT-11	Loss of GPS Indication for Three String GPS Vehicles	32-11.1

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LCC VIOLATION CALL: Loss of TACAN Indication | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	TACAN No 1	(4)				
V74X0071X	TACAN No 1 Power Status	(1,5)	ON	NA	Event	CI
V74J1552B	TACAN 1 Range Status WD1B00-01	(2)	(6)	NA	DEC	CI
V74H1534B	TACAN 1 Bearing/Status WD1B01-02	(2)	(6)	NA	DEC	CI
V74X1558B	TAC 1 RNG BLT-IN TST STATUS WD2B04	(1,7)	OFF	NA	Event	CI
V74X1560B	TAC 1 RNG SUPR PULS PRESENT WD2B07	(1,8)	ON	NA	Event	CI
	TACAN No 2	(4)				
V74X0081X	TACAN No 2 Power Status	(1,5)	ON	NA	Event	CI
V74J1652B	TACAN 2 Range Status WD1B00-01	(2)	(6)	NA	DEC	CI
V74H1634B	TACAN 2 Bearing/Status WD1B01-02	(2)	(6)	NA	DEC	CI
V74X1658B	TAC 2 RNG BLT-IN TST STATUS WD2B04	(1,7)	OFF	NA	Event	CI
V74X1660B	TAC 2 RNG SUPR PULS PRESENT WD2B07	(1,8)	ON	NA	Event	CI
	TACAN No 3	(4)				
V74X0091X	TACAN No 3 Power Status	(1,5)	ON	NA	Event	CI
V74J1752B	TACAN 3 Range Status WD1B00-01	(2)	(6)	NA	DEC	CI
V74H1734B	TACAN 3 Bearing/Status WD1B01-02	(2)	(6)	NA	DEC	CI
V74X1758B	TAC 3 RNG BLT-IN TST STATUS WD2B04	(1,7)	OFF	NA	Event	CI
V74X1760B	TAC 3 RNG SUPR PULS PRESENT WD2B07	(1,8)	ON	NA	Event	CI
	GPS 2	(4)				
V74X1922B	GPS2 Data Valid	(2)	ON	NA	Event	BU
V74X1463B	GPS2 RPU Fail	(1)	OFF	NA	Event	BU

TIME PERIOD:

(1) From TACAN Activation (T-3 hours) to Go For RSLS Start (T-31 seconds)
(2) From TACAN Activation (T-3 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES: 32-01

(3) This SSID is effective only for TACAN equipped vehicles.
(4) 3 of 3 TACANs are required to be operational for launch, except as noted below.
    a) A TACAN is operational if all 5 monitored measurements meet minimum criteria and the MDM TACAN/RA Bypass is OFF (ref DPS-17). (5,6,7,8)
    b) Exceptions for one failed TACAN:
        - For loss of TACAN 2 on OV-104, GPS 2 is an acceptable Backup if both GPS monitored measurements meet minimum criteria (ref. CT-11).
          * OR *
        - If High Speed C-Band Radar tracking is scheduled for EOM, it is an acceptable Backup for loss of any single TACAN. Availability can be confirmed by the KSC NASA Test Director (NTD) via the Mission Control Center (MCC) - Houston Flight Director.
    c) For any two TACAN failures, LCC violation confirmed, No Go for launch.

REQUIREMENTS: (Continued)

(5) The Power Status ON indication is required for an operational TACAN unless confirmed as instrumentation failure. (9)
(6) Valid Range and Bearing Status is required for an operational TACAN. (10)
    a) 0 = Range valid.
    b) 0 or 3 = Bearing valid; any other combination indicates invalid data.
(7) A Range Built-In Test Status indicating no BITE failures is required for an operational TACAN.
    a) OFF = no BITE failures.
    b) ON = indicates BITE failures.
(8) Range Suppression detection is required for an operational TACAN when any TACAN is in T/R (transmit/receive) mode. (11)
    a) ON = suppression pulses detected (minimum requirement).
    b) OFF = failure condition.

PREPLANNED CONTINGENCY PROCEDURE:

(9) For Power Status (V74X00n1X) OFF: (ref: S0007.500 Preplanned Contingency Procedures)
    a) Perform an LDB read of the associated Power Status measurement. If the output from the GPC indicates ON, TACAN is operational, instrumentation failure confirmed; LCC violation cleared, continue countdown.
    b) If GPC output indicates OFF, cycle the mode switch and/or power circuit breaker for the affected TACAN. If Power Status ON indication is recovered, TACAN is operational; LCC violation cleared, continue countdown.
(10) Range Status (V74J1n52B) or Bearing Status (V74H1n34B) not valid: (ref: S0007.500 Preplanned Contingency Procedures)
    a) All available TACANs with invalid Range and Bearing Status is an indication of a ground station failure (refer to the S0007.500 Ground Station Failure preplanned Contingency Procedure). If the TACAN ground station is restored or if an alternate TACAN ground station is selected and TACANs are locked in range and bearing (Alternate TACAN ground station lock-on from the Pad can be marginal and therefore the Range and Bearing may not be solid, which is acceptable) then LCC violation cleared, continue countdown.
    b) For one or more TACANs with invalid Range or Bearing Status and multipath behavior confirmed or nominal self test, affected TACAN(s) are operational. LCC violation cleared, continue countdown.
    c) For TACANs with degraded Range and Bearing Status on an X-mode station, if any TACAN is transmitting continuous suppression, the TACAN is not operational. Power off the affected TACAN. A Backup Navaid must be substituted to continue countdown (reference (4)b). If backup is available, LCC violation cleared, continue countdown.
(11) Range Suppression Pulse Present (V74X1n60B) OFF: (ref: S0007.500 Preplanned Contingency Procedures) Isolate the TACAN with a suppression pulse problem.
    a) If a TACAN is not detecting suppression pulses which are present, the TACAN is not operational but should be left in T/R (transmit/receive) mode.
    b) If any TACAN is not transmitting suppression pulses, the TACAN is not operational. Place the offending TACAN in RCV (receive-only) mode.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

c) If a TACAN is transmitting continuous suppression, the TACAN is not operational. Power off the offending TACAN.

For a non-operational TACAN, a Backup Navaid must be substituted to continue countdown (reference (4)b). If a backup is available, LCC violation cleared, continue countdown.

NOTES:

(12) The Navaid Requirements Flight Rule A3-201 for TACAN details ground transponder redundancy requirements.

(13) Multipath behavior may exhibit any of the following symptoms:
a) Abnormal AGC voltage variations.
b) Poor bearing lock or loss of bearing lock with range locked.
c) Multiple or sustained 40-degree bearing errors.
d) Bearing lock quality affected by switching antennas or ground stations.
e) Range locked, but abnormal variations in range data.
f) Poor range lock with abnormal variations in range data.

(14) A Range Suppression Pulse Present OFF indication is nominal for TACANs when all TACANs are in RCV (receive-only) mode.

(15) Loss of TACAN suppression will have no effect if on Y-mode station.

(16) For OV-103 the use of GPS 2 to replace TACAN 2 (with no EOM C-Band tracking scheduled) does not provide two-fault tolerance for safe entry because the loss of Main Bus C will result in the loss of both GPS 2 and TACAN 3.

REDLINE DERIVATION: CRITICALITY: 1R

(17) a. SSID Intent Summary - On TACAN equipped vehicles, the TACAN system is the primary navigational tool to provide the onboard navigation state vector update for reentry. There are three TACAN transceivers which interact with TACAN ground station signals to determine range and bearing to the TACAN ground station. There is also a GPS receiver which senses satellite ranging signals to determine position and velocity. This navigational data is provided to the Flight Control System (FCS) via the GPCs and the flight critical MDMs. This requirement assures two-fault tolerance at liftoff for updating the entry navigation state (via TACAN, GPS, or command delta-state (MCC)) on EOM, and single-fault tolerance for any intact abort entry. The TACAN Range Status, Bearing Status, Range Built-In Test Status and Range suppression Pulse Present flags are all monitored to assure TACANs are transmitting, receiving and decoding TACAN ground station signals, and to assure the onboard TACAN equipment is healthy. The GPS Data Valid flag and GPS RPU Fail flag are monitored to assure GPS 2 is an acceptable Backup for TACAN 2 on OV-104 only. High speed C-band radar tracking is the source for Command delta-state (MCC) updates, which can be used to provide fault tolerance for entry navigation if not all TACANs are available. Three of three TACANs are required in the event EOM C-Band tracking is unavailable.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - Power Status indicates TACAN power is applied. GPC software requires Power Status indication ON to

REDLINE DERIVATION: (Continued)

enable processing of TACAN data. Loss of TACAN power does not result in an element bypass. Valid Range and Bearing Status indicates a TACAN is locked to a ground station and provides an end-to-end verification of the TACANs transceiver circuitry. Multipath behavior affects these indications. Multipath is a complex phenomenon requiring expert engineering evaluation of available data to confirm, therefore these indications should not be automated. The presence of multipath does not affect self-test performance. TACANs provide a downlinked indication of Range Built-in BITE Status. BITE circuitry monitors necessary functions which may fail without immediately affecting Range or Bearing Status. A TACAN with failed-on (continuous) suppression is not operational and must be powered off or placed in Receive-only mode in order to restore full functionality to the remaining TACANs. TACANs provide a downlinked indication that range suppression pulses are being detected. Suppression prevents a TACAN's receiver from being saturated when another TACAN transmits. A TACAN which is not detecting suppression pulses is left in T/R (transmit/receive) mode to retain Y-mode capability, but will lose X-mode capability. A TACAN which is not transmitting suppression pulses is placed in RCV (receive-only) mode to prevent saturation of the other TACAN receivers. The GPS Data Valid and the GPS RPU Fail measurements are the primary means of determining the operational integrity of the GPS receiver. The GPS Data Valid flag ON indicates valid navigation data is being provided while a RPU Fail flag ON indicates a failure with the GPS receiver which renders data output unreliable.

d. Time Period - The starting time period effectivity for this SSID is approximately T-3 hours. All TACAN and GPS equipment will have been configured and should be operational at this point. The TACAN Range and Bearing Status flags and the GPS Data Valid flag will be monitored until T-9 minutes since the TACAN and GPS systems are functionally stable at this point. A failure not attributed to momentary data dropouts after this point is considered unlikely and is an acceptable risk. However, the TACAN Power Status, TACAN Range Built-In Test Status, TACAN Range suppression Pulse Present, and GPS RPU Fail flag will be monitored until T-31 seconds because the TACAN and GPS are criticality 1R entry navigation systems. A failure of these measurements after T-31 seconds is considered an acceptable risk.

e. Requirements - Two of three TACANs are required in the event EOM C-Band Tracking is scheduled. This ensures two-fault tolerance at liftoff for updating the entry navigation state by TACAN or by high speed C-Band Radar tracking on EOM, and single-fault tolerance at liftoff for any intact abort entry. If high speed C-Band Radar tracking is scheduled for EOM then it is an acceptable backup for the loss of any single TACAN because command delta-state (MCC) can be used to provide fault tolerance for entry navigation if not all TACANs are available. For TACAN 2 on OV-104 only, GPS 2 is an acceptable Backup if both GPS monitored measurements meet minimum criteria. Three of three TACANs are required in the event EOM C-Band Tracking is unavailable. This ensures two-fault tolerance at liftoff for updating the entry navigation state by TACAN on

REDLINE DERIVATION: (Continued)

EOM, and single-fault tolerance for any intact abort entry. TACAN Power Status indicates TACAN power is applied. GPC software requires Power Status indication ON to enable processing of TACAN data. Loss of TACAN power does not result in an element bypass. A TACAN with failed-on (continuous) suppression is not operational and must be powered off in order to restore full functionality to the remaining TACANs. Valid Range and Bearing Status indicates a TACAN is locked to a ground station and provides an end-to-end verification of the TACANs transceiver circuitry. Multipath behavior affects these indications. Multipath is a complex phenomenon requiring expert engineering evaluation of available data to confirm, therefore these indications should not be automated. The presence of multipath does not affect self-test performance. TACANs provide a downlinked indication of Range Built-in BITE Status. BITE circuitry monitors necessary functions which may fail without immediately affecting Range or Bearing Status. TACANs provide a downlinked indication that range suppression pulses are being detected. Suppression prevents a TACANs receiver from being saturated when another TACAN transmits. A TACAN which is not detecting suppression pulses is left in T/R (transmit/receive) mode to retain Y-mode capability, but will lose X-mode capability. A TACAN which is not transmitting suppression pulses is placed in RCV (receive-only) mode to prevent saturation of the other TACAN receivers. The GPS Data Valid flag is an indication that sufficient signals are being received from the GPS satellite network. The GPS RPU Fail flag is a means of determining the health of the Receiver Processing Unit (RPU).

f. Pre-planned Contingency Procedures - The LDB read procedure for TACAN Power Status OFF will determine if the GPC can read TACAN Power Status. GPC software requires Power Status indication ON to enable processing of TACAN data. The procedure for TACAN Range Status and Bearing Status NOT VALID will determine if the TACAN ground station signal is degraded (either by the presence of multipath or by a ground station related problem), or if a TACAN is transmitting continuous suppression. Multipath or a ground station problem is not a violation. Continuous suppression will degrade signal reception of all three on board TACANs. The affected TACAN is considered failed and must be placed in Receive-only mode or powered OFF. The procedure for TACAN Range Suppression Pulse Present OFF will isolate the TACAN with a suppression pulse problem. A TACAN not detecting suppression pulses may still be able to function and may be left ON but is not operational. A TACAN not transmitting suppression pulses must be placed in Receive-only mode to prevent saturation of the other TACAN receivers. This TACAN can still provide valid bearing data.

CONSEQUENCES OF EXCEEDING REDLINE:

(18) Loss of two-fault tolerance at liftoff for updating the entry navigation state for EOM, and loss of single-fault tolerance for intact abort. For the exceptions, if TACAN 2 is failed but GPS is available, then the system can still sustain any two independent failures after liftoff and maintain the ability to update entry navigation state allowing for a safe landing.

CONSEQUENCES OF EXCEEDING REDLINE: (Continued)

The same is true for any single TACAN failure if EOM C-Band radar tracking is available and scheduled. In this case, the radar provides the required data to support a ground commanded delta state in the event that the other two TACAN's suffer independent failures in-flight. For any intact abort, the system can still sustain the required single failure after the abort and result in a safe landing.

(19) GPC detection of Power Status OFF inhibits processing of data from the affected TACAN. Loss of TACAN power does not result in an element bypass.

(20) Failure to transmit suppression pulses while transmitting an RF signal may result in delayed lock or loss of lock in all TACANs.

(21) Failed-on (continuous) suppression causes degraded performance with X-mode stations on all remaining TACANs.

(22) Reference Orbiter Hazard Report ORBI 211.

CAUSES OF EXCEEDING REDLINE:

(23) Power Status OFF:
 a) TACAN voltage supply below 24 volts.

(24) Range Status or Bearing Status not valid:
 a) Range or bearing computer not operating properly.
 b) Loss of TACAN ground station.
 c) Failed on (continuous) suppression.

(25) TACAN Range Built-in Test Status ON:
 a) Circuit failures (see Table 32-01 for functions monitored with BITE).

(26) TACAN Suppression Pulse Present OFF:
 a) An open or short on TACAN blanking lines.
 b) TACAN suppression circuit failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 9.2	SHEET 1	ZONE A-H,1-8
	DWG NO 9.18	SHEET 1	ZONE A-D,1-8
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-974099	SHEET 15-17.1	ZONE
	DWG NO VS70-974099	SHEET 19-24.1	ZONE

ELEMENT: Orbiter SUBSYSTEM: C & T

SUPPORTING DATA:

Table 32-01 Functions Monitored During TACAN Self Test

	Periodic	Continuous	Power Up
CPU	X		X
RAM	X		X
ROM (Checksum)	X		X
ROM (CRC)			X
2 Port RAM	X		X
2 Port Data		X	
NOV RAM	X		X
Synthesizer	X	X	X
Receiver	X		X
Power Supply	X	X	X
Xmit Power		X	
Audio			X
MDM			X

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LCC VIOLATION CALL: S-Band PM Transponder AGC Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V74E4080A	S-Bd PM Xpndr 1 AGC Sig Strength		+60	NA	cnts	CI
V74E4081A	S-Bd PM Xpndr 2 AGC Sig Strength		+60	NA	cnts	CI

TIME PERIOD:

(1) From S-Band transponder to high power (Approx T-45 minutes) until Go for GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) 2 of 2 transponders and 2 of 2 preamps are functionally required. Only one transponder and one preamp are powered at a time. Both are verified operational at comm activation.
(3) For a confirmed instrumentation failure, LCC violation cleared, continue countdown. (4)

PREPLANNED CONTINGENCY PROCEDURE:

(4) If the measurement is out of limits and determined by use of the OPF monitor to be an Orbiter problem, use this procedure as a backup to the AGC measurements:

A. For total signal level loss of AGC parameter (a reading of 0 +/- 3 cnts on the LCC screen). Procedure time is approximately 4 minutes.
   1. Check NSP Frame Sync LCC - if not OK, LCC violation confirmed, No Go for launch.
   2. If OK, perform two-way voice check.
   3. If OK, LCC violation cleared, continue countdown; if not OK, LCC violation confirmed, No Go for launch.

B. For a partial signal strength level loss of AGC parameter (a reading outside the redline limits but not 0 +/- 3 cnts). Procedure time to select each transponder and perform a threshold comparison is approximately 10 minutes and is documented in S0007 Volume 5.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(5) Actual values were derived from KSC "open loop" testing with MILA/Launch Pad. Based on KSC general calibration curve in a region where the transponder is not in saturation. This value is considered a worst case value for all vehicles and is designed to find gross failure. (Loss of greater than 30 dB.)

REDLINE DERIVATION: (Continued)

(6) 2 transponders and 2 preamps allow single-fault tolerance for command, tracking, and voice during all mission phases.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Min: On uplink from STDN or TDRS, insufficient signal strength to lock on carrier. Loss of command, S-band tracking and S-band voice.

CAUSES OF EXCEEDING REDLINE:

(8) Transponder failure.
(9) Power 28 Vdc failure.
(10) Ground station radiated power too low.
(11) Preamp failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 16.2	SHEET 1 of 3	ZONE 5-K
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: C&T

LCC VIOLATION CALL: GCIL Active Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V74X5052E	GCIL Active		ON	NA	Event	CI

TIME PERIOD:

(1) From PM High Power (Approximately T-45 minutes) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) If change of state, see Preplanned Contingency Procedure (3).

PREPLANNED CONTINGENCY PROCEDURE:

(3) Suggested procedure to be used as a backup to the GCIL active measurement.

A. 1. If change of state and S-Band in string 2 - send GCIL active CMD. If "Go", LCC violation cleared, continue countdown. If "No-Go", send "Checkout" CMDS*. If "Go", then LCC violation cleared, continue countdown. (Procedure time approximately 4 minutes.)

2. Loss of 1 of 2 GCIL power supplies and/or 1 of 2 GCIL decoders is acceptable for launch.

B. If change of state and S-Band String 1 -

1. Go to backup procedure** (procedure time approximately 15 minutes).
2. Loss of 1 of 2 GCIL power supplies and/or 1 of 2 GCIL decoders is acceptable for launch.

*"Checkout" CMDS

1a. Decoder 1 - "Preamp Heaters Off" If "Go", go to step 2a
1b. If "No-Go" Decoder 2 - "Preamp Heater Off" If "No-Go", LCC violation confirmed, No Go for launch.
2a. Decoder 2 - "Preamp Heaters On" If "Go", LCC violation cleared, continue countdown.
2b. If "No-Go" Decoder 1 - "Preamp Heaters On "No-Go", LCC violation confirmed, No Go for launch. (intermittent commanding)

**Backup Procedure

1. MILA reacquire
2. Send "checkout" commands
3a. If "No-Go, LCC violation confirmed, No Go for launch.
3b. If "Go", reconfigure to String 2 via commands, LCC violation cleared, continue countdown.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(4) GCIL is required for comm switching capability during ascent because of the crews inability to reach the switch.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Commanded S-Band comm system will revert to panel switch configuration (string 1).
(6) Loss of uplink command capability to reconfigure S-Band communication system.

CAUSES OF EXCEEDING REDLINE:

(7) Power failure.
(8) Circuit breakers not closed.
(9) Instrumentation failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET 74DY	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: C&T

LCC VIOLATION CALL: Loss of Network Signal Processor Frame Sync Lock | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V74X5176E	NSP Frame Sync Lock 1	(2)	ON (3)	NA	Event	CI(4
V74X5177E	NSP Frame Sync Lock 2	(2)	ON (3)	NA	Event	CI(4

TIME PERIOD:

(1) From S-Band-PM to High Power (Approx T-45 minutes) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 2 of 2 network signal processors (NSPs) functionally required at lift-off. Selected NSP frame sync lock is mandatory; other will be off. NSP 1 verified operational at comm activation.
(3) Failure shall be defined as an OFF state for 3 or more consecutive samples, LCC violation confirmed, No Go for launch.
A momentary OFF for less than 3 samples due to RF multipath or atmospheric conditions shall not be a LCC violation.

PREPLANNED CONTINGENCY PROCEDURE:

(4) Backup procedure for NSP frame sync lock indication.
A. If change in state (not attributable to MILA), check for two-way S-Band voice, and ground downlink RF telemetry. If "OK", LCC violation cleared, continue countdown. (procedure time is 30 seconds).
B. If NSP frame sync lock loss due to confirmed comsec failure, for NASA mission, enter Orbiter, configure for encryption bypass "BYPASS", and configure U/L for "GPC BLOCK" except when commanding.

NOTES:

(5) Downlink validation is to be done by MILA (see Section 44).
(6) The data rate is one sample per second.

REDLINE DERIVATION: CRITICALITY: 1R

(7) Provides uplink commands and voice capability.
(8) Provides downlink telemetry and voice capability.
(9) Multi-path effects due to NASCOM MDM drops, atmospheric conditions, RF propagation effects, birds, aircraft, etc., have been known to result in changes in state not exceeding 2 seconds.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Commands and voice will not be processed.

CAUSES OF EXCEEDING REDLINE:

(11) False data lock on sidebands.
(12) Improper format.
(13) NSP failure.
(14) No NSP power.
(15) Insufficient RF power to subsystem.
(16) No bit sync.
(17) Too many errors in data uplink.
(18) Ground station problems, MCC problems.
(19) Comsec problem (when encrypted).

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 16.3	SHEET 1 of 2	ZONE A-7
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: C&T

LCC VIOLATION CALL: Voice Communication System Anomaly | EMERG COND: Yellow (14)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	S-Bd A/G1 Voice	1 of	(2)	NA	NA	CI
NA	S-Bd A/G2 Voice	2	(2)	NA	NA	CI
NA	UHF A/A Voice	(4)	(3)	NA	NA	CI
NA	UHF A/G2 Voice	(4)	(3)	NA	NA	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) To Go for APU Start (T-5 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) Must be functional.
(3) Must be functional. (5)
(4) Mission dependent:
    A. 1 of 2 for missions with Space to Space Orbiter Radio (SSOR) not installed.
    B. 1 of 1 for UHF A/A voice for missions with SSOR installed. UHF A/G2 not applicable.

PREPLANNED CONTINGENCY PROCEDURE:

(5) Mission dependent:
    A. For missions with SSOR not installed use following procedure. Select UHF alternate frequency on panel O6 (S7). Perform voice check. If unsuccessful, select UHF to A/G2 on panel A1R (S32). Perform voice check. Orbiter access required to reach switch. (Crew cannot reach switch.) If successful, LCC violation cleared, continue countdown. If unsuccessful, LCC violation confirmed, No Go for launch.
    B. For missions with SSOR installed, use following procedure. Select UHF alternate frequency on panel O6 (S7). Perform UHF A/A voice check. If successful, LCC violation cleared, continue countdown. If unsuccessful, LCC violation confirmed, No Go for launch.
(6) Crew will attempt to establish voice contact as defined by procedures in the Crew Flight Checklist. If voice contact is restored when ACCU 1 (S6) is switched to ACCU 2, it can be assumed that ACCU 1 has failed, LCC violation confirmed, No Go for launch. If either A/G1 or A/G2 is available in both NSPs, LCC violation cleared, continue countdown.

NOTES:

(7) No specific measurements exist that monitor the ACCU voice channel. ACCU 1 is selected for launch. ACCU 2 if OFF; it is last verified operational at comm activation.
(8) An "ON" indication for measurement V92X6096XX NSP Status may indicate a S-Bd voice failure.

NOTES: (Continued)

(9) S-Bd A/G2 is only available when the Network Signal Processor is configured to high data rate. Use of low data rate mode will prevent the use of S-Bd A/G2 to satisfy this LCC.

REDLINE DERIVATION: CRITICALITY: 1R

(10) Two independent communication paths mandatory for ascent (S-Bd A/G1 or S-Bd A/G2 and UHF).
(11) A/G1 or A/G2 are necessary for TDRSS operations.
(12) 2 of 2 audio center control units; 2 of 2 Network Signal Processors; and CDR, PLT, and MS2 audio terminal units (MS2 last check at T-20 minutes) are required operational on A/G (1,2) and UHF. Communication on any channel between all crew members is required for crew activity coordination.
(13) The time period for this SSID ends at T-5 minutes because there is no data or visibility to reliably verify the communication links late in the count. In addition, the Merritt Island Launch Area (MILA) and KSC Communication LCC requirements (reference SSID's: MILA-01,-02,-03 and COM-01) are discretely monitored until T-31 seconds for S-Band and UHF capability.

CONSEQUENCES OF EXCEEDING REDLINE:

(14) Total loss of voice communications including "hard line" is an Emergency Condition "YELLOW".
(15) Loss of redundant voice capabilities. Violation of Flight Rule.

CAUSES OF EXCEEDING REDLINE:

(16) Ground problem.
(17) ACCU hardware failure.
(18) S-Band hardware failure.
(19) UHF hardware failure.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 16.1 SHEET 2 of 4 ZONE 2-F
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: C&T

Improper TACAN Blanking Pulse

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TACAN Range/Bearing Operation Anomaly

(Requirement Integrated Into SSID CT-01)

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LCC VIOLATION CALL: Radar Altimeter Ready Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V74X0176X	Radar Altimeter No 1 Ready	(2)	ON	NA	Event	CI
V74X0186X	Radar Altimeter No 2 Ready	(2)	ON	NA	Event	CI

TIME PERIOD:

(1) From LRU power up (T-3 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 radar altimeters required. 2 of 2 radar altimeters required if less than 3 onboard MSBLS available.
(3) MDM TACAN/RA Bypass ON is considered as a loss of the affected RA (ref DPS-17).

PREPLANNED CONTINGENCY PROCEDURE:

(4) Evaluate RA Height Data with LDB Read, or cycle power, as applicable (Ref S0007 Vol 5). If RA Ready indication is regained or RA Height Data and LDB Data are good, then Radar Altimeter is operational; LCC violation cleared, continue countdown.

NOTES:

(5) RA by itself is single-fault tolerant only for power and comm fault failures.
(6) Considered highly desirable for night landings.
(7) Refer to Appendix H, Section 4, for minimum MSBLS requirements.

REDLINE DERIVATION: CRITICALITY: 1R

(8) Two-fault tolerance requirement for precise altitude/altitude rate data exists to ensure a safe landing. In addition to the radar altimeter, the MSBLS is an adequate source of altitude/altitude rate data.
(9) 1 of 2 mandatory requirement for launch is contingent upon successful completion of the MSBLS self test at T-30 hours.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Loss of radar altimeter READY indication (power status) would cause the software to inhibit the processing of the altimeter data. (Crew display only.)

CAUSES OF EXCEEDING REDLINE:

(11) Electronic failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: C & T

LCC VIOLATION CALL: S-Band Phase Modulated Power Amplifier Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V74E4512A	S-Band Pwr Amp RF Out 1		90		Watts	CI
V74E4512A	S-Band Pwr Amp RF Out 1			250	Cnts.	CI
V74E4513A	S-Band Pwr Amp RF Out 2		90		Watts	CI
V74E4513A	S-Band Pwr Amp RF Out 2			250	Cnts.	CI

TIME PERIOD:

(1) From S-Band PM High Power (Approx T-45 minutes) until Go for GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) 2 of 2 power amplifiers are functionally required. Only one power amplifier is "powered" at a time. PA 1 is verified operational at comm activation; PA 2 is verified operational at Command to Launch Configuration.
(3) For a confirmed instrumentation failure, LCC violation cleared, continue countdown. (4)

PREPLANNED CONTINGENCY PROCEDURE:

(4) Suggested procedure to be used to evaluate power amplifier out-of-limit:

A. Perform contingency procedure to evaluate power amplifier condition. If evaluation does not confirm failure, LCC violation cleared, continue countdown. If failure is confirmed, LCC violation confirmed, No Go for launch.

CONTINGENCY PROCEDURE:

1. Use ground station to compare output power and frequency spectra of PA 1 to PA 2. Ground station can detect power degradation >3 dB.
2. Evaluate other PA telemetry (Temperature, Reflected Power).
3. Assess trend data (rate of change to redline) against PA failure modes.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(5) The power amplifier nominal power out is 120 to 130 watts. The power amplifier specification is 100 watts minimum; telemetry accuracy is +/- 10 percent. A degradation of 3 dB is the minimum detectable delta at a ground station in open loop operation (antenna to antenna). Therefore, there is limited capability to verify degradation below the spec. There are known power amp anomalies which can cause the output power measurement to read

REDLINE DERIVATION: (Continued)

off-scale high. The use of counts for the maximum limit permits a generic value to be used for all power amps.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Min. A. Loss of downlink signal lock at ground stations and at the TDRS ground station (TDRS and STDN Hi).
B. Loss of downlink S-Band telemetry, S-Band Tracking and voice.

CAUSES OF EXCEEDING REDLINE:

(7) Power amplifier failure.
(8) Power 28 Vdc failure.
(9) Transponder power out degradation.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 16.2-2 SHEET 2 of 3 ZONE 7B
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: C&T

LCC VIOLATION CALL: Crew Communication System Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	Crew Worn Communication Equipment		(2)	NA	NA	CI
NA	ACCU 1	(3)	(2)	NA	NA	CI
NA	ACCU 2	(3)	(2)	NA	NA	CI
NA	ATU Commander (CDR)	4	(2)	NA	NA	CI
NA	ATU Pilot (PLT)	of	(2)	NA	NA	CI
NA	ATU Mission Specialist (MS)	4	(2)	NA	NA	CI
NA	ATU Mid Deck (MDK)		(2)	NA	NA	CI

TIME PERIOD:

(1) From Crew Module Hatch Closure (approximately T-1 hour 20 minutes) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) Two-way voice communications on any channel between all crewmembers. (4)
(3) Two of two Audio Central Control Units (ACCUs) are required to be functional. ACCU 1 is selected for launch, ACCU 2 is off and verified operational in Communication (COMM) System Activation. (4)

PREPLANNED CONTINGENCY PROCEDURE:

(4) Switch to ACCU 2 and perform COMM Checks (Reference S0007.500 "LCC Procedure - Crewmember Loss of Comm (SSID CT-10)").
   A. If ACCU 2 COMM Checks good, then ACCU 1 has failed. LCC violation confirmed, No Go for launch.
   B. If ACCU 2 COMM Checks are bad then perform Audio Terminal Unit (ATU) troubleshooting.
      1. If the COMM problem is with the Mission Specialist (MS) ATU, then switch MS ATU control to Payload Station (PS) ATU and perform COMM Checks.
         a. If PS ATU COMM Checks good, then MS ATU has failed. LCC violation confirmed, No Go for launch.
         b. If PS ATU COMM Checks bad, then check MS1/MS2 configuration, cable connections and/or swap out Headset Interface Unit (HIU)/pigtail unit with a spare.
            - If COMM Checks still bad, then MS1/MS2 crew equipment or Multiple Headset Adapter (MHA) has failed. LCC violation confirmed, No Go for launch.
            - If COMM Checks good, then return MS ATU control to normal, ACCU switch to 1 and perform COMM Checks. If COMM Checks good, LCC violation cleared, continue countdown.
      2. If the COMM problem is with the Mid Deck (MDK) ATU, then check MS3/4/5 suit COMM connections and/or swap out Headset Interface Unit (HIU)/pigtail unit with a spare.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

a. If COMM Checks still bad, then MS3/4/5 ATU, MHA or crew COMM equipment has failed. LCC violation confirmed, No Go for launch.
b. If COMM Checks good, then return ACCU switch to 1 and perform COMM Checks. If COMM Checks good, then LCC violation cleared, continue countdown.

3. If the COMM problem is with the Pilot (PLT) ATU or Commander (CDR) ATU then switch ATU control to backup (CDR or PLT).
   a. If PLT or CDR ATU COMM Checks good, then PLT or CDR ATU has failed. LCC violation confirmed, No Go for launch.
   b. If PLT or CDR ATU COMM Checks bad, then check PLT/CDR configuration, cable connections and/or swap out HIU/pigtail unit with a spare.
      - If COMM Checks still bad, then PLT or CDR crew COMM equipment has failed. LCC violation confirmed, No Go for launch.
      - If COMM Checks good, then return PLT or CDR ATU control to normal and ACCU switch to 1 and perform COMM checks. If COMM checks good, LCC violation cleared, continue countdown.

NOTES:

(5) Helmet contains dual micro switches that mute the microphone in the Communications Carrier Assembly (CCA) during oxygen (O2) flow (inhalation, open visor or leaking neck dam seal).
(6) The Crew Communications Umbilical (CCU) must be powered to transmit. Receive capability not affected by CCU power switch.
(7) The MDK ATU, CCU and MHA cannot be reached nor configuration verified by seated crew members.
(8) Powering off the CCU is not required when performing pre-planned contingency procedures. Demating powered crew-worn communication equipment is within limits (not greater than 500mA, 32V).
(9) A spare HIU/COMM pigtail is flown on the flight deck in MS2's Flight Data File (FDF) saddlebag and also on the middeck.
(10) The PS ATU is not required for launch.
(11) Bad COMM is defined as intermittent, nonexistent or unacceptable communications between the crew members.

REDLINE DERIVATION: CRITICALITY: 2

(12) a. SSID Intent Summary - The intent of this SSID is to ensure that the crew is able to communicate and coordinate routine and emergency activities. There are two redundant ACCUs that act as the central switchboard to gather and route audio signals throughout the orbiter. There are six ATUs located at the CDR, PLT, MS, MDK, PS and Airlock stations that permit crew members to talk and listen. The CDR, PLT, MS and Airlock ATUs have the capability to switch to an alternate ATU in case of a malfunction. For launch, the PS and Airlock ATUs are not used.

During launch and entry each crew member wears a Launch and Entry Helmet (LEH) to lessen noise and to allow intelligible communication. Each headset comes equipped with a CCA that contains microphones and earphones that fits over the crew members head. A connector and cable

REDLINE DERIVATION: (Continued)

(which penetrates the LEH via a helmet pass-thru plug) interconnects the CCA to the HIU. The HIU is connected to the respective ATU via a CCU outlet. A MHA allows several crew members to be connected to the same CCU outlet.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - N/A

d. Time Period - The starting time period effectivity of crew module hatch closure was selected because all crew communication equipment has been configured and verified operational at this point. The ending time period effectivity of Go For GLS Start was chosen because the system has been activated and considered stable at T-9 minutes.

e. Requirements - All crew members must be able to communicate with each other on any channel to coordinate routine and emergency operations. To ensure adequate redundancy in case of a malfunction, both ACCUs and all ATUs, with the exception of PS and Airlock, are required for launch. Additionally, all crew worn communication equipment must be properly configured to ensure two way communication.

f. Pre-planned Contingency Procedure - Determines if failure is with the ACCU, ATU or crew worn COMM equipment. Launch may not occur with the loss of an ACCU or ATU. Crew worn equipment cables, connections and controls may be checked and reconfigured to reestablish communications.

CONSEQUENCES OF EXCEEDING REDLINE:

(13) Loss of COMM may result in inability to coordinate crew operations to react to routine or emergency events.

CAUSES OF EXCEEDING REDLINE:

(14) ACCU or ATU failure.
(15) Failure of crew worn communication equipment (cables, HIU, MHA, CCA, LEH, etc.)

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 16.1 SHEET 2 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: C&T

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LCC VIOLATION CALL: Loss of GPS Indication for Three String GPS Vehicles | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	GPS No. 1	(6)				
V74X4922B	GPS1 Data Valid	(2)	ON(4,5)	NA	Event	CI
V74X4463B	GPS1 RPU Fail	(1)	OFF	NA	Event	CI
	GPS No. 2	(6)				
V74X1922B	GPS2 Data Valid	(2)	ON(4,5)	NA	Event	CI
V74X1463B	GPS2 RPU Fail	(1)	OFF	NA	Event	CI
	GPS No. 3	(6)				
V74X5922B	GPS3 Data Valid	(2)	ON(4,5)	NA	Event	CI
V74X3463B	GPS3 RPU Fail	(1)	OFF	NA	Event	CI

TIME PERIOD:

(1) From GPS Activation (approximately T-4 hours) to Go For RSLS Start (T-31 seconds)
(2) From 30 minutes after GPS Activation (approximately T-4 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(3) This SSID is effective only for three string GPS equipped vehicles. For TACAN equipped vehicles refer to CT-01.
(4) Transient GPS Data Valid Flag OFF indications are acceptable provided the transient condition can be shown to have been caused by OPS transition, multipath, signal blockage, satellite switch, or satellite geometry that resulted in a transient high Figure of Merit (FOM) of 8 or 9. Transient GPS Data Valid Flag OFF indications that cannot be attributed to one of these acceptable causes is indicative of a GPS anomaly and the associated GPS will be considered non-operational.
(5) Non-transient GPS Data Valid Flag OFF indications are acceptable and do not indicate that a GPS is non-operational provided the OFF indication can be attributed to the known GPS software problem (Ref. GPS Flight Software DR 110646) and the GPS Data Valid Flag ON is recovered per the Preplanned Contingency Procedure. (7)
(6) Two of three operational GPS (Data Valid ON and RPU Fail OFF) are required for launch if high speed C-Band radar tracking is scheduled for End-Of-Mission (EOM). C-Band availability can be confirmed by the KSC NASA Test Director (NTD) via the Mission Control Center (MCC)- Houston Flight Director.

PREPLANNED CONTINGENCY PROCEDURE:

(7) If GPS Data Valid (V74Xn922B) ON was not achieved after GPS activation or has not recovered from a high FOM, then Command affected GPS to INIT and then to NAV Mode. If GPS Data Valid ON indication is recovered and can be attributed to multipath, signal blockage, poor satellite geometry or a

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

known software problem (i.e., GPS Flight Software DR 110646), then GPS is operational. LCC violation cleared, continue countdown.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(8) a. SSID Intent Summary - The GPS system is the primary navigational tool to provide the onboard navigation state vector update for reentry. There are three GPS receivers which sense satellite ranging signals to determine position and velocity. This navigational data is provided to the Flight Control System (FCS) via the GPCs and the flight critical MDMs. The GPS Data Valid flag is an indication that sufficient signals are being received from the GPS satellite network. The GPS RPU Fail flag is a means of determining the health of the Receiver Processing Unit (RPU). The GPS Data Valid flag and GPS RPU Fail flag are monitored to assure two-fault tolerance at liftoff for updating the entry navigation state for EOM, and single-fault tolerance for any intact abort entry. High speed C-band radar tracking is the source for Command delta-state (MCC) updates, which can be used to provide fault tolerance for entry navigation if not all GPS are available. Three of three GPS are required in the event EOM C-Band tracking is unavailable. This ensures two-fault tolerance at liftoff for updating the entry navigation state by GPS for EOM, and single-fault tolerance for any intact abort entry.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - The GPS Data Valid and the GPS RPU Fail measurements are the primary means of determining the operational integrity of the GPS receiver. The GPS Data Valid flag ON indicates valid navigation data is being provided while a RPU Fail flag ON indicates a failure with the GPS receiver which renders data output unreliable.

d. Time Period - The starting time period effectivity for this SSID is 30 minutes following GPS Activation which is approximately T-4 hours. The 30 minutes is to allow collection of satellite almanac and ephemeris. All GPS equipment will have been configured and should be operational at this point. The GPS Data Valid flag will be monitored until T-9 minutes since the GPS system is functionally stable at this point. A failure not attributed to momentary data drop outs after this point is considered unlikely and is an acceptable risk. However, the GPS RPU Fail flag will be monitored till T-31 seconds because the GPS is a criticality 1R entry navigation system. A failure of this measurement after T-31 seconds is considered an acceptable risk.

e. Requirements - Two of three GPS are required in the event EOM C-Band Tracking is scheduled. This ensures two-fault tolerance at liftoff for updating the entry navigation state by GPS or by high speed C-Band Radar

REDLINE DERIVATION: (Continued)

tracking on EOM, and single-fault tolerance at liftoff for any intact abort entry. If high speed C-Band Radar tracking is scheduled for EOM then it is an acceptable backup for the loss of any single GPS because command delta-state (MCC) can be used to provide fault tolerance for entry navigation if not all GPS are available.

Three of three GPS are required in the event EOM C-Band Tracking is unavailable. This ensures two-fault tolerance at liftoff for updating the entry navigation state by GPS on EOM, and single-fault tolerance for any intact abort entry.

A transient GPS Data Valid OFF indication due to OPS transition, or an environmental condition such as multipath, signal blockage, satellite switch, or satellite geometry resulting in High FOM (i.e., FOM = 8 or 9), is acceptable, if it can be determined through the use of ground tools that the condition is due to the environment and not due to a receiver problem. Such transient events are expected and, due to the software structure and built-in Quality Assurance checks, will not effect the performance of the GPS receiver. Transient GPS Data Valid Flag OFF indications that cannot be attributed to one of these acceptable causes is indicative of a GPS anomaly and the associated GPS will be considered non-operational.

Non-transient GPS Data Valid Flag OFF indications are acceptable and do not indicate that a GPS is non-operational provided the OFF indication can be attributed to the known GPS software problem (Ref. GPS Flight Software DR 110646) and the GPS Data Valid Flag ON is recovered per the Preplanned Contingency Procedure (7). Following recovery the GPS receiver will resume nominal operation with no impact to future performance.

f. Pre-planned Contingency Procedures - Satellite geometry and signal path environment (multipath) can cause the GPS receiver to fail to lock on to sufficient satellite signals. Also, a known software problem (GPS Flight Software DR 110646), OPS transition, or satellite switch can cause a loss of GPS Data Valid ON. These problems can be corrected by performing the Preplanned Contingency Procedure (7), which will reinitialize the receiver and allow it to lock on to a signal.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Possible loss of two-fault tolerance at liftoff for updating the criticality one entry navigation state for EOM.
(10) Possible loss of single-fault tolerance for updating the criticality one entry navigation state for an intact abort.
(11) Reference Orbiter Hazard Report ORBI 211.

CAUSES OF EXCEEDING REDLINE:

(12) GPS Data Valid Flag OFF:
a.) Internal GPS Kalman Filter estimated error >1000 m.

CAUSES OF EXCEEDING REDLINE: (Continued)

b.) GPS receiver is not in NAV Mode.
c.) Performance Monitoring(continuous BITE software) detected a critical failure in previous second.
d.) Environmental (i.e., multipath, signal blockage, satellite geometry, satellite switch).
e.) Known software problem documented on GPS Flight Software DR 110646.
f.) OPS transition.
g.) Instrumentation failure.

(13) RPU FAIL ON:
a.) GPS RPU failure.
b.) Instrumentation failure.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 9.19 SHEET 1 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-974099 SHEET 58.1-4 ZONE

ELEMENT: Orbiter SUBSYSTEM: C&T

SECTION 33

OPERATIONAL INSTRUMENTATION

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SECTION 33: OPERATIONAL INSTRUMENTATION

SSID No.	Description/Violation Call	Page
INS-01	Operational Instrumentation Anomaly	33-01.1
INS-02	OPS Recorder Anomaly (REQUIREMENT DELETED)	33-02.1
INS-02a	SSR Anomaly	33-02a.1
INS-03	MTU Signal Distribution	33-03.1
INS-04	Operational Instrumentation	33-04.1
INS-05	Operational Instrumentation Anomaly	33-05.1
INS-06	Caution and Warning System Fail Anomaly	33-06.1

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LCC VIOLATION CALL: Operational Instrumentation Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V75X2121D	PCM Unit Power Status Good	PCM-BSR	(1,4)	1	NA	Event	CI
V75X2122D	MTU Good	PCM-BSR	(1,4)	1	NA	Event	CI
V75X2123D	Fetch PROM Parity Good	PCM-BSR	(1,5)	1	NA	Event	CI
V75X2124D	128 kbps TLM Downlink Good	PCM-BSR	(2,5)	1	NA	Event	CI
V75X2126D	128 kbps TLM Parity Good	PCM-BSR	(2,5)	1	NA	Event	CI
V75X2127D	128 kbps TLM Counters Good	PCM-BSR	(2,5)	1	NA	Event	CI
V75X2130D	Input Data Valid	PCM-BSR	(2,5,6	1	NA	Event	CI
V75X2131D	OI RAM Parity Good	PCM-BSR	(1,5)	1	NA	Event	CI
V75X2132D	PDI RAM Parity Good	PCM-BSR	(1,5)	1	NA	Event	CI
V75X2133D	Toggle Buffer Parity Good	PCM-BSR	(2,5)	1	NA	Event	CI
V75X2134D	No Response Computer Bus	PCM-BSR	(2,5,6	1	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)
(2) From Start of ET Cryo Tanking (T-6 hours) to Go For ME Ignition (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

(3)

MEAS. NO.	BITE	MEASUREMENT DESCRIPTION	AFFECTED DATA	PCP
V75X2121D	1	PCM Unit Power Status Good	OI & GPC	(7)
V75X2122D	2	MTU Good	OI & GPC	(8)
V75X2123D	3	Fetch PROM Parity Good	OI	(9,12)
V75X2124D	4	128 kbps TLM Downlink Good	OI & GPC	(10,12)
V75X2126D	6	128 kbps TLM Parity Good	OI & GPC	(10,12)
V75X2127D	7	128 kbps TLM Counters Good	OI & GPC	(10,12)
V75X2130D	10	Input Data Valid	OI & GPC	(9,12)
V75X2131D	11	OI RAM Parity Good	OI	(9,12)
V75X2132D	12	PDI RAM Parity Good	OI	(9,12)
V75X2133D	13	Toggle Buffer Parity Good	GPC	(9,12)
V75X2134D	14	No Response Computer Bus	GPC	(11,12)

(4) For confirmed instrumentation failure, LCC violation cleared, continue countdown.
(5) One momentary (single sample) failure is acceptable prior to T-2M55S. LCC violation cleared, continue countdown. After T-2M55S, momentary and non-momentary failures are not acceptable - work the applicable PCP.
(6) Failure of bits 10 and/or 14 due to the failure of a downlisting GPC that can be recovered by reassignement of downlist to a different GPC per SSID DPS-29 is acceptable prior to T-2M55S. LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE:

(7) For redline violation, check for OI decom lock loss (testing for loss of vehicle telemetry from active PCMMU). If no OI decom lock loss, instrumentation failure is confirmed. LCC violation cleared, continue countdown.

(8) For redline violation, check for OI decom lock loss. If OI decom lock lost, switch to alternate PCMMU to recover data. LCC violation confirmed, no go for launch.

If no OI decom lock loss and there is sufficient time before coming out of the T-9 minute hold, monitor for GPC sync loss and/or PDI 1.152 MHz BITE failure. If none occur, instrumentation failure confirmed. LCC violation cleared, continue countdown. If a GPC sync loss or PDI 1.152 MHz BITE failure occurs, the failure is acceptable with reconfiguration of the PCMMU. Switch to the alternate PCMMU and reload HDR/LDR TFLs if required by MCC. LCC violation cleared, continue countdown.

If no OI decom lock loss and there is not sufficient time prior to coming out of the T-9M hold or there has been a GPC sync loss and/or PDI 1.152 MHz BITE failure, switch to alternate PCMMU and reload HDR/LDR TFLs if required by MCC. LCC violation cleared, continue countdown.

If no OI decom lock loss and after T-2M55S, LCC violation cleared, continue countdown.

(9) There is no workaround for this failure. The integrity of vehicle data to the ground cannot be verified and will be recovered by selecting the alternate OI PCMMU at the earliest possible opportunity. LCC violation confirmed, No Go for launch.

(10) The integrity of vehicle data to the ground cannot be verified and will be recovered by selecting the alternate OI PCMMU at the earliest possible opportunity. Prior to T-2M55S, it is possible that the PCMMU can recover from this failure. Power cycle back to the original PCMMU and verify BITE is "GOOD". If BITE indicates "GOOD", reload HDR/LDR TFLs if required by MCC. LCC violation cleared, continue countdown. If BITE does not indicate "GOOD", switch to alternate PCMMU to recover integrity of vehicle data. LCC violation confirmed, NO GO for launch.

(11) There is no workaround for this failure if DPS is unable to recover GPC downlist (SSID DPS-29) or BFS downlist (SGPCAREA2) is lost (SSID BFS-08). Downlist will be recovered by selecting the alternate OI PCMMU at the earliest possible opportunity. LCC violation confirmed, No Go for launch.

(12) If failure occurs after T-2M55S, then immediately initiate safing to ensure ET pressurization is terminated in the event that downlist is loss. LCC failure confirmed, No Go for launch.

NOTES:

(13) "0" = OFF (KSC), MML contains no designation for "0"; "1" = ON (KSC), 1 = GOOD (MML) except V75X2130D for which 1 = VALID.

(14) PASS downlist (GPC) data is used by the LOX/LH2 ground software for control of ET pressurization, a loss or potential loss of downlist after the start of ET pressurization presents a risk of pressurizing to the point of relief valve operation.

NOTES: (Continued)

(15) TFL reload requires that G9 be available.

REDLINE DERIVATION: CRITICALITY: 1R

(16) a) SSID Intent Summary

The intent of this SSID is to ensure OI and GPC data provided by the vehicle is valid through launch. OI and GPC data is required for the ground to maintain insight into the state of the vehicle, including detecting vehicle fault conditions and LCC violations, synchronizing onboard and ground countdown sequences, safing the vehicle in the event of an abort or scrub, and detecting and responding to emergency conditions. Loss of OI or GPC data will affect the ground's ability to perform these vital functions.

Overall system fault tolerance is provided by two redundant PCMMUs, only one of which is actively providing telemetry at any given time. In the event of a failure, swapping to the alternate PCMMU will restore data to the ground.

A single momentary (single frame) failure of BITE bits 3, 4, 6, 7, 10, 11, 12, 13 and 14 are indicative of data bus transmission noise or a self-correcting single event upset and are acceptable before T-2M55S. Multiple occurrences of momentary failures could be indicative of a failing PCMMU and are not acceptable. LOX/LH2 are sensitive to GPC data provided by the PCMMU, therefore no momentary failures can be tolerated after T-2M55S.

Failure of PCMMU BITE bit 1 without a corresponding loss of OI decom lock is indicative of PCMMU BITE circuitry failure. This is an acceptable instrumentation failure mode.

Failure of PCMMU BITE bit 2 without a corresponding loss of OI decom lock indicates the PCMMU has lost the timing signal provided by the MTU and is operating on internal time. This does not affect the ability of the PCMMU to provide OI data before or after launch and is an acceptable failure mode. However, allowing a PCMMU to remain on internal time prior to launch could lead to either PASS or BFS GPC data shifting within the Area 1 or Area 2 windows, resulting in a loss of GPC synch, resulting in a dropout of GPC data due to FEP re-acquisition (reference SSIDs DPS-29 and BFS-08).

Failure of PCMMU BITE bits 4, 6, 7, 10, 13 and 14 after T-2M55S and before T-10S affect the GPC data provided by the PCMMU and will result in the requirement for GLS to perform immediate safing due to LOX/LH2 sensitivity.

Failure of PCMMU BITE bits 3, 11, and 12 between T-2M55S and T-31S require a PCMMU swap to restore OI data. Due to LOX/LH2 sensitivity to GPC data (lost when a PCMMU swap is performed), this will also result in a requirement for GLS to perform immediate safing prior to data recovery

REDLINE DERIVATION: (Continued)

via PCMMU swap.

b) Voting Logic - N/A

c) Minimum and/or Maximum Redline Development

Violating redlines for any of the listed measurements indicates an improperly functioning PCM system.

NOTE: "Good" is Logic 1. "Bad" is Logic 0.

A. (Bit 1) V75X2121D PCM Unit Power Status Good PCM-BSR:
The PCMMU power has dropped below an operational level since the last BSR reset. Failure indication without a corresponding OI decom lock loss is indicative of BITE circuitry failure. A true PCMMU power supply failure may result in the inhibition of communications between the PCMMU and external devices, PCMMU internal RAM memories may be affected, and the PCMMU may transition to the fixed OI format (129).

B. (Bit 2) V75X2122D MTU Good PCM-BSR:
The PCMMU is operating on its internal clock. Violation indicates a malfunctioning 4.608 MHz interface between the PCMMU and MTU, which could result in OI dropouts or occasional momentary loss of GPC sync. Loss of GPC sync will result in a dropout of GPC data.

C. (Bit 3) V75X2123D Fetch PROM Parity Good PCM-BSR:
One or more fetch PROM parity errors have been detected since the last BSR reset. Errors in the fetch command indicate some data is not being retrieved or stored correctly. OI data integrity cannot be confirmed. GPC I/O errors may occur.

D. (Bit 4) V75X2124D 128-kbps TLM Downlink Good PCM-BSR:
The comparison check of the MDM OF01 static wraparound pattern (10101010) has failed since the last BSR reset. The PCM 128-kbps TLM format memory cannot access data from the OI and PDI data RAM. Possible causes are a failed BSR, pattern checker, or the TLM format memory is not functioning properly. OI and GPC data integrity cannot be confirmed.

E. (Bit 6) V75X2126D 128-kbps TLM Parity Good PCM-BSR:
One or more 128-kbps RAM (or PROM) parity errors have occurred since the last BSR reset. The formatter is not accessing all of the correct data from the PCMMU memories. OI and GPC data integrity cannot be confirmed.

F. (Bit 7) V75X2127D 128-kbps TLM Counters Good PCM-BSR:
An error has been detected in one of the 128-kbps sample rate counters since the last BSR reset. The formatter is not accessing all of the correct data from the PCMMU memories. OI and GPC data integrity cannot be confirmed.

REDLINE DERIVATION: (Continued)

G. (Bit 10) V75X2130D Input Data Valid PCM-BSR:
One or more input-data invalid errors have been detected on one or more of the seven data buses since the last BSR reset. This bit can also fail if the MTU serial/digital input is not found at MDM OF1 and OF2. OI and GPC data integrity cannot be confirmed.

H. (Bit 11) V75X2131D OI RAM Parity Good PCM-BSR (Lower RAM):
One or more OI data RAM parity errors have been detected since the last BSR reset. OI data integrity cannot be confirmed. Note: The OI RAM region contains OI and PDI data.

I. (Bit 12) V75X2132D PDI RAM Parity Good PCM-BSR (Upper RAM):
One or more PDI RAM parity errors have been detected since the last BSR reset. OI data integrity cannot be confirmed. Note: The PDI RAM region contains OI and PDI data.

J. (Bit 13) V75X2133D Toggle Buffer Parity Good PCM-BSR:
One or more toggle buffer parity errors have been detected in one or more of the five toggle buffers since the last BSR reset. GPC data integrity cannot be confirmed.

K. (Bit 14) V75X2134D No Response Computer Bus PCM-BSR:
One or more "no-response" conditions have been detected on one or more of the five computer buses since the last BSR reset. GPC data integrity cannot be confirmed. This bit may be set if there is a violation of SSID DPS-29.

d) Time Period

PCMMU functionality is required from start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds) in order to ensure valid OI telemetry (including GPC data) is provided to the Ground (applicable to V75X2121D, V75X2122D, V75X2123D, V75X2131D and V75X2132D, bits 1, 2, 3, 11, and 12, respectively).

LOX/LH2 is sensitive to loss of downlist (GPC) data through Go For ME Ignition (T-10 seconds), therefore status indicators impacting the ability of the PCMMU to provide GPC data are effective to T-10 seconds (applicable to V75X2124D, V75X2126D, V75X2127D, V75X2130D, V75X2133D and V752134D, bits 4, 6, 7, 10, 13, and 14, respectively).

e) Requirements

The PCMMU is required to provide telemetry to the Ground for use in evaluating vehicle health prior to launch. Redundancy at liftoff is required to support flight rules that state the PCMMU must be able to provide data to the GPCs, forward GNC data provided by the GPCs and supply high data rate telemetry (128 KBPS) to one of the two NSPs for visibility by the MCC. Loss of one PCMMU would result in a minimum duration flight (MDF) and loss of two PCMMUs would result in a next

REDLINE DERIVATION: (Continued)

primary landing site (PLS) landing (reference Flight Rules A11-74 and A11-75).

f) Preplanned Contingency Procedures

These procedures provide a means to determine if the out-of-limits condition is caused by an instrumentation failure or a hardware failure. If loss of OI decom lock has occurred or data integrity is suspect, the alternate PCMMU is selected to restore data to the Ground.

Since PASS downlist data is used by the LOX/LH2 ground software for control of ET pressurization, a loss of downlist after the start of ET pressurization presents a risk of pressurizing to the point of relief valve operation before valid downlist can be restored. Therefore, the requirement to perform immediate GLS safing for a loss of downlist after T-2M55S is imposed to ensure the pressurization process is terminated.

CONSEQUENCES OF EXCEEDING REDLINE:

(17) Loss of redundancy and possible early mission termination from loss of critical flight data.

CAUSES OF EXCEEDING REDLINE:

(18) Faulty operation of PCMMU/MIA, PCMMU power, data bus, BTU/MIA, MTU or downlisting GPC.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 17.2	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: OI

OPS Recorder Anomaly

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LCC VIOLATION CALL: SSR Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V75X2943E	SSR1 OST Critical BITE	1 of 2	GOOD(4)	NA	Event	CI
V75X2843E	SSR2 OST Critical BITE		GOOD(4)	NA	Event	CI

TIME PERIOD:

(1) From start of ET Cryo tanking (T-6 hours) to APU start (T-5 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) Applicable only to Solid State Recorders.
(3) 1 of 2 SSRs is required for launch.

PREPLANNED CONTINGENCY PROCEDURE:

(4) If SSR1 and SSR2 redlines are violated simultaneously (ref. S0007 Vol 5):
    A: Perform CST (Comprehensive Self Test) on SSRs to determine cause of OST Critical BITE failure to capture additional data prior to power cycle. (Note: bit 6 is a spare/unused bit.) Performance of CST after OPS transition will require JSC to issue commands. Perform power cycle in an attempt to remove the redline violation from the SSRs when the Solid State Mass Memory (SSMM) is not being accessed. If power cycle clears the redline condition, LCC violation cleared, continue countdown.
    B: If SSR1 and SSR2 redlines can not be cleared, JSC will record and playback both SSRs while KSC verifies data by decom lock via T-0 umbilical (approximately 5 minutes per recorder). If record and playback identifies a usable SSR, select the usable SSR(s) for OI recording, LCC violation cleared, continue countdown.

NOTES:

(5) During ascent, OI data is recorded on both SSR1 & SSR2 simultaneously. There is no requirement to reconfigure the SSR if one should fail.
(6) A logic _0_ (FAIL) for the OST Critical BITE indicates that the Built-In Test Equipment (BITE) has detected a critical failure.
(7) If CST, power cycle, or a record test results in a successful preplanned contingency, reconfiguration of the SSR to launch configuration will be required.
(8) Logic _0_ (FAIL) on status bit 13 of SSR1 or SSR2, MSID V75X2960E or V75X2860E respectively, indicates a rejection of an undefined SSR command. This is considered a non-critical BITE failure.
(9) Logic _0_ (FAIL) on status bit 21 of SSR1 or SSR2, MSID V75X2942E or V75X2842E respectively, indicates double bits or a uncorrectable error by the Error Detection & Correction (EDAC) in the memory board, or no response from VME/PCI bridge when CPU initiated the transaction in the SBC board. These are non-critical BITE failures.

NOTES: (Continued)

(10) V72S7185E indicates control power is applied to PCA #1 RPC 48, which supplies MN bus A voltage to Modular Memory Unit #1.
(11) V72S7186E indicates control power is applied to PCA #2 RPC 53, which supplies MN bus B voltage to Modular Memory Unit #2.
(12) A logic _0_ (OFF) for the switch scan indicates the possibility of power failure to the affected MMU (SSR).
(13) EIU data is hardwired only to MMU2 (SSR2).
(14) In a nominal ascent configuration, SSR2 records EIU data from input _E_ (E1, E2, E3) in parallel mode at 60 kbps while simultaneously recording OI data from input _A_ in serial mode at 192 kbps. SSR1 records OI data from input _A_ in serial mode at 192 kbps.
(15) OST is continuously running in the background except during the Start-up sequence, Remap operation and Comprehensive Self Test.
(16) An _ON_ indication for measurement V92X6090XX Record Mode Mux may indicate that one or more errors have been detected in the telemetry minor frame sync pattern. Therefore, erroneous data may be output to the SSR.

REDLINE DERIVATION: CRITICALITY: 3

(17) OST status bit 22 (Critical BITE) Logic _0_ (FAIL) can be generated by any of the following:
a. Unexpected critical software exception.
b. Uncorrectable application software memory error.
c. CPU Bus and memory controller interface error.
d. System memory DRAM selection error.
e. System memory DRAM refresh overflow.
f. Application software flashes write error.
g. I/O channel event Queue overflow.

CONSEQUENCES OF EXCEEDING REDLINE:

(18) Loss or degradation of in-flight data where air-to-ground communication is not available.

CAUSES OF EXCEEDING REDLINE:

(19) Faulty operation of the recorder.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 16.21 SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO 74JA, 71MA SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: OI

LCC VIOLATION CALL: MTU Signal Distribution | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V75X3542D	MTU-PCM Voted Osc No 1 Amptd Fail	(2)	OFF	NA	Event	CI
V75X3543D	MTU-PCM Voted Osc No 2 Amptd Fail	(2)	OFF	NA	Event	CI
V75X3544D	MTU-PCM Voted Osc Freq Diff Fail	(2)	OFF	NA	Event	CI
V75X3545D	MTU-PCM Voted Osc No 1 Temp Fail	(2)	OFF	NA	Event	CI
V75X3546D	MTU-PCM Voted Osc No 2 Temp Fail	(2)	OFF	NA	Event	CI
V75X3547D	MTU-PCM Voted PS 1 Volt Amptd Fail	(3)	OFF	NA	Event	CI
V75X3548D	MTU-PCM Voted PS 2 Volt Amptd Fail	(3)	OFF	NA	Event	CI
V75X3549D	MTU-PCM Voted Cmd Channel A Fail	(4)	OFF	NA	Event	CI
V75X3550D	MTU-PCM Voted Cmd Channel B Fail	(4)	OFF	NA	Event	CI
V75X3551D	MTU-PCM Voted Cmd Channel C Fail	(4)	OFF	NA	Event	CI
V75X3552D	MTU-PCM Voted Any IRIG B Chan Fail	(5)	OFF	NA	Event	CI
V75X3553D	MTU-PCM Voted Freq Divider 1 Fail	(6)	OFF	NA	Event	CI
V75X3554D	MTU-PCM Voted Freq Divider 2 Fail	(6)	OFF	NA	Event	CI
V75X3555D	MTU-PCM Voted Freq Divider 3 Fail	(6)	OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 MTU oscillators is required. (7)
(3) 1 of 2 MTU power supplies is required.
(4) 2 of 3 MTU command channels are required. (8)
(5) Payload requirement for IRIG B channel is mission dependent. Reference Appendix H SSID MEL-13. (9)
(6) Function requirement for frequency dividers is mission dependent. Reference Appendix H SSID MEL-13. (10)

PREPLANNED CONTINGENCY PROCEDURE:

(7) For an oscillator amplitude fail or temperature fail indication on the selected oscillator, confirm automatic switchover or manually switch to the good oscillator, LCC violation cleared, continue countdown. For an oscillator frequency difference fail indication, identify and select the good oscillator, LCC violation cleared, continue countdown. (ref: S0007 Vol. 5).
(8) For multiple command channel fail indications, if two of three accumulator strings are confirmed accurate and available to the GPC, LCC violation cleared, continue countdown. (ref: S0007 Vol. 5).
(9) If MTU IRIG B Any Channel BITE Error (bit 12) is set, send Test Uplink. If uplink is successful, LCC violation cleared, continue countdown. If uplink test fails, reconfigure uplink to Encryption "BYPASS", and configure uplink for "GPC BLOCK" except when commanding (ref: S0007 Vol. 5).
    A. If crew is unable to reconfigure "BYPASS" switch on panel A1L, ground crew may be required for access to flight deck switch.

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

B. After reconfiguration, retest uplink. If successful, LCC violation cleared, continue countdown. If unsuccessful, LCC violation confirmed, No Go for launch.

(10) Freq Divider 1, 2 or 3 Fail indication (ref: S0007 Vol. 5):
A. Freq Divider 1 Fail (V75X3553D1): verify payload mission specific timing, and either Payload Signal Processor (PSP) 1 or FM Signal Processor (FMSP) 1 for functionality.
B. Freq Divider 2 Fail (V75X3554D1): verify PSP 2 functionality. If PCMMU 2 is active and Bite Bit 2 is failed, switch to PCMMU 1.
C. Freq Divider 3 Fail (V75X3555D1): verify payload mission specific timing. If PCMMU 1 is active and Bite Bit 2 is failed, switch to PCMMU 2.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R2

(11) One oscillator provides full functionality of the MTU for all outputs. Second failure results in loss of the MTU.
(12) Oscillator temperature BITEs are dependent on the BITE temperature monitoring window tolerance which can age without necessarily indicating oven out of spec condition. There are other methods to check oscillator performance. The one oscillator requirement for launch is verified by monitoring V75X3542D, V75X3543D, V75X3545D, and V75X3546D. V75X3544D oscillator frequency difference verifies oscillator drift rates are not excessive. Oscillators may drift excessively without any of the health monitoring BITEs showing fail. Excessive drift rates will yield accumulated GMT time errors that may become unacceptable. A frequency difference BITE indicates that one or both oscillators may be drifting out of specification. One of two oscillators is required for launch because one oscillator at any given time is the single frequency source GMT/MET accumulators. The MTU time function is Criticality 1/R2.
(13) One power supply provides full functionality of the MTU for all inputs. Second failure results in loss of the MTU. Monitoring V75X3547D and V75X3548D is required to verify one of two power supplies is operational for launch. The MTU GMT/MET time function is Criticality 1/R2.
(14) Voted command channel failures give insight into the health of the MTU accumulators. With only two accumulators there is still one more functional level of fault tolerance; i.e., GPC internal time, to support flight safety requirements. Monitoring V75X3549D, V75X3550D, V75X3551D is required to determine if there are any discrepancies between the three command channels. A discrepancy of this nature is an indication of a potential problem with an accumulator. Accumulators accumulate GMT and MET time which is cyclically provided to GPCs for time updating purposes. A time error in the accumulator will cause the GPCs to deselect that accumulator. If all three accumulators default the GPC will default to internal GPC runtime as a time source. Two of three accumulators are required for launch. The MTU GMT time function is Criticality 1/R2.
(15) IRIG B provides mission-dependent timing signals for payload commanding.

REDLINE DERIVATION: (Continued)

(16) Frequency divider fail indication may only reflect failure in a part of the divider not required for a given mission. Freq Divider 1 provides mission dependent clock signals for the payload and Payload Signal Processor 1 (PSP1) command capability. Freq Divider 2 provides mission dependent clock signals for the PSP2 command capability. Freq Divider 3 provides mission dependent clock signals for the payload.

CONSEQUENCES OF EXCEEDING REDLINE:

(17) GPC/OI PCM pseudo sync losses. GPCs will revert to internal time.
(18) Loss of timing to event timers and payloads.
(19) IRIG B loss will result in loss of encrypted uplink command capability.

CAUSES OF EXCEEDING REDLINE:

(20) MTU hardware failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 8.9	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: OI

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LCC VIOLATION CALL: Operational Instrumentation | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V75X2171E	Bay1 DSC OF1 BITE	(3)	ON	NA	Event	CI
V75X2172E	Bay2 DSC OF2 BITE	(3)	ON	NA	Event	CI
V75X2173E	Bay3 DSC OF3 BITE	(3)	ON	NA	Event	CI
V42T1308A	Fwd L Fu Pr Line Temp Bkup DSC OF4	1	30	NA	deg F	CI
V42T1304A	RCS-Fwd Fu Fill Line Temp DSC OF4	of	30	NA	deg F	CI
V09T1510A	RH Fwd Fus RCS Mod Skin T DSC OF4	3	30	NA	deg F	CI
V75X2174E	Bay4 DSC OA1 BITE	(3)	ON	NA	Event	CI
V75X2175E	Bay5 DSC OA2 BITE	(3)	ON	NA	Event	CI
V75X2176E	Bay6 DSC OA3 BITE	(3)	ON	NA	Event	CI
V75X2181E	Mid 1 DSC (LH Side) OM1 BITE	(3)	ON	NA	Event	CI
V75X2182E	Mid 2 DSC (Rt Side) OM2 BITE	(3)	ON	NA	Event	CI
V75X2183E	Mid 3 DSC (LH Side) OM3 BITE	(3)	ON	NA	Event	CI
V75X2184E	DSC OP1 BITE	(2)	ON	NA	Event	CI
V75X2185E	DSC OP2 BITE	(2)	ON	NA	Event	CI
V42T2204A	RCS-L Aft Ox Manf Temp-1 DSC OL1	1	30	NA	deg F	CI
V43T4704A	OMS-L Pod Ox Drain Pnl T-1 DSC OL1	of	30	NA	deg F	CI
V43T4708A	OMS-L Pod Ox/He TP Ftg T-1 DSC OL1	3	30	NA	deg F	CI
V42T2304A	RCS-L Aft Hsg Therm Sw T-1 DSC OL2	1	30	NA	deg F	CI
V42T2305A	RCS-L Aft Hsg Therm Sw T-2 DSC OL2	of	30	NA	deg F	CI
V43T4707A	OMS-L Pod Eng Svc Pnl Temp DSC OL2	3	30	NA	deg F	CI
V42T3204A	RCS-R Aft Ox Manf Temp-1 DSC OR1	1	30	NA	deg F	CI
V43T5704A	OMS-R Pod Ox Drain Pnl T-1 DSC OR1	of	30	NA	deg F	CI
V43T5708A	OMS-R Pod Ox/He TP Ftg T-1 DSC OR1	3	30	NA	deg F	CI
V42T3304A	RCS-R Aft Hsg Therm Sw T-1 DSC OR2	1	30	NA	deg F	CI
V43T5707A	OMS-R Pod Eng Svc Pnl Temp DSC OR2	of	30	NA	deg F	CI
V43T5711A	OMS-R RCS Hsg Ver Cmpt T-2 DSC OR2	3	30	NA	deg F	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 2 (DSC OP1 and OP2) required for EDO pallet, mission unique only. (Refer to Minimum Equipment List 13, Appendix H) (4)

PREPLANNED CONTINGENCY PROCEDURE:

(3) For redline violation, if any one of the three parameters on the affected DSC as listed below are equal to or greater than 30 deg F., LCC violation cleared, continue countdown.

Bay4 DSC (OA1):
V46T0150A APU 1 Gearbox Lube Oil Return Temp.
V46T0174A APU 1 Inj Tube Temp.
V46T0183A APU 1 Fuel Test Line Temp 1.
Bay5 DSC (OA2):
V46T0250A APU 2 Gearbox Lube Oil Return Temp.
V46T0274A APU 2 Inj Tube Temp.
V46T0283A APU 2 Fuel Test Line Temp 1.
Bay6 DSC (OA3):
V46T0350A APU 3 Gearbox Lube Oil Return Temp.
V46T0374A APU 3 Inj Tube Temp.
V46T0383A APU 3 Fuel Test Line Temp 1.
Bay1 DSC (OF1):
V61T2723A H2O Loop 2 Intchgr Inlet Line Temp.
V63T1208A FCL 1 Rad Outlet Temp.
V58T0126A Hyd Sys 1 NLG Uplk Actr Lock Ln T.
Bay2 DSC (OF2):
V61T2624A Loop 1 Avns Bay 1 H2O Outlet Temp.
V63T1408A FCL 2 Rad Outlet Temp.
V42T1208A Fwd R Ox Press Line Temp Backup.
Bay3 DSC (OF3):
V45T0450A H2O Relief Line Temp.
V62T0439A Supply H2O Dump Nozzle Temp B.
V61T2724A H2O Loop 2 Intchgr Outlet Ln Temp.
Mid 1 DSC (LH Side) (OM1):
V45T0345A Fuel Cell No 3 Coolant Return Temp.
V63T1870A Flash Evaporator H2O Fdln Temp 1-L.
V61T2407A Sys 1 N2 Tank 2 Temp.
Mid 2 DSC (RH Side) (OM2):
V63T1871A Flash Evaporator H2O Fdln Temp 1-R.
V61T2406A Sys 1 N2 Tank 1 Temp.
V45T0145A Fuel Cell No 1 Coolant Return Temp.
Mid 3 DSC (LH Side) (OM3):
V43T5722A OMS-R Eng Compt BHS.
V45T0422A FC No 2 H2O Relief Valve Temp.
V45T0382A FCP No 3 Alt Product H2O Line Temp.

(4) For redline violation, if any one of the three parameters on the affected DSC as listed below are equal to or greater than -400 deg F., LCC violation cleared, continue countdown.

EDO DSC (OP1):
V45T3107A PRSD O2 TANK 6 HTR ASSY 1 TEMP
V45T3307A PRSD O2 TANK 8 HTR ASSY 1 TEMP
V45T3209A PRSD O2 TANK 7 HTR ASSY 2 TEMP

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

EDO DSC (OP2):
V45T3207A PRSD O2 TANK 7 HTR ASSY 1 TEMP
V45T3407A PRSD O2 TANK 9 HTR ASSY 1 TEMP
V45T3109A PRSD O2 TANK 6 HTR ASSY 2 TEMP

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(5) This SSID confirms that each DSC is functioning with at least one internal power supply. (Refer to Minimum Equipment List 11, Appendix H)
(6) Functional DSCs are required for flight since they process operational measurements required for critical subsystem operation insight. Although critical measurements are governed by their own LCC, detection of a DSC failure may provide earlier insight into the failure of critical measurement processing.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Loss of measurements acquired by affected DSC.
(8) Loss of redundant power on DSCs with BITE circuits.

CAUSES OF EXCEEDING REDLINE:

(9) DSC hardware failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: OI

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LCC VIOLATION CALL: Operational Instrumentation Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V75X4020D	PCM Dynamic Wraparound MDM OF1		(2)	NA	NA	CI
V75X4021D	PCM Dynamic Wraparound MDM OF2		(2)	NA	NA	CI
V75X4022D	PCM Dynamic Wraparound MDM OF3		(2)	NA	NA	CI
V75X4023D	PCM Dynamic Wraparound MDM OF4		(2)	NA	NA	CI
V75X4024D	PCM Dynamic Wraparound MDM OA1		(2)	NA	NA	CI
V75X4025D	PCM Dynamic Wraparound MDM OA2		(2)	NA	NA	CI
V75X4026D	PCM Dynamic Wraparound MDM OA3		(2)	NA	NA	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) MDM wraps are digital patterns that toggle from AA to 55 ten times per second. Verification of each dynamic wrap is verified by two duplicate words. The duplicate words sample five times per second and are static when MDM wraps are good. If wrap fails, one of the two duplicates change value. The duplicates for each PCM Dynamic Wraparound are as follows:
V75X4020D PCM Dynamic Wraparound MDM OF1: D75V4020A1 and D75V4020B1
V75X4021D PCM Dynamic Wraparound MDM OF2: D75V4021A1 and D75V4021B1
V75X4022D PCM Dynamic Wraparound MDM OF3: D75V4022A1 and D75V4022B1
V75X4023D PCM Dynamic Wraparound MDM OF4: D75V4023A1 and D75V4023B1
V75X4024D PCM Dynamic Wraparound MDM OA1: D75V4024A1 and D75V4024B1
V75X4025D PCM Dynamic Wraparound MDM OA2: D75V4025A1 and D75V4025B1
V75X4026D PCM Dynamic Wraparound MDM OA3: D75V4026A1 and D75V4026B1

PREPLANNED CONTINGENCY PROCEDURE:

(3) For a redline violation, select the alternate PCMMU to recover data. If the data is recovered, LCC violation cleared, continue countdown. The Minimum Equipment List requires 1 of 2 ports for all OI MDMs. After selecting the alternate PCMMU, reload HDR/LDR TFLs if required. This requires that G9 be available. If the MDM/data does not recover, power cycle affected MDM. If MDM is recovered, LCC violation cleared, continue countdown. (MDM experienced a temporary SCU halt).

NOTES:

(4) MDM BITE fail indications will be assessed and secondary cues such as displayed telemetry data, GPC I/O errors, and PCMMU BITE word will be scrutinized. For absence of confirming secondary cues, continue countdown. (Refer to the telemetry listing included for each MDM and verify data quality unaffected.) If required data is affected - No Go for launch.

REDLINE DERIVATION: CRITICALITY: 1R

(5) "Good" = duplicate's static; "Fail" = change in state of either duplicate.
(6) For redline violation, MDM data becomes static for the affected MDM. MDM operation may be recovered by switching to the redundant PCMMU. MDMs process up to 400 operational measurements necessary for subsystem operational insight.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Loss of measurements acquired by affected MDM.

CAUSES OF EXCEEDING REDLINE:

(8) Failure of affected OI MDM.
(9) Failure of one port of affected OI MDM.
(10) Failure of PCMMU MIA.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: OI

LCC VIOLATION CALL: Caution and Warning System Fail Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V73X1567E	C/W Master Alarm TLM output		OFF	NA	Event	CI
NA	Onboard MASTER ALARM Light or Audio Alarm		OFF	NA	Event	
NA	PRIMARY C/W Light (Pnl F7)	(2)	OFF	NA	Event	
NA	BACKUP C/W ALARM Light (Pnl F7)	(2)	OFF	NA	Event	

TIME PERIOD:

(1) From Start of ET Cryo Loading (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) For a confirmed failed-on light, LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE:

(3) Master alarms must be explained prior to launch to determine if a C/W fail has occurred or a C/W system out-of-limits indication has occurred. This LCC does not address alarms caused by systems out-of-limits conditions.

(4) If an unexplained master alarm occurs when the crew cabin is unoccupied, INST will reset the alarm by command. If the crew is in the cabin or when the crew enters the cabin, they should be requested to report all indications (lights, audio, CRT messages, etc.).

Pnl F7:

PRIMARY C/W indication with audio tone or BACKUP C/W ALARM indication:
LCC violation confirmed, No Go for launch. This indicates a C/W internal fail (which may be a power supply fail, self test or system timing fail).

PRIMARY C/W indication without audio tone:
This indicates that the light has failed ON. Remove bulbs or ignore indication, LCC violation cleared, continue countdown.

BACKUP C/W ALARM indication with no audio or PRIMARY C/W indication:
LCC violation cleared, continue countdown. This indicates failed-on light.

No indications:
Troubleshoot as follows:

Pnl C3: Verify C/W MODE sw - NORMAL (if C/W MODE sw is not NORMAL, place switch to NORMAL and repeat (4)).
Pnl O6: LAMP TEST sw - LEFT (hold);
Pnl F7: Verify that C/W annunciator panel lights in the two left columns and top four of the center column are illuminated.
Pnl O6: LAMP TEST sw - RIGHT (hold);
Pnl F7: Verify that C/W annunciator panel lights in the two right columns and bottom four of the center column are illuminated. (A good lamp test indicates that C/W A

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

circuit breaker and Panel F7 power is good.)
Pnl C3: CAUTION AND WARNING: MEMORY sw - READ (hold);
Pnl F7: Record ON indicators.
Pnl R13: (access may be difficult);
CAUTION AND WARNING: MEMORY sw - READ (hold);
Record ON indicators.
PARAMETER STATUS sw - TRIPPED (hold);
Record ON indicators.
PARAMETER STATUS sw - INHIBITED, (hold);
Record ON indicators.
(Engineering will compare reads to determine which system is responsible for the out-of-tolerance condition. If no system can be isolated through reads or data retrievals, the problem may be intermittent inputs caused by a system hardware problem and may result in a NO-GO condition.)

NOTES:

(5) Refer to Appendix E, CW-01 and CW-02 for Caution and Warning Listing.

REDLINE DERIVATION: CRITICALITY:

CONSEQUENCES OF EXCEEDING REDLINE:

CAUSES OF EXCEEDING REDLINE:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: C&W

SECTION 34

GUIDANCE, NAVIGATION AND CONTROL

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SECTION 34: GUIDANCE, NAVIGATION AND CONTROL

SSID No.	Description/Violation Call	Page
GNC-01	Forward Rotational Hand Controller Command Anomaly	34-01.1
GNC-02	Forward Translational Hand Controller Output Anomaly	34-02.1
GNC-03	Rudder Pedal Command Anomaly	34-03.1
GNC-04	Right SBTC CMD and Takeover Anomaly	34-04.1
GNC-05	SSIDs GNC-05 thru GNC-07 Reserved	34-05.1
GNC-08	Orbiter Rate Gyro Power Anomaly	34-08.1
GNC-09	Accelerometer Power Anomaly	34-09.1
GNC-10	SRB Bus C Power Anomaly	34-10.1
GNC-11	Orbiter RGA Spin Motor Anomaly	34-11.1
GNC-12	Orbiter Rate Gyro Fail	34-12.1
GNC-13	Accelerometer Fail	34-13.1
GNC-14	SRB RGA Fail Anomaly	34-14.1
GNC-15	SRB RGA 1, 2, 3, 4 SMRD Anomaly	34-15.1
GNC-16	SRB RGA Rate Anomaly	34-16.1
GNC-17	SSIDs GNC-17 thru GNC-21 Reserved	34-17.1
GNC-22	Elevon Actuator Position Anomaly	34-22.1
GNC-23	Elevon Actuator Primary Delta Pressure Anomaly	34-23.1
GNC-24	Elevon Actuator Secondary Delta Pressure Anomaly	34-24.1
GNC-25	Elevon Aerosurface Profile Anomaly	34-25.1
GNC-26	Rudder/Speedbrake Position Anomaly	34-26.1
GNC-27	Rudder/Speedbrake PDU Secondary Delta Pressure Anomaly	34-27.1

SECTION 34: GUIDANCE, NAVIGATION AND CONTROL (CONTINUED)

SSID No.	Description/Violation Call	Page
GNC-28	Rudder Speedbrake Aerosurface Profile - Anomaly	34-28.1
GNC-29	Body Flap Control Discrete Anomaly	34-29.1
GNC-30	Body Flap Launch Position	34-30.1
GNC-31	Bodyflap Aerosurface Profile - Anomaly	34-31.1
GNC-32	Orbiter ASA Power Anomaly	34-32.1
GNC-33	SSIDs GNC-33 thru GNC-37 Reserved	34-33.1
GNC-38	Flight Control System Channel Failure Indication	34-38.1
GNC-39	Orbiter ATVC Power Anomaly	34-39.1
GNC-40	MPS TVC Actuator Position Anomaly	34-40.1
GNC-41	MPS TVC Actuator Secondary Delta Pressure Anomaly	34-41.1
GNC-42	MPS Engine TVC Actuator Profile Anomaly	34-42.1
GNC-43	OMS Actuator Launch Position Anomaly	34-43.1
GNC-44	OMS Gimbal Profile Anomaly	34-44.1
GNC-45	RJD Jet Chamber Pressure Indication Anomaly	34-45.1
GNC-46	RCS Vernier Driver Out Anomaly	34-46.1
GNC-47	RCS Vernier Logic RPC Anomaly	34-47.1
GNC-48	RCS Driver Power Anomaly	34-48.1
GNC-49	RJD Trickle Current Anomaly	34-49.1
GNC-50	SSIDs GNC-50 thru GNC-55 Reserved	34-50.1
GNC-56	IMU Hardware Bite Indication	34-56.1
GNC-57	Orbiter IMU Power Anomaly	34-57.1
GNC-58	IMU Temperature Ready Anomaly	34-58.1

SECTION 34: GUIDANCE, NAVIGATION AND CONTROL (CONTINUED)

SSID No.	Description/Violation Call	Page
GNC-59	IMU Over Temperature Indication	34-59.1
GNC-60	Redundancy Management IMU Failure Indication	34-60.1
GNC-61	IMU Software BITE Anomaly	34-61.1
GNC-62	IMU Gyrocompass Anomaly	34-62.1
GNC-63	IMU Gyrocompass Alignment 1 Anomaly	34-63.1
GNC-64	IMU Requirements When IRAMS In Use	34-64.1
GNC-65	IMU Transition Time to OPS 1 Exceeded (REQUIREMENT DELETED)	34-65.1
GNC-66	IMU Transmission Word Failure	34-66.1
GNC-67	IMU PRESSURE/COMMUNICATION ANOMALY	34-67.1
GNC-68	SSIDs GNC-68 thru GNC-72 Reserved	34-68.1
GNC-73	Air Data Transducer Assembly BITE Anomaly	34-73.1
GNC-74	Air Data Transducer Assembly (ADTA) Pressure Anomaly	34-74.1
GNC-75	Air Data Transducer Assembly Temperature Anomaly (REQUIREMENT DELETED)	34-75.1
GNC-76	SSIDs GNC-76 thru GNC-78 Reserved	34-76.1
GNC-79	Brake Pressure Anomaly	34-79.1
GNC-80	Brake Power Anomaly	34-80.1
GNC-81	Landing Gear Anti-Skid Anomaly	34-81.1
GNC-82	ANTI-SKID FAIL Light Anomaly	34-82.1
GNC-83	Nose Wheel Steering Anomaly	34-83.1
GNC-84	Nosewheel Position Signal Path Anomaly	34-84.1
GNC-85	DDU Power Supply Anomaly	34-85.1

SECTION 34: GUIDANCE, NAVIGATION AND CONTROL (CONTINUED)

SSID No.	Description/Violation Call	Page
GNC-FG02	Figure 34-02 Aerosurface Gimbal Profiles	34-FG02.1
GNC-FG03	Figure 34-03 SRB Bus C Power	34-FG03.1

LCC VIOLATION CALL: Forward Rotational Hand Controller Command Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V72K1155C	LH RHC Roll Cmd-A		(2,3,4)	(2,3,4)	deg	CI
V72K1170C	LH RHC Roll Cmd-B		(2,3,4)	(2,3,4)	deg	CI
V72K1185C	LH RHC Roll Cmd-C		(2,3,4)	(2,3,4)	deg	CI
V72K1156C	LH RHC Pitch Cmd-A		(2,3,4)	(2,3,4)	deg	CI
V72K1171C	LH RHC Pitch Cmd-B		(2,3,4)	(2,3,4)	deg	CI
V72K1186C	LH RHC Pitch Cmd-C		(2,3,4)	(2,3,4)	deg	CI
V72K1157C	LH RHC Yaw Cmd-A		(2,3,4)	(2,3,4)	deg	CI
V72K1172C	LH RHC Yaw Cmd-B		(2,3,4)	(2,3,4)	deg	CI
V72K1187C	LH RHC Yaw Cmd-C		(2,3,4)	(2,3,4)	deg	CI
V72K1205C	RH RHC Roll Cmd-A		(2,3,4)	(2,3,4)	deg	CI
V72K1220C	RH RHC Roll Cmd-B		(2,3,4)	(2,3,4)	deg	CI
V72K1235C	RH RHC Roll Cmd-C		(2,3,4)	(2,3,4)	deg	CI
V72K1206C	RH RHC Pitch Cmd-A		(2,3,4)	(2,3,4)	deg	CI
V72K1221C	RH RHC Pitch Cmd-B		(2,3,4)	(2,3,4)	deg	CI
V72K1236C	RH RHC Pitch Cmd-C		(2,3,4)	(2,3,4)	deg	CI
V72K1207C	RH RHC Yaw Cmd-A		(2,3,4)	(2,3,4)	deg	CI
V72K1222C	RH RHC Yaw Cmd-B		(2,3,4)	(2,3,4)	deg	CI
V72K1237C	RH RHC Yaw Cmd-C		(2,3,4)	(2,3,4)	deg	CI

TIME PERIOD:

(1) From OPS-1 Transition (T-20 minutes) To Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Redlines (RM limits) are: Pitch, 5.1 degrees; Roll, 6.8 degrees; Yaw 2.8 degrees. If a redline is violated perform the following computations. (For values indicated for right and left RHC.)
|Cmd A - Cmd B| greater than or equal to RM limit.
|Cmd B - Cmd C| greater than or equal to RM limit.
|Cmd A - Cmd C| greater than or equal to RM limit.
A fault exists if two or more are true.

(3) Verify in OPS-1 prior to Go For GLS start (T-9 minutes) that each set of of commands track within RM limits.

(4) If RHC is moved from detent and all three channels track each other within RM limits, the system is OK.

PREPLANNED CONTINGENCY PROCEDURE:

(5) Call crew to verify RHC out of detent if all three channels fail simultaneously.

NOTES:

(6) MCC Display: Roll/Pitch: 1 deg = 4.17 pct; Yaw: 1 deg = 6.99 pct.

REDLINE DERIVATION: CRITICALITY: 1R

(7) Fault Detection, Identification, and Recovery (FDIR) limits are applied for LCC.
(8) Rotational hand controller (RHC) is required for manual flight capability and for aborts. Redline allows determination of hardover failures.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) "Hot stick" control at MECO and for RTLS.
(10) If a fault exists, the system is no longer two-fault tolerant. A second failure will result in a dilemma being annunciated and no commands being executed.

CAUSES OF EXCEEDING REDLINE:

(11) Electronics failure.
(12) Transducer failure.
(13) Inadvertent motion of RHC by crew (i.e., during RHC communications switch operation).
(14) Mechanical failure.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
UNITS-->	deg								
V72K1155C	0.048	-23.8	23.8						
V72K1170C	0.048	-23.8	23.8						
V72K1185C	0.048	-23.8	23.8						
V72K1156C	0.048	-23.8	23.8						
V72K1171C	0.048	-23.8	23.8						
V72K1186C	0.048	-23.8	23.8						
V72K1157C	.0277	-13.88	13.88						
V72K1172C	.0277	-13.88	13.88						
V72K1187C	.0277	-13.88	13.88						
V72K1205C	0.048	-23.8	23.8						
V72K1220C	0.048	-23.8	23.8						
V72K1235C	0.048	-23.8	23.8						
V72K1206C	0.048	-23.8	23.8						
V72K1221C	0.048	-23.8	23.8						
V72K1236C	0.048	-23.8	23.8						
V72K1207C	.0277	-13.88	13.88						
V72K1222C	.0277	-13.88	13.88						
V72K1237C	.0277	-13.88	13.88						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 9.17	SHEET 1	ZONE Q-M(1-8
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-971099	SHEET 71A,B	ZONE
	DWG NO VS70-971102	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

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LCC VIOLATION CALL: Forward Translational Hand Controller Output Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V72K1315X	Fwd THC Pos X Output-A	2 of 3	0 (2)	NA	Event	CI
V72K1335X	Fwd THC Pos X Output-B		0 (2)	NA	Event	CI
V72K1355X	Fwd THC Pos X Output-C		0 (2)	NA	Event	CI
V72K1316X	Fwd THC Neg X Output-A		0 (2)	NA	Event	CI
V72K1336X	Fwd THC Neg X Output-B		0 (2)	NA	Event	CI
V72K1356X	Fwd THC Neg X Output-C		0 (2)	NA	Event	CI
V72K1320X	Fwd THC Pos Y Output-A		0 (2)	NA	Event	CI
V72K1340X	Fwd THC Pos Y Output-B		0 (2)	NA	Event	CI
V72K1360X	Fwd THC Pos Y Output-C		0 (2)	NA	Event	CI
V72K1321X	Fwd THC Neg Y Output-A		0 (2)	NA	Event	CI
V72K1341X	Fwd THC Neg Y Output-B		0 (2)	NA	Event	CI
V72K1361X	Fwd THC Neg Y Output-C		0 (2)	NA	Event	CI
V72K1325X	Fwd THC Pos Z Output-A		0 (2)	NA	Event	CI
V72K1345X	Fwd THC Pos Z Output-B		0 (2)	NA	Event	CI
V72K1365X	Fwd THC Pos Z Output-C		0 (2)	NA	Event	CI
V72K1326X	Fwd THC Neg Z Output-A		0 (2)	NA	Event	CI
V72K1346X	Fwd THC Neg Z Output-B		0 (2)	NA	Event	CI
V72K1366X	Fwd THC Neg Z Output-C		0 (2)	NA	Event	CI

TIME PERIOD:

(1) From OPS 1 Transition (T-20 minutes) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) If the THC is moved from detent and all three channels track each other the system is OK.

PREPLANNED CONTINGENCY PROCEDURE:

(3) Call crew to verify THC out of detent if all three channels fail simultaneously.

NOTES:

(4) Only one THC is available to the crew and to the downlist. Aft THC is available for forward THC replacement on-orbit.
(5) Only A outputs available in OPS 9.
(6) The tank avoidance maneuver is standard for all flights X & Z axes.
(7) Measurements are monitored by Redundancy Management (RM).

REDLINE DERIVATION: CRITICALITY: 1R

(8) All THC X & Z outputs are required to be logic "0". THC Y outputs are allowed to be 2 of 3.
(9) THC is required to back up auto -Z maneuver at external tank separation and +X output to back up OMS.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Reduced fault tolerance - Two THC X or Z failures will result in possible loss of vehicle translational capability.

CAUSES OF EXCEEDING REDLINE:

(11) Failed electronics.
(12) Failed switches.
(13) THC out of detent.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 9.17	SHEET 1	ZONE I2
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-971099	SHEET 71D	ZONE
	DWG NO VS70-971102	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: Rudder Pedal Command Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V72K1530C	Left Rudder Pedal Cmd-A		(2,3)	(2,3)	deg	CI
V72K1531C	Left Rudder Pedal Cmd-B		(2,3)	(2,3)	deg	CI
V72K1532C	Left Rudder Pedal Cmd-C		(2,3)	(2,3)	deg	CI
V72K1540C	Right Rudder Pedal Cmd-A		(2,3)	(2,3)	deg	CI
V72K1541C	Right Rudder Pedal Cmd-B		(2,3)	(2,3)	deg	CI
V72K1542C	Right Rudder Pedal Cmd-C		(2,3)	(2,3)	deg	CI

TIME PERIOD:

(1) From OPS 1 Transition (T-20 minutes) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Redline is 3.6 degrees. If a redline is violated, perform the following computations. (For right and left side.)
|Cmd A - Cmd B| greater than or equal to 3.6 degrees.
|Cmd B - Cmd C| greater than or equal to 3.6 degrees.
|Cmd A - Cmd C| greater than or equal to 3.6 degrees.
A fault exists if two or more are true.

(3) Verify in OPS 1 prior to Go for GLS Start (T-9 minutes) that each set of commands is within 3.6 deg of each other.

(4) If the rudder pedals are moved from neutral and all three channels track each other within RM limits, the system is OK.

PREPLANNED CONTINGENCY PROCEDURE:

(5) Call crew to verify rudder pedals out of neutral if all three channels fail simultaneously.

NOTES:

(6) There is no redundancy management (RM) in OPS 1; therefore, the ground must communicate failure notification to the crew for action.

(7) Left and right rudder pedals are mechanically linked which provides a dual set of triply redundant sensors.

(8) Related O/I Measurements: V73H1504A Left Rudder Pedal Output-A.
V73H1505A Left Rudder Pedal Output-B.
V73H1506A Left Rudder Pedal Output-C.
V73H1507A Right Rudder Pedal Output-A.
V73H1508A Right Rudder Pedal Output-B.
V73H1509A Right Rudder Pedal Output-C.

(9) MCC Display: One degree = 4.44 percent.

REDLINE DERIVATION: CRITICALITY: 1R

(10) FDIR not processed in OPS 1; therefore, LCC check for FDIR limits is required because crew can induce inadvertent inputs during countdown/prelaunch.

REDLINE DERIVATION: (Continued)

(11) Function required for normal landing.
(12) FDIR limits for MM 602, 603, 304, 305 are applied for LCC.

CONSEQUENCES OF EXCEEDING REDLINE:

(13) Loss of one element of RPTA redundancy.
(14) If an RPTA output is failed at maximum and a second output fails the same way prior to MECO, then a hardover rudder is commanded on an RTLS or TAL when CSS Roll/Yaw is selected after Mach 5.

CAUSES OF EXCEEDING REDLINE:

(15) Failed transducer.
(16) Electronics failure.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
n = 3 AND 4 FOR LEFT AND RIGHT CONTROLLERS RESPECTIVELY									
UNITS-->	deg								
V72K15n0C	-.045	+22.5	-22.5						
V72K15n1C	-.045	+22.5	-22.5						
V72K15n2C	-.045	+22.5	-22.5						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 9.17 SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: Right SBTC CMD and Takeover Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V72K1585C	RH SBTC Cmd-A		(3)	(3)	deg	DI
V72K1588C	RH SBTC Cmd-B		(2,3)	(2,3)	deg	DI
V72K1591C	RH SBTC Cmd-C		(2,3)	(2,3)	deg	DI
V72K1587X	RH SBTC Takeover-A		0	NA	Event	DI
V72K1590X	RH SBTC Takeover-B		0 (2)	NA	Event	DI
V72K1593X	RH SBTC Takeover-C		0 (2)	NA	Event	DI

TIME PERIOD:

(1) Verify one time prior to OPS 1 Transition (T-20 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) MDM BITE test 4 required to verify limits (measurements not available in downlist) (6). If this redline is violated, perform the following computations. (For Right SBTC.)
|Cmd A - Cmd B| greater than or equal to 5.3 degrees.
|Cmd B - Cmd C| greater than or equal to 5.3 degrees.
|Cmd A - Cmd C| greater than or equal to 5.3 degrees.
A fault exists if two or more are true.
(3) Commands A, B, and C must track within 5.3 degrees of each other.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) Left SBTC is not functional in OPS 1.
(5) No redundancy management (RM) during OPS 1.
(6) Right SBTC Cmd-A and Right SBTC Takeover-A are downlisted in formats 44 and 60. All measurements are available in format 42.

REDLINE DERIVATION: CRITICALITY: 1R

(7) Manual throttle is required for systems TAL aborts (to allow time for OMS dump).
(8) FDIR limits for MM602, 603, 304, and 305 are applied for LCC.
(9) Three good commands and contacts required.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) If a fault exists, SBTC is no longer single-fault tolerant. In OPS 1, a second failure of a command or takeover discrete may result in loss of manual throttle capability.

CAUSES OF EXCEEDING REDLINE:

(11) Failed electronics.
(12) Failed switches.
(13) Failed transducer.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	deg								
V72K1585C	.1164	-56.8	59.6						
V72K1588C	.1164	-56.8	59.6						
V72K1591C	.1164	-56.8	59.6						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-971099 SHEET 71F ZONE
DWG NO VS70-971102 SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

SSIDs GNC-05 thru GNC-07 Reserved

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LCC VIOLATION CALL: Orbiter Rate Gyro Power Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76X4293E	PCA Flt Cont RGA 1 RPC A On	(2,3)	ON	NA	Event	CI
V76X4295E	PCA Flt Cont RGA 4 RPC A On	(2,3)	ON	NA	Event	CI
V76X4296E	PCA Flt Cont RGA 4 RPC C On	(2,3)	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) If both PCA Flt Cont RGA 1 RPCs (V76X4293E and V76X4294E) or both PCA Flt Cont RGA 4 RPCs (V76X4295E and V76X4296E) indications are OFF, then perform the following switch verifications for the appropriate RGA (ref. S0007.500).
- Verify RGA 1 Switch is ON (Pnl O14:A)
- Verify RGA 4 Switch is ON (Pnl O15:A)

If the respective RGA switch is not in the correct position then reposition. If both RGA indications are recovered, then LCC violation cleared, continue countdown.

(3) If a PCA Flt Cont RGA RPC indicates OFF, then perform the following (ref. S0007.500).
- Drop the specified control bus and verify that the appropriate Spin Motor Run Detector (SMRDs) remain ON with redundant RPC unpowered (ref OMRS S00GEN.780).
  - For RGA 1 RPC A, drop Control Bus AB2.
  - For RGA 4 RPC A, drop Control Bus CA3.
  - For RGA 4 RPC C, drop Control Bus CA1.
- If the appropriate SMRDs remain ON, then instrumentation failure is confirmed. LCC violation cleared, continue countdown.

NOTES:

(4) Loss of V76X4294E PCA Flt Cont RGA 1 RPC B ON is acceptable since a subsequent MN A or Control Bus AB1 failure removes power from Orbiter RGA 1 only.

(5) RGA Power Indications

RGA 1:	V79S1829E RGA 1 Pwr ON Cmd A	(switch scan)
	V76X4293E PCA Flt Cont RGA 1 RPC A On	(LCC GNC-08)
	V76X4294E PCA Flt Cont RGA 1 RPC B On	
RGA 2:	V79S1834E RGA 2 Pwr On Cmd B	(switch scan)
RGA 3:	V79S1839E RGA 3 Pwr On Cmd C	(switch scan)
RGA 4:	V79S1844E RGA 4 Pwr On Cmd C	(switch scan)
	V76X4295E PCA Flt Cont RGA 4 RPC A On	(LCC GNC-08)
	V76X4296E PCA Flt Cont RGA 4 RPC C On	(LCC GNC-08)

REDLINE DERIVATION: CRITICALITY: 1R

(6) a. SSID Intent Summary - The listed RGA functions are required to maintain two-fault tolerance. Two fault tolerance is necessary to prevent a single fault from eliminating multiple RGAs. The RGAs provide roll, pitch and yaw rates to the flight software. This data is used to develop the aerosurface, SSME and SRB TVC position commands during ascent and landing. Erroneous rates could result in excessive structural loading that may result in loss of vehicle.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development -

1. PCA Flt Cont RGA 1 RPC A ON is required to protect against the loss of MN B or APCA 5 (removes power from RGA 2 and remaining RPC on RGA 1).

2. PCA Flt Cont RGA 4 RPC A ON is required to protect against the loss of MN C or MPCA 3 (loss of either MN C or MPCA 3 removes power from RGA 3 and remaining RPC on RGA 4).

3. PCA Flt Cont RGA 4 RPC C ON is required to protect against the loss of Control Bus CA1 (removes power from RGA 3 and remaining RPC on RGA 4).

d. Time Period - The RGAs are nominally turned ON during the T-11 hour hold, prior to the start of LCC effectivity. The time period effectivity for this SSID begins at the Start of ET Cryo Tanking at approximately T-6 hours. This system is functionally stable throughout the time period. Due to the criticality of the system, the time period ends at Go For RSLS Start at T-31 seconds. This ensures continuous health monitoring of RGA 1 and RGA 4 power busses for this 1R hardware system.

e. Requirement - N/A

f. Preplanned Contingency Procedure -

1. Multiple RGA OFF indications will most likely be caused by switch position. RGA 1 and RGA 4 power switches are a Double Pole Single Throw configuration. One panel switch throw energizes both RPC bus feeds simultaneously. A single RGA RPC OFF indication will not direct an immediate crew action (switch check) on the improbable chance that one switch contact is not valid.

2. The PCP will determine if the instrumentation monitoring the RGA power source fails. Powering down the control bus feeding the redundant RPC and verifying the associated RGA SMRD signal remains ON verifies only the suspect RPC monitoring instrumentation has failed.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Loss of Orbiter RGA two-fault tolerance.
(8) Erroneous RGA rate data could result in loss of vehicle due to excessive structural loading.
(9) Reference Orbiter Hazard Report ORBI-061.

CAUSES OF EXCEEDING REDLINE:

(10) Wiring failure.
(11) RPC failure.
(12) Switch failure.
(13) Instrumentation failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 9.8	SHEET 1	ZONE V,U,T
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-971099	SHEET 71P	ZONE 19A
	DWG NO VS70-971099	SHEET 71T	ZONE 13B,16D

ELEMENT: Orbiter SUBSYSTEM: GNC

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LCC VIOLATION CALL: Accelerometer Power Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76X4297E	PCA Flt Cont Accel 3 RPC A On	(2)	ON	NA	Event	CI
V76X4298E	PCA Flt Cont Accel 3 RPC C On	(2)	ON	NA	Event	CI
V76X4299E	PCA Flt Cont Accel 4 RPC C On	(2)	ON	NA	Event	CI
V76X4300E	PCA Flt Cont Accel 4 RPC B On	(2)	ON	NA	Event	CI
V79S2004E	Accel Assy 1 Pwr On Cmd A	(3)	ON	NA	Event	CI
V79S2007E	Accel Assy 2 Pwr On Cmd B	(3)	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Loss of RPC ON indication requires evaluation. (3,4)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Verify AA power switches are configured correctly (ref S0007 Vol 5). If switch repositioning clears problem, LCC violation cleared, continue countdown.

(4) To confirm instrumentation failure (for single measurement failure) drop specified control bus (ref OMRS S00GEN.780) and verify torquing capability with redundant RPC unpowered (Ref S0007 Vol 5).
  For Accelerometers 1 and 2, no control bus drop is required;
  For Accelerometer 3 RPC A, drop Control Bus CA3;
  For Accelerometer 3 RPC C, drop Control Bus CA2;
  For Accelerometer 4 RPC C, drop Control Bus BC1;
  For Accelerometer 4 RPC B, drop Control Bus BC3.
  For confirmed instrumentation failure, LCC violation cleared, continue countdown.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(5) All indications required as shown to be two-fault tolerant.

(6) PCA Flt Cont Accel 3 RPC A is required to protect against the loss of MN C FPC 3 (takes RPC C of AA 4 and remaining RPC of AA 3) and MN B (takes AA 2 and RPC B of AA 4) resulting in the loss of three AAs and bad feedback into flight control.

(7) PCA Flt Cont Accel 3 RPC C is required to protect against the loss of MN A (takes AA 1 and remaining RPC of AA 3) and another AA resulting in the loss of three AAs and bad feedback into flight control.

(8) PCA Flt Cont Accel 4 RPC C is required to protect against the loss of MN B (takes AA 2 and remaining RPC of AA 4) and another AA resulting in the loss of three AAs and bad feedback into flight control.

REDLINE DERIVATION: (Continued)

(9) PCA Flt Cont Accel 4 RPC B is required to protect against the loss of MN C FPC 3 (takes RPC C of AA 3 and remaining RPC of AA 4) and MN A (takes AA 1 and RPC A of AA 3) resulting in the loss of three AAs and bad feedback into flight control.
(10) Accel Assy 1 and 2 power are required to protect against two AA failures resulting in the loss of three AAs and bad feedback into flight control.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Loss of two-fault tolerance.

CAUSES OF EXCEEDING REDLINE:

(12) Wiring failure.
(13) RPC failure.
(14) Switch failure.
(15) Instrumentation failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 9.8	SHEET 9-8	ZONE U4,T3
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-971099	SHEET 71U,V,W	ZONE
	DWG NO VS70-971102	SHEET Y	ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: SRB Bus C Power Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76X4399E	PCA L SRB Bus C RPC A On		ON	NA	Event	CI
V76X4390E	PCA R SRB Bus C RPC A On		ON	NA	Event	CI
V76X4393E	PCA L SRB Bus C RPC C On		ON	NA	Event	CI
V76X4394E	PCA R SRB Bus C RPC C On		ON	NA	Event	CI

TIME PERIOD:

(1) From SRGA 3 and 4 Power Application (T-3 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES: 34-03

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) To confirm instrumentation failure, command off alternate Remote Power Controller (RPC) for affected bus. If affected SRB Rate Gyro Assembly (SRGA) remains on, instrumentation failure is confirmed. Command alternate RPC back on, LCC violation cleared, continue countdown. Reference S0007.500, SRB Bus C Power Anomaly.

NOTES:

(4) SRGA 3 is left SRB, SRGA 4 is right SRB.

REDLINE DERIVATION: CRITICALITY: 1R

(5) a. SSID Intent Summary - This redline ensures that both SRB Bus C RPC A (fed by Orbiter Bus A) and RPC C (fed by Orbiter Bus C) are present and providing redundant power to SRGA 3 and SRGA 4. Redundant power is essential to prevent simultaneous loss of two SRGAs. The simultaneous power loss to two of the four SRGAs causes erroneous rate data to propagate through and be selected by the ascent Digital Autopilot (DAP). The vehicle will respond to the selected erroneous rates until the absolute value of the actual vehicle rates, which are in the opposite direction, become the higher values. Possible loss of vehicle control and structural failure could result due to erroneous rates being selected and the subsequent switch back to actual rates. The power loss signature for the SRGA plateaus are approximately 4.5 deg/sec and decays to zero within 5-10 seconds. If only one SRGA loses power, the Redundancy Management (RM) software will reject the erroneous rate.

b. Voting Logic - N/A

REDLINE DERIVATION: (Continued)

c. Minimum and Maximum Redline Development - The minimum redline limit of ON indicates that the SRB Bus C RPC is operational. All four RPCs are required to be on in order to maintain a two-fault tolerance during ascent. There are no maximum redline limits.

d. Time Period - The time period of SRGA 3 and SRGA 4 power application at T-3 hours to commitment for launch at T-31 seconds ensures continuous health monitoring from power application down through commitment for launch for 1R hardware systems.

e. Requirement - This requirement ensures that the two RPCs for both SRGA3 and SRGA4 are operational down to T-31 seconds.

f. Preplanned Contingency Procedure - The PCP will determine if the problem is related to the instrumentation that monitors the SRGA power feeds. Powering the alternate RPC off and verifying that the affected SRGA remains on confirms a failure of the RPC indication only.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Loss of SRB RGA two-fault tolerance.
(7) Loss of redundant power for SRB chamber pressure indications.
(8) May allow a single fault scenario during ascent that could result in loss of vehicle due to excessive structural loading.

CAUSES OF EXCEEDING REDLINE:

(9) Wiring failure.
(10) RPC failure.
(11) Electronics failure.
(12) Instrumentation failure.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 9.8 SHEET ZONE L4, L8
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS72-948099 SHEET 48G, H ZONE 22

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: Orbiter RGA Spin Motor Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V79X1860X	RGA 1 Roll SMRD Ind		1	NA	Event	CI
V79X1861X	RGA 1 Pitch SMRD Ind		1	NA	Event	CI
V79X1862X	RGA 1 Yaw SMRD Ind		1	NA	Event	CI
V79X1865X	RGA 2 Roll SMRD Ind		1	NA	Event	CI
V79X1866X	RGA 2 Pitch SMRD Ind		1	NA	Event	CI
V79X1867X	RGA 2 Yaw SMRD Ind		1	NA	Event	CI
V79X1870X	RGA 3 Roll SMRD Ind		1	NA	Event	CI
V79X1871X	RGA 3 Pitch SMRD Ind		1	NA	Event	CI
V79X1872X	RGA 3 Yaw SMRD Ind		1	NA	Event	CI
V79X1875X	RGA 4 Roll SMRD Ind		1	NA	Event	CI
V79X1876X	RGA 4 Pitch SMRD Ind		1	NA	Event	CI
V79X1877X	RGA 4 Yaw SMRD Ind		1	NA	Event	CI

TIME PERIOD:

(1) From 2 Minutes After "Power Application to RGA" to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES: 34-03

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(2) Four RGAs are required to be two-fault tolerant.
(3) When the motor is running outside the + or - 2% synchronous speed limit, the detector shall issue a logic 0 (fail condition); otherwise, a logic 1 (pass condition).

CONSEQUENCES OF EXCEEDING REDLINE:

(4) Gyro performance will be degraded.
(5) System will not be two-fault tolerant.

CAUSES OF EXCEEDING REDLINE:

(6) Gyro failure.
(7) Electronics failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 9.8	SHEET	ZONE P7
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-971099	SHEET 71P, R,	ZONE
	DWG NO VS70-971102	SHEET 71S, T	ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: Orbiter Rate Gyro Fail | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V93X4516X	RGA 1 Des Cmd/Fail		OFF	NA	Event	CI
V93X4518X	RGA 2 Des Cmd/Fail		OFF	NA	Event	CI
V93X4520X	RGA 3 Des Cmd/Fail		OFF	NA	Event	CI
V93X4522X	RGA 4 Des Cmd/Fail		OFF	NA	Event	CI

TIME PERIOD:

(1) OPS 1 Transition (T-20 minutes) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) The following parameters provide insight into the status of the RGAs.
Compensated Yaw Rate 1 - V95R4061C Compensated Roll Rate 1 - V95R4001C
Compensated Yaw Rate 2 - V95R4062C Compensated Roll Rate 2 - V95R4002C
Compensated Yaw Rate 3 - V95R4063C Compensated Roll Rate 3 - V95R4003C
Compensated Yaw Rate 4 - V95R4064C Compensated Roll Rate 4 - V95R4004C
Compensated Pitch Rate 1 - V95R4031C Selected RGA Roll Rate - V90R5301C
Compensated Pitch Rate 2 - V95R4032C Selected RGA Pitch Rate - V90R5321C
Compensated Pitch Rate 3 - V95R4033C Selected RGA Yaw Rate - V90R5341C
Compensated Pitch Rate 4 - V95R4034C
(3) An "OFF" = RGA not failed; an "ON" = RGA failed indication.

REDLINE DERIVATION: CRITICALITY: 1R

(4) Four RGAs are required to maintain two-fault tolerance.
(5) FDIR $|Si - Ss| > tau$ for ten consecutive times, then Si is identified as failed.
where: Si is the incoming signal,
Ss is the selected signal, and
tau is the FDIR threshold limit.
$tau = |Ss|(LSF)+C$ = Threshold Limit

where:	LSF is the Limit Scale Factor	C is a constant
Roll	0.08	0.8
Pitch	0.065	0.55
Yaw	0.065	0.63

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Loss of Orbiter RGA two-fault tolerance.

CAUSES OF EXCEEDING REDLINE:

(7) Gyro failure.
(8) Electronics failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: Accelerometer Fail | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V93X4435X	AA 1 Des Cmd/Fail		OFF	NA	Event	CI
V93X4436X	AA 2 Des Cmd/Fail		OFF	NA	Event	CI
V93X4437X	AA 3 Des Cmd/Fail		OFF	NA	Event	CI
V93X4438X	AA 4 Des Cmd/Fail		OFF	NA	Event	CI

TIME PERIOD:

(1) OPS 1 Transition (T-20 minutes) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) The following parameters provide insight into the status of the AAs:
Compensated Lat Acceln 1 - V95A4101C Compensated Norm Acceln 1 - V95A4151C
Compensated Lat Acceln 2 - V95A4102C Compensated Norm Acceln 2 - V95A4152C
Compensated Lat Acceln 3 - V95A4103C Compensated Norm Acceln 3 - V95A4153C
Compensated Lat Acceln 4 - V95A4104C Compensated Norm Acceln 4 - V95A4154C
Selected AA Lat Acceln - V90A5361C1 Selected AA Norm Acceln - V90A5381C1

(3) An "OFF" = AA not failed indication, an "ON" = AA failed indication.

REDLINE DERIVATION: CRITICALITY: 1R

(4) Four AAs are required to maintain two-fault tolerance.

(5) FDIR
If $|Si - Ss|$ exceeds tau five consecutive times then Si is identified as failed.

where: Si is the incoming signal,
Ss is the selected signal, and
tau is the FDIR threshold limit.

Lateral Threshold Limit = 0.08G Normal Threshold Limit = 0.063G

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Loss of AA two-fault tolerance.

CAUSES OF EXCEEDING REDLINE:

(7) Electronic failure.

(8) Sensing element failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: SRB RGA Fail Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V90X6748X	String 1 SRGA Fail		OFF	NA	Event	CI
V90X6749X	String 2 SRGA Fail		OFF	NA	Event	CI
V90X6750X	String 3 SRGA Fail		OFF	NA	Event	CI
V90X6751X	String 4 SRGA Fail		OFF	NA	Event	CI

TIME PERIOD:

(1) From OPS 1 Transition (T-20 minutes) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) Fail flag cannot be reset without GPC IPL and resultant loss of redundant set, LCC violation confirmed, No Go for launch.

NOTES:

(3) Data: V95R4260C String 1 SRGA Comp Pitch Rate.
V95R4262C String 2 SRGA Comp Pitch Rate.
V95R4270C String 3 SRGA Comp Pitch Rate.
V95R4272C String 4 SRGA Comp Pitch Rate.
V95R4261C String 1 SRGA Comp Yaw Rate.
V95R4263C String 2 SRGA Comp Yaw Rate.
V95R4271C String 3 SRGA Comp Yaw Rate.
V95R4273C String 4 SRGA Comp Yaw Rate.
V90R2511C SRGA Sel Pitch Rate.
V90R2512C SRGA Sel Yaw Rate.

(4) An "OFF" = SRGA not failed, an "ON" = SRGA failed.

REDLINE DERIVATION: CRITICALITY: 1R

(5) Four SRGAs are required to maintain two-fault tolerance.

(6) FDIR: If $|Si - Ss|$ exceeds tau five consecutive times, then Si is identified as failed.

where: Si is the incoming signal,
Ss is the selected signal, and
tau is the FDIR threshold limit.

$tau = |Ss|(LSF)+C$

where values for LSF (Limit Scale Factor) and C (a constant) are shown below:

	LSF	C
Pitch	0.05	0.45
Yaw	0.05	0.45

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Loss of SRB RGA two-fault tolerance.

CAUSES OF EXCEEDING REDLINE:

(8) Gyro failure.
(9) Electronics failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: SRB RGA 1, 2, 3, 4 SMRD Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B79X1845X	SRGA 1 Pitch SMRD		ON	NA	Event	CI
B79X1846X	SRGA 3 Pitch SMRD		ON	NA	Event	CI
B79X1848X	SRGA 1 Yaw SMRD		ON	NA	Event	CI
B79X1849X	SRGA 3 Yaw SMRD		ON	NA	Event	CI
B79X2845X	SRGA 2 Pitch SMRD		ON	NA	Event	CI
B79X2846X	SRGA 4 Pitch SMRD		ON	NA	Event	CI
B79X2848X	SRGA 2 Yaw SMRD		ON	NA	Event	CI
B79X2849X	SRGA 4 Yaw SMRD		ON	NA	Event	CI

TIME PERIOD:

(1) From 10 Seconds After Applying Power to Rate Gyros (approximately T-3 hours) To Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) No Spin Motor Run Detector (SMRD) dropouts are allowed, LCC violation confirmed, No Go for launch.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) SRB Rate Gryo Assemblies (SRGAs) 1 and 3 are on the left side. SRGAs 2 and 4 are on the right side.
(4) All SRGAs contain krytox gyros.

REDLINE DERIVATION: CRITICALITY:

(5) The SRGA SMRD ON indication ensures that the gyros are at the correct run speed (the synchronous speed, 24,000 RPM +/- 2%).
(6) All SRGAs are required to maintain two-fault tolerance.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Loss of one spin motor results in loss of redundancy.

CAUSES OF EXCEEDING REDLINE:

(8) Failure of spin motor.
(9) Loss of power.
(10) Electronics failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 9.8	SHEET 1 of 1	ZONE D7-G8
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO V572-948099	SHEET 48 C,D	ZONE 5
	DWG NO V572-948102	SHEET E,F,G,H	ZONE

ELEMENT: SRB SUBSYSTEM: GNC

LCC VIOLATION CALL: SRB RGA Rate Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
B79R1410C	SRGA 1 Pitch Rate		-0.22	+0.22	(4)	CI
B79R2410C	SRGA 2 Pitch Rate		-0.22	+0.22	(4)	CI
B79R1411C	SRGA 1 Yaw Rate		-0.22	+0.22	(4)	CI
B79R2411C	SRGA 2 Yaw Rate		-0.22	+0.22	(4)	CI
B79R1412C	SRGA 3 Pitch Rate		-0.22	+0.22	(4)	CI
B79R2412C	SRGA 4 Pitch Rate		-0.22	+0.22	(4)	CI
B79R1413C	SRGA 3 Yaw Rate		-0.22	+0.22	(4)	CI
B79R2413C	SRGA 4 Yaw Rate		-0.22	+0.22	(4)	CI

TIME PERIOD:

(1) Rate gyro 1/2/3/4 Null Test From Completion of RGA Torque Test (T-3 hours) to OPS 1 Transition (T-20 Minutes)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) RGA RM fail discretes are used for LCC evaluation post OPS-1 Transition (T-20 minutes) (Reference SSID: GNC-14).
(3) RGAs 1 and 3 are on the left SRB. RGAs 2 and 4 are on the right SRB.
(4) Degrees per second.

REDLINE DERIVATION: CRITICALITY:

(5) Four SRGAs are required to maintain fail operational/fail safe capability.
(6) This redline verifies that the RGA output signals do return to null after being torqued and remain within tolerance.
(7) The redlines are set to protect the OPS 1 FDIR limit of 0.45 degrees per second (+0.22 and -0.22 express the widest range of acceptable outputs).

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Loss of rate gyro two-fault tolerance.

CAUSES OF EXCEEDING REDLINE:

(9) Rate gyro failure.
(10) Electronics malfunction.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	deg/sec								
B79R1410C	0.02	-10	10						
B79R2410C	0.02	-10	10						
B79R1411C	0.02	-10	10						
B79R2411C	0.02	-10	10						
B79R1412C	0.02	-10	10						
B79R2412C	0.02	-10	10						
B79R1413C	0.02	-10	10						
B79R2413C	0.02	-10	10						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 9.8 SHEET ZONE N/A
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SRB SUBSYSTEM: GNC

SSIDs GNC-17 thru GNC-21 Reserved

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LCC VIOLATION CALL: Elevon Actuator Position Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V58H0802A	L Inbd Elevon Actr Chan 1 Posn	(2)	-0.52	1.18	Deg	CI
V58H0803A	L Inbd Elevon Actr Chan 2 Posn	(2)	-0.52	1.18	Deg	CI
V58H0804A	L Inbd Elevon Actr Chan 3 Posn	(2)	-0.52	1.18	Deg	CI
V58H0805A	L Inbd Elevon Actr Chan 4 Posn	(2)	-0.52	1.18	Deg	CI
V58H0852A	L Outbd Elevon Actr Chan 1 Posn	(2)	-0.36	1.34	Deg	CI
V58H0853A	L Outbd Elevon Actr Chan 2 Posn	(2)	-0.36	1.34	Deg	CI
V58H0854A	L Outbd Elevon Actr Chan 3 Posn	(2)	-0.36	1.34	Deg	CI
V58H0855A	L Outbd Elevon Actr Chan 4 Posn	(2)	-0.36	1.34	Deg	CI
V58H0902A	R Inbd Elevon Actr Chan 1 Posn	(2)	-0.52	1.18	Deg	CI
V58H0903A	R Inbd Elevon Actr Chan 2 Posn	(2)	-0.52	1.18	Deg	CI
V58H0904A	R Inbd Elevon Actr Chan 3 Posn	(2)	-0.52	1.18	Deg	CI
V58H0905A	R Inbd Elevon Actr Chan 4 Posn	(2)	-0.52	1.18	Deg	CI
V58H0952A	R Outbd Elevon Actr Chan 1 Posn	(2)	-0.36	1.34	Deg	CI
V58H0953A	R Outbd Elevon Actr Chan 2 Posn	(2)	-0.36	1.34	Deg	CI
V58H0954A	R Outbd Elevon Actr Chan 3 Posn	(2)	-0.36	1.34	Deg	CI
V58H0955A	R Outbd Elevon Actr Chan 4 Posn	(2)	-0.36	1.34	Deg	CI

TIME PERIOD:

(1) Post Aerosurface Profile Check (approximately T-3 minutes) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 3 of 4 acceptable for confirmed instrumentation failure (exclusive of transducer) with no accompanying occurrence of a channel anomaly. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) If equivalent GPC position indication agrees with other 3 OI position indications, instrumentation failure is confirmed, LCC violation cleared, continue countdown (Ref: S0007 Vol 5).

NOTES:

(4) Transducer is used in the elevon position feedback circuitry.
(5) There is no position feedback RM (FDIR or SF) during OPS 1.

REDLINE DERIVATION: CRITICALITY: 1R

(6) - Ensures availability of four good transducers.
- Ensures Elevons are in the proper position for launch.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Structural damage caused by improper launch configuration.
(8) Elevons not responding as design requires.
(9) Launch would be single-fault tolerant with one failure not associated with instrumentation.

CAUSES OF EXCEEDING REDLINE:

(10) ASA failure.
(11) Actuator failure.
(12) DPS command problem.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 8 AND 9 FOR LEFT AND RIGHT ELEVON ACTUATORS									
UNITS-->	deg								
V58H0n02A	0.232	-36.4	21.6						
V58H0n03A	0.232	-36.4	21.6						
V58H0n04A	0.232	-36.4	21.6						
V58H0n05A	0.232	-36.4	21.6						
V58H0n52A	0.232	-36.4	21.6						
V58H0n53A	0.232	-36.4	21.6						
V58H0n54A	0.232	-36.4	21.6						
V58H0n55A	0.232	-36.4	21.6						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 9.11	SHEET	ZONE
	DWG NO 9.16	SHEET 1	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-971102	SHEET 71AT,AU	ZONE A, A
	DWG NO VS70-971099	SHEET 71AW,AY	ZONE A, A

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: Elevon Actuator Primary Delta Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V58P0916C	R Inbd Elevon Pri Delta Press 1		-230	+230	psid	CI
V58P0917C	R Inbd Elevon Pri Delta Press 2		-230	+230	psid	CI
V58P0918C	R Inbd Elevon Pri Delta Press 3		-230	+230	psid	CI
V58P0919C	R Inbd Elevon Pri Delta Press 4		-230	+230	psid	CI
V58P0966C	R Outbd Elevon Pri Delta Press 1		-230	+230	psid	CI
V58P0967C	R Outbd Elevon Pri Delta Press 2		-230	+230	psid	CI
V58P0968C	R Outbd Elevon Pri Delta Press 3		-230	+230	psid	CI
V58P0969C	R Outbd Elevon Pri Delta Press 4		-230	+230	psid	CI
V58P0816C	L Inbd Elevon Pri Delta Press 1		-230	+230	psid	CI
V58P0817C	L Inbd Elevon Pri Delta Press 2		-230	+230	psid	CI
V58P0818C	L Inbd Elevon Pri Delta Press 3		-230	+230	psid	CI
V58P0819C	L Inbd Elevon Pri Delta Press 4		-230	+230	psid	CI
V58P0866C	L Outbd Elevon Pri Delta Press 1		-230	+230	psid	CI
V58P0867C	L Outbd Elevon Pri Delta Press 2		-230	+230	psid	CI
V58P0868C	L Outbd Elevon Pri Delta Press 3		-230	+230	psid	CI
V58P0869C	L Outbd Elevon Pri Delta Press 4		-230	+230	psid	CI

TIME PERIOD:

(1) From Hydraulic Activation (T-5 minutes) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Redline limits are not applicable during aerosurface check.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) RM in major mode 102 only.

REDLINE DERIVATION: CRITICALITY: 1R

(4) Required for load relief. Vehicle is not two-fault tolerant for ascent.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Loss of interloop stability.
(6) Not two-fault tolerant for load relief capability.

CAUSES OF EXCEEDING REDLINE:

(7) Actuator failure.
(8) Electronics failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 8 AND 9 FOR LEFT AND RIGHT ELEVON ACTUATORS									
UNITS-->	psid								
V58P0n16C	5.988	-2994	2994						
V58P0n17C	5.988	-2994	2994						
V58P0n18C	5.988	-2994	2994						
V58P0n19C	5.988	-2994	2994						
V58P0n66C	5.988	-2994	2994						
V58P0n67C	5.988	-2994	2994						
V58P0n68C	5.988	-2994	2994						
V58P0n69C	5.988	-2994	2994						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 9.11	SHEET	ZONE
	DWG NO 9.16	SHEET 1	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-971102	SHEET 71AT,AU	ZONE A, A
	DWG NO VS70-971099	SHEET 71AW,AY	ZONE A, A

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: Elevon Actuator Secondary Delta Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V58P0912A	R Inbd Elevon Sec Delta Press 1	(3)	-850	+850	psid	CI
V58P0913A	R Inbd Elevon Sec Delta Press 2	(3)	-850	+850	psid	CI
V58P0914A	R Inbd Elevon Sec Delta Press 3	(3)	-850	+850	psid	CI
V58P0915A	R Inbd Elevon Sec Delta Press 4	(3)	-850	+850	psid	CI
V58P0962A	R Outbd Elevon Sec Delta Press 1	(3)	-850	+850	psid	CI
V58P0963A	R Outbd Elevon Sec Delta Press 2	(3)	-850	+850	psid	CI
V58P0964A	R Outbd Elevon Sec Delta Press 3	(3)	-850	+850	psid	CI
V58P0965A	R Outbd Elevon Sec Delta Press 4	(3)	-850	+850	psid	CI
V58P0812A	L Inbd Elevon Sec Delta Press 1	(3)	-850	+850	psid	CI
V58P0813A	L Inbd Elevon Sec Delta Press 2	(3)	-850	+850	psid	CI
V58P0814A	L Inbd Elevon Sec Delta Press 3	(3)	-850	+850	psid	CI
V58P0815A	L Inbd Elevon Sec Delta Press 4	(3)	-850	+850	psid	CI
V58P0862A	L Outbd Elevon Sec Delta Press 1	(3)	-850	+850	psid	CI
V58P0863A	L Outbd Elevon Sec Delta Press 2	(3)	-850	+850	psid	CI
V58P0864A	L Outbd Elevon Sec Delta Press 3	(3)	-850	+850	psid	CI
V58P0865A	L Outbd Elevon Sec Delta Press 4	(3)	-850	+850	psid	CI

TIME PERIOD:

(1) Post Aerosurface Profile Check (approximately T-3 minutes, 20 seconds) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) The algebraic sum of the four secondary delta pressure measurements for each of the elevon actuators shall equal 0 + 370 or - 440 psid, one time verification after profile test.

(3) 3 of 4 required for verifiable instrumentation failure (exclusive of transducer) (4).

PREPLANNED CONTINGENCY PROCEDURE:

(4) If 4 of 4 elevon secondary delta pressures are not within + or - 850 psid, then hold at T-31 seconds. If not clear at T-31 seconds rerun aero slew to attempt clear. If clear, LCC violation cleared, continue countdown. If not clear, LCC violation confirmed, No Go for launch.

NOTES:

(5) The transducers are in the equalization and failure detection circuitry.

REDLINE DERIVATION: CRITICALITY: 1R

(6) Channel pressures can be expected to be below the redline for a healthy system. Channel pressures above the redlines are indications of failures in DPS, MDMs, ASAs, or actuators.

(7) Derivation of the algebraic sum in Requirement (2) is as follows:

A. Sum of four secondary pressure measurements (Aerosurface actuators). Each channel (Calculated at delta P of 850 psid).

Pressure transducer error	179.6 psi
Power supply tolerance	19.6 psi
ASA pressure monitor output	25.5 psi
MDM error	34.4 psi
Root sum square	185.7 psi

B. Sum of Four Delta Pressures:

1. Root sum square of 4 Channels (185.7) (square root of 4) 371.4 psi
   Power valve friction (50 lb max) 127.3 psi
   Variation in sum of four delta pressures (RSS) +/-392.6 psi
2. Bias due to truncation of two bits (8.982 psi/chan) -35.9 psi
3. +392.6 - 35.9 = +356.7 psi +356.7/23.952 = 14.89
   -392.6 - 35.9 = -428.5 psi -428.5/23.952 = -17.89
4. 15 X 23.952 = +359.28 Upper limit = +370 psi
   -18 X 23.952 = -431.14 Lower limit = -440 psi

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Flight Control System would not be two-fault tolerant with a channel pressure stuck above the redline limit.

CAUSES OF EXCEEDING REDLINE:

(9) Transducer failure.
(10) Electronics failure.
(11) Actuator failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 8 AND 9 FOR LEFT AND RIGHT ELEVON ACTUATORS									
UNITS-->	psid								
V58P0n12A	23.95	-2994	2994						
V58P0n13A	23.95	-2994	2994						
V58P0n14A	23.95	-2994	2994						
V58P0n15A	23.95	-2994	2994						
V58P0n62A	23.95	-2994	2994						
V58P0n63A	23.95	-2994	2994						
V58P0n64A	23.95	-2994	2994						
V58P0n65A	23.95	-2994	2994						

METER/DISPLAY RANGE - MSID: V58P0n12A LOW: -3000 HIGH: +3000
V58P0n13A LOW: -3000 HIGH: +3000
V58P0n14A LOW: -3000 HIGH: +3000
V58P0n15A LOW: -3000 HIGH: +3000
V58P0n62A LOW: -3000 HIGH: +3000
V58P0n63A LOW: -3000 HIGH: +3000
V58P0n64A LOW: -3000 HIGH: +3000
V58P0n65A LOW: -3000 HIGH: +3000

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 9.11 SHEET ZONE
DWG NO 9.16 SHEET 1 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-971102 SHEET 71AT,AU ZONE A, A
DWG NO VS70-971099 SHEET 71AW,AY ZONE A, A

ELEMENT: Orbiter SUBSYSTEM: GNC

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LCC VIOLATION CALL: Elevon Aerosurface Profile Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V58H0802A	L Inbd Elevon Actr Ch 1 Posn	(4)	(2,3)	(2,3)	deg	DI
V58H0803A	L Inbd Elevon Actr Ch 2 Posn	(4)	(2,3)	(2,3)	deg	DI
V58H0804A	L Inbd Elevon Actr Ch 3 Posn	(4)	(2,3)	(2,3)	deg	DI
V58H0805A	L Inbd Elevon Actr Ch 4 Posn	(4)	(2,3)	(2,3)	deg	DI
V58H0852A	L Outbd Elevon Actr Ch 1 Posn	(4)	(2,3)	(2,3)	deg	DI
V58H0853A	L Outbd Elevon Actr Ch 2 Posn	(4)	(2,3)	(2,3)	deg	DI
V58H0854A	L Outbd Elevon Actr Ch 3 Posn	(4)	(2,3)	(2,3)	deg	DI
V58H0855A	L Outbd Elevon Actr Ch 4 Posn	(4)	(2,3)	(2,3)	deg	DI
V58H0902A	R Inbd Elevon Actr Ch 1 Posn	(4)	(2,3)	(2,3)	deg	DI
V58H0903A	R Inbd Elevon Actr Ch 2 Posn	(4)	(2,3)	(2,3)	deg	DI
V58H0904A	R Inbd Elevon Actr Ch 3 Posn	(4)	(2,3)	(2,3)	deg	DI
V58H0905A	R Inbd Elevon Actr Ch 4 Posn	(4)	(2,3)	(2,3)	deg	DI
V58H0952A	R Outbd Elevon Actr Ch 1 Posn	(4)	(2,3)	(2,3)	deg	DI
V58H0953A	R Outbd Elevon Actr Ch 2 Posn	(4)	(2,3)	(2,3)	deg	DI
V58H0954A	R Outbd Elevon Actr Ch 3 Posn	(4)	(2,3)	(2,3)	deg	DI
V58H0955A	R Outbd Elevon Actr Ch 4 Posn	(4)	(2,3)	(2,3)	deg	DI
Positive	(+) Slew Test = +10.7 nominal		+9.2	+12.2	deg	
Negative	(-) Slew Test = -9.8 nominal		-11.3	-8.3	deg	

TIME PERIOD:

(1) Test initiated at T-3 minutes, 55 seconds

REQUIREMENTS: FIGURES/TABLES: 34-02

(2) Verify positive (+) slew test actuator positions (minimum: +9.2 deg; maximum: +12.2 deg) when at the positive plateau (steady state). (See Fig. 34-02.)
(3) Verify negative (-) slew test actuator positions (minimum: -11.3 deg; maximum: -8.3 deg) when at the negative plateau (steady state). (See Fig. 34-02.)
(4) 3 of 4 acceptable for confirmed instrumentation failure (exclusive of transducer) with no accompanying occurrence of a channel anomaly. (5)

PREPLANNED CONTINGENCY PROCEDURE:

(5) Instrumentation failure is confirmed by monitoring the proper operation of the redundant (position feedback) GPC position measurements (Ref: S0007 Vol 5). For confirmed instrumentation failure, LCC violation cleared, continue countdown.

NOTES:

(6) Nominal value for positive (+) slew test is +10.7 degrees; nominal value for negative (-) slew test is -9.8 degrees.

REDLINE DERIVATION: CRITICALITY: 1R

(7) The transducer is part of the control feedback circuitry.
(8) These redlines ensure Elevon Flight Control System positioning performance is sufficient to maintain commanded elevon position during ascent and entry.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Flight control system would not be two fault tolerant.

CAUSES OF EXCEEDING REDLINE:

(10) ASA failure.
(11) Actuator failure.
(12) MDM failure.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
n = 8 AND 9 FOR LEFT AND RIGHT ELEVON ACTUATORS									
UNITS-->	deg								
V58H0n02A	0.232	-36.4	21.6						
V58H0n03A	0.232	-36.4	21.6						
V58H0n04A	0.232	-36.4	21.6						
V58H0n05A	0.232	-36.4	21.6						
V58H0n52A	0.232	-36.4	21.6						
V58H0n53A	0.232	-36.4	21.6						
V58H0n54A	0.232	-36.4	21.6						
V58H0n55A	0.232	-36.4	21.6						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 9.16	SHEET 1	ZONE 2T
	DWG NO 9.11	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-971102	SHEET 71AT,AW	ZONE
	DWG NO VS70-971099	SHEET 71AY,AU	ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: Rudder/Speedbrake Position Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V57H0250A	SpeedBrake Actr Chan 1 Posn	(7)	(4,6)	(4,6)	deg	(4,6
V57H0251A	SpeedBrake Actr Chan 2 Posn	(7)	(4,6)	(4,6)	deg	(4,6
V57H0252A	SpeedBrake Actr Chan 3 Posn	(7)	(4,6)	(4,6)	deg	(4,6
V57H0253A	SpeedBrake Actr Chan 4 Posn	(7)	(4,6)	(4,6)	deg	(4,6
V57H0150A	Rudder Actr Chan 1 Posn	(7)	(4,5)	(4,5)	deg	(4,5
V57H0151A	Rudder Actr Chan 2 Posn	(7)	(4,5)	(4,5)	deg	(4,5
V57H0152A	Rudder Actr Chan 3 Posn	(7)	(4,5)	(4,5)	deg	(4,5
V57H0153A	Rudder Actr Chan 4 Posn	(7)	(4,5)	(4,5)	deg	(4,5

TIME PERIOD:

(1) Verify prior to hydraulic Activation (T-5 minutes) (4)
(2) From after Aerosurface Profile Check (approximately T-3 minutes, 20 seconds) to Go for RSLS Start (T-31 seconds) (5), (6)A
(3) Verify between T-15 seconds and Go for SSME Start (T-10 seconds) (6)B

REQUIREMENTS: FIGURES/TABLES:

(4) Verify gravity position (DI).
Speedbrake: minimum +2.45 deg, maximum +7.55 deg.
Rudder: minimum -0.95 deg, maximum +0.95 deg.
Hold hydraulic activation if not in the gravity position. LCC violation confirmed, No Go for launch.

(5) Verify launch position of the Rudder after the Aerosurface Profile Check (CI).
Rudder: minimum -0.95 deg, maximum +0.95 deg.
If Rudder is not in the launch position, LCC violation confirmed, No Go for launch.

(6) A. Verify gravity position of the Speedbrake after the Aerosurface Profile Check (CI).
If the speedbrake is not in the gravity position, LCC violation confirmed, No Go for launch.

B. Verify launch position (DI).
Speedbrake: minimum NA deg, maximum +3.0 deg.
If the Speedbrake is not in the launch position, LCC violation confirmed, No Go for launch.

(7) 3 of 4 acceptable for confirmed instrumentation failure (exclusive of transducer) with no accompanying occurrence of the channel anomaly. (8)

PREPLANNED CONTINGENCY PROCEDURE:

(8) If equivalent GPC position indication agrees with other 3 OI position indications, instrumentation failure is confirmed, LCC violation cleared, continue countdown (Ref: S0007 Vol 5).

NOTES:

(9) Closure of speedbrake is by GPC command after RSLS Start (T-31 seconds).
(10) Scale factor conversion for Deg/Pct. Rudder MCC display: 1 degree = 4.44 percent.

REDLINE DERIVATION: CRITICALITY: 1R

(11) There is no position feedback RM (FDIR or SF) in OPS 1.
(12) This SSID verifies correct rudder and speedbrake position prior to hydraulic activation.
(13) This SSID verifies correct launch configuration of rudder and speedbrake positions.

CONSEQUENCES OF EXCEEDING REDLINE:

(14) Structural damage to rudder/speedbrake panels and PDU because of improper launch configuration.

CAUSES OF EXCEEDING REDLINE:

(15) ASA failure.
(16) Actuator failure.
(17) Failure in MDM.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 0, 1, 2, AND 3 FOR CHANNELS 1, 2, 3, AND 4 RESPECTIVELY									
UNITS-->	deg								
V57H025nA	0.43	-9.7	98.7						
V57H015nA	0.22	-27.5	27.7						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 9.11 SHEET 1 ZONE 3C
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-971102 SHEET 71BC ZONE B
DWG NO VS70-971099 SHEET 71BD ZONE B

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: Rudder/Speedbrake PDU Secondary Delta Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V57P0160A	Rudder Delta Press 1	(3)	-850	+850	psid	CI
V57P0161A	Rudder Delta Press 2	(3)	-850	+850	psid	CI
V57P0162A	Rudder Delta Press 3	(3)	-850	+850	psid	CI
V57P0163A	Rudder Delta Press 4	(3)	-850	+850	psid	CI
V57P0260A	Speed Brake Delta Press 1	(3)	-850	+850	psid	CI
V57P0261A	Speed Brake Delta Press 2	(3)	-850	+850	psid	CI
V57P0262A	Speed Brake Delta Press 3	(3)	-850	+850	psid	CI
V57P0263A	Speed Brake Delta Press 4	(3)	-850	+850	psid	CI

TIME PERIOD:

(1) Post Aerosurface Profile Check (T-3 minutes, 20 seconds) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) The algebraic sum of the four secondary delta pressure measurements for both the rudder and the speedbrake actuation subsystems shall equal 0 +370 or -440 psid, one time verification after profile test. Check performed at approximately T-3 minutes.
(3) 3 of 4 required for verifiable instrumentation failure exclusive of transducer. (4)

PREPLANNED CONTINGENCY PROCEDURE:

(4) If 4 of 4 rudder/speedbrake secondary delta pressures are not within + or -850 psid, then hold at T-31 seconds. If not clear at T-31 seconds, rerun aero slew to attempt clear. If clear, LCC violation cleared, continue countdown. If not clear, LCC violation confirmed, No Go for launch.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(5) Channel pressures can be expected to be below the redline for a healthy system. Channel pressures above the redlines are indications of failures in DPs, MDMs, ASAs, or actuators.
(6) Derivation of the algebraic sum in Requirement (2) is as follows:
A. Sum of four secondary pressure measurements (Aerosurface actuators); Each channel (Calculated at delta P of 850 psid):

Pressure transducer error	179.6 psi
Power supply tolerance	19.6 psi
ASA pressure monitor output	25.5 psi
MDM error	34.4 psi

REDLINE DERIVATION: (Continued)

Root sum square	185.7 psi
B. Sum of four delta pressures:	
1. Root sum square of 4 channels (185.7 X the square root of 4)	371.4 psi
Power Valve Friction (50 lb max)	127.3 psi
Variation in sum of four delta pressures (RSS)	+/-392.6 psi
2. Bias due to truncation of two bits (8.982 psi/chan)	-35.9 psi
3. +392.6 - 35.9 = +356.7 psi +356.7/23.952 = 14.89	
-392.6 - 35.9 = -428.5 psi -428.5/23.952 = -17.89	
4. 15 X 23.952 = +359.28 Upper limit = +370 psi.	
-18 X 23.952 = -431.14 Lower limit = -440 psi.	

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Flight Control System would not be two-fault tolerant with a channel pressure stuck above the redline limit.

CAUSES OF EXCEEDING REDLINE:

(8) Transducer failure.
(9) Electronics failure.
(10) Actuator failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 0, 1, 2, AND 3 FOR CHANNELS 1, 2, 3, AND 4 RESPECTIVELY									
UNITS-->	psid								
V57P016nA	23.95	-2994	2994						
V57P026nA	23.95	-2994	2994						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 9.11	SHEET	ZONE
	DWG NO 9.16	SHEET 2	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-971099	SHEET 71BC	ZONE B
	DWG NO VS70-971102	SHEET 71BC	ZONE B

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: Rudder Speedbrake Aerosurface Profile - Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V57H0250A	Speedbrake Actr Chan 1 Posn	(4)	(2,3)	(2,3)		DI
V57H0251A	Speedbrake Actr Chan 2 Posn	(4)	(2,3)	(2,3)		DI
V57H0252A	Speedbrake Actr Chan 3 Posn	(4)	(2,3)	(2,3)		DI
V57H0253A	Speedbrake Actr Chan 4 Posn	(4)	(2,3)	(2,3)		DI
Positive	(+) Slew Test = Null +2 (nominal)		null +1	Null +3	deg	
Negative	(-) Slew Test = Null -2 (nominal)		null -3	null -1	deg	
V57H0150A	Rudder Actr Chan 1 Posn	(4)	(2,3)	(2,3)		DI
V57H0151A	Rudder Actr Chan 2 Posn	(4)	(2,3)	(2,3)		DI
V57H0152A	Rudder Actr Chan 3 Posn	(4)	(2,3)	(2,3)		DI
V57H0153A	Rudder Actr Chan 4 Posn	(4)	(2,3)	(2,3)		DI
Positive	(+) Slew Test = +14 nominal		+12.5	+15.5	deg	
Negative	(-) Slew Test = -14 nominal		-15.5	-12.5	deg	

TIME PERIOD:

(1) Test initiated at T-3 minutes, 55 seconds

REQUIREMENTS: FIGURES/TABLES: 34-02

(2) Verify positive (+) slew test rudder/speedbrake PDU positions (Speedbrake minimum: null +1 deg; maximum: null +3 deg; Rudder minimum: +12.5 deg; maximum: +15.5 deg) when at the positive plateau (steady state). (Reference Figure 34-02.)
(3) Verify negative (-) slew test rudder/speedbrake PDU positions (Speedbrake minimum: null -3 deg; maximum: null -1 deg; Rudder minimum: -15.5 deg; maximum: -12.5 deg) when at the negative plateau (steady state). (Reference Figure 34-02.)
(4) 3 of 4 acceptable for confirmed instrumentation failure (exclusive of transducer). (5)

PREPLANNED CONTINGENCY PROCEDURE:

(5) Instrumentation failure is confirmed by monitoring the proper operation of the redundant (position feedback) GPC position measurements (Ref: S0007 Vol 5). For confirmed instrumentation failure, LCC violation cleared, continue countdown.

NOTES:

(6) Null = position of speedbrake PDU at the beginning of the aerosurface profile checks.
(7) Nominal value for rudder positive (+) slew test is +14 degrees; nominal value for rudder negative (-) slew test is -14 degrees.

REDLINE DERIVATION: CRITICALITY: 1R

(8) The transducer is part of the control feedback circuitry.
(9) These redlines insure Rudder/Speedbrake Flight Control System positioning performance is sufficient to maintain commanded Rudder/Speedbrake position during ascent and entry.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Flight Control System would not be two fault tolerant.

CAUSES OF EXCEEDING REDLINE:

(11) ASA failure.
(12) Actuator failure.
(13) MDM failure.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
n = 0, 1, 2, AND 3 FOR CHANNELS 1, 2, 3, AND 4 RESPECTIVELY									
UNITS-->	deg								
V57H025nA	0.43	-9.7	98.7						
V57H015nA	0.22	-27.5	27.7						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 9.11 SHEET 1 ZONE 3C
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-971102 SHEET 71BD,BC ZONE B
DWG NO VS70-971099 SHEET 71BD,BC ZONE B

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: Body Flap Control Discrete Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V79X3201E	Body Flap Enable 1 Output		0	NA	Event	CI
V79X3202E	Body Flap Up 1 Output		0	NA	Event	CI
V79X3203E	Body Flap Down 1 Output		0	NA	Event	CI
V79X3204E	Body Flap Enable 2 Output		0	NA	Event	CI
V79X3205E	Body Flap Up 2 Output		0	NA	Event	CI
V79X3206E	Body Flap Down 2 Output		0	NA	Event	CI
V79X3207E	Body Flap Enable 3 Output		0	NA	Event	CI
V79X3208E	Body Flap Up 3 Output		0	NA	Event	CI
V79X3209E	Body Flap Down 3 Output		0	NA	Event	CI

TIME PERIOD:

(1) From Post-Aerosurface Profile (approximately T-3 minutes, 20 seconds) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) "Enable" and "up" or "down" are required for a valid command.
(3) No manual capability exists to drive body flap in OPS 1.
(4) A body flap failed in the full up position has the potential for collision with the SSME bells. Failure in the full down position may result in scraping of the body flap during landing.
(5) No Body Flap command failures allowed to protect two-fault tolerance.

REDLINE DERIVATION: CRITICALITY: 1R

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Degraded flight control.
(7) Reduced fault tolerance. Violation of the redline is an indication of an actuated body flap or that there is the potential for activation.

CAUSES OF EXCEEDING REDLINE:

(8) ASA failure.
(9) Actuator failure.
(10) DPS command problem.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 9.11	SHEET	ZONE 1&2K-G
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-971102	SHEET 71AV	ZONE 19
	DWG NO VS70-971099	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: Body Flap Launch Position | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V57H0065C	Body Flap Posn Fdbk-1		-1.85	+1.85	Deg	CI
V57H0066C	Body Flap Posn Fdbk-2		-1.85	+1.85	Deg	CI
V57H0067C	Body Flap Posn Fdbk-3		-1.85	+1.85	Deg	CI
V57H0068C	Body Flap Posn Fdbk-4		-1.85	+1.85	Deg	CI

TIME PERIOD:

(1) Post Aerosurface Profile (approximately T-3 minutes) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) Body flap position feedback RM operable in OPS 1.
(3) Scale factor conversion for Deg/Pct: Deg = (Pct -34.2)/2.92.
(4) Volts = (Pct Deflection + 50)/12.9.

REDLINE DERIVATION: CRITICALITY: 1R

(5) Measurement used by DAP for closed-loop control of body flap.
(6) Redline Development:

	Minimum	Maximum
Deadband	-1.41 deg	+1.41 deg
Instrumentation Error	-0.44 deg	+0.44 deg
	-1.85 deg	+1.85 deg

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Structural damage because of improper launch configuration.
(8) Flight control system would not be two-fault tolerant.

CAUSES OF EXCEEDING REDLINE:

(9) ASA failure.
(10) Actuator failure.
(11) DPS command problem.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 5, 6, 7, AND 8 FOR CHANNELS 1, 2, 3, AND 4 RESPECTIVELY									
UNITS-->	deg								
V57H006nC	0.044	-16.6	27.5						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 9.11 SHEET 1 ZONE 1E
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-971102 SHEET 71AV ZONE 1O
DWG NO VS70-971099 SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: Bodyflap Aerosurface Profile - Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V57H0065C	Body Flap Posn Fdbk-1		(2,3)	(2,3)	deg	DI
V57H0066C	Body Flap Posn Fdbk-2		(2,3)	(2,3)	deg	DI
V57H0067C	Body Flap Posn Fdbk-3		(2,3)	(2,3)	deg	DI
V57H0068C	Body Flap Posn Fdbk-4		(2,3)	(2,3)	deg	DI
Positive	(+) slew test = null +3 (nominal)		Null +1.5	Null +4.5	 deg	
Negative	(-) slew test = null -3 (nominal)		Null -4.5	Null -1.5	 deg	

TIME PERIOD:

(1) Test initiated at T-3 minutes, 55 seconds

REQUIREMENTS: FIGURES/TABLES: 34-02

(2) Verify positive (+) slew test bodyflap PDU positions (minimum: null +1.5 deg; maximum: null +4.5 deg) when at the positive plateau (steady state). (Reference Figure 34-02.)
(3) Verify negative (-) slew test bodyflap PDU positions (minimum: null -4.5 deg; maximum: null -1.5 deg) when at the negative plateau (steady state). (Reference Figure 34-02.)

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) Null = position of bodyflap PDU at the beginning of the aerosurface profile checks.
(5) Nominal value for positive (+) slew test is +3 degrees; Nominal value for negative (-) slew test is -3 degrees.
(6) Scale factor conversion for Deg/Pct: Deg = (Pct-34.2)/2.92.

REDLINE DERIVATION: CRITICALITY: 1R

(7) The transducer is part of the control feedback circuitry.
(8) These redlines insure Body Flap Flight Control System positioning performance is sufficient to maintain commanded Body Flap position during ascent and entry.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Flight control system would not be two-fault tolerant.

CAUSES OF EXCEEDING REDLINE:

(10) ASA failure.
(11) Actuator failure.
(12) DPS command problem.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 5, 6, 7, AND 8 FOR CHANNELS 1, 2, 3, AND 4 RESPECTIVELY									
UNITS-->	deg								
V57H006nC	0.044	-16.6	27.5						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 9.11 SHEET 1 ZONE 1,2
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-971099 SHEET 71AV ZONE
DWG NO VS70-971102 SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: Orbiter ASA Power Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76X4201E	PCA Flt Cont ASA 1 RPC A On	(4)	ON	NA	Event	CI
V76X4202E	PCA Flt Cont ASA 1 RPC B On	(4)	ON	NA	Event	CI
V76X4203E	PCA Flt Cont ASA 1 RPC 3 On	(5)	ON	NA	Event	CI
V76X4204E	PCA Flt Cont ASA 2 RPC B On	(4)	ON	NA	Event	CI
V76X4205E	PCA Flt Cont ASA 2 RPC C On	(4)	ON	NA	Event	CI
V76X4206E	PCA Flt Cont ASA 2 RPC 3 On	(5)	ON	NA	Event	CI
V76X4207E	PCA Flt Cont ASA 3 RPC C On	(4)	ON	NA	Event	CI
V76X4208E	PCA Flt Cont ASA 3 RPC A On	(4)	ON	NA	Event	CI
V76X4209E	PCA Flt Cont ASA 3 RPC 3 On	(5)	ON	NA	Event	CI
V76X4210E	PCA Flt Cont ASA 4 RPC C On	(4)	ON	NA	Event	CI
V76X4211E	PCA Flt Cont ASA 4 RPC A On	(4)	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Loss of RPC ON indication requires evaluation. (3,4,5)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Verify FCS channel and ASA power switches configured correctly (ref S0007 Vol 5). If switch repositioning clears problem, LCC violation cleared, continue countdown.

(4) To confirm instrumentation failure, drop specified control bus (ref OMRS S00GEN.780) and verify that channel does not bypass with redundant RPC unpowered (Ref S0007 Vol 5).
For PCA Flt Cont ASA 1 RPC A (V76X4201E); Drop Cntl BC1.
For PCA Flt Cont ASA 1 RPC B (V76X4202E); Drop Cntl AB1.
For PCA Flt Cont ASA 2 RPC B (V76X4204E); Drop Cntl CA3.
For PCA Flt Cont ASA 2 RPC C (V76X4205E); Drop Cntl BC2.
For PCA Flt Cont ASA 3 RPC A (V76X4208E); Drop Cntl CA1.
For PCA Flt Cont ASA 3 RPC C (V76X4207E); Drop Cntl AB2.
For PCA Flt Cont ASA 4 RPC A (V76X4211E); Drop Cntl CA2.
For PCA Flt Cont ASA 4 RPC C (V76X4210E); Drop Cntl AB3.
For confirmed instrumentation failure, LCC violation cleared, continue countdown.

(5) To confirm instrumentation failure, take associated FCS channel switch to OFF and verify that channel DOES bypass (Ref S0007 Vol 5).
For PCA Flt Cont ASA 1 RPC 3(C) (V76X4203E); FCS Chnl 1 OFF.
For PCA Flt Cont ASA 2 RPC 3(A) (V76X4206E); FCS Chnl 2 OFF.
For PCA Flt Cont ASA 3 RPC 3(B) (V76X4209E); FCS Chnl 3 OFF.
If performed in OPS 1, recovery from this procedure requires deselection/reselection of the associated SURF FDBK on SPEC 53 (CONTROLS). These actions will regain the body flap position feedback, which will fail RM

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

when the FCS channel switch is taken to the OFF position.
For confirmed instrumentation failure, LCC violation cleared, continue countdown.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(6) Off (Logic 0) indicates power failure at the point under test. All RPCs are required in order to retain a certified FCS channel configuration after two failures. The minimum certified FCS configuration is two good channels and the two failed channels isolated (bypassed).

(7) PCA Flt Cont ASA 1 RPC B (V76X4202E) and PCA Flt Cont ASA 2 RPC B (V76X4204E) are required to protect for loss of two main buses resulting in one good channel against one with unisolable null driver output.

(8) PCA Flt Cont ASA 1 RPC A (V76X4201E) and PCA Flt Cont ASA 3 RPC C (V76X4207E) are required to protect for loss of two main buses resulting in two good channels against one with unisolable null driver output and loss of body flap control.

(9) The following RPCs are required to protect for loss of two main buses resulting in two good channels against one with unisolable null driver output:
PCA Flt Cont ASA 2 RPC C (V76X4205E),
PCA Flt Cont ASA 3 RPC A (V76X4208E),
PCA Flt Cont ASA 4 RPC C (V76X4210E), &
PCA Flt Cont ASA 4 RPC A (V76X4211E).

(10) The following RPCs are required to allow manual bypass of FCS channels 1, 2 or 3 after an in-flight failure of MDM FA1, FA2 or FA3:
PCA Flt Cont ASA 1 RPC 3 (C) (V76X4203E),
PCA Flt Cont ASA 2 RPC 3 (A) (V76X4206E), &
PCA Flt Cont ASA 3 RPC 3 (B) (V76X4209E).
- With any of these RPCs failed, taking the associated FCS channel switch to OFF will result in an unisolable null driver output.
- If the switch is left in AUTO, the affected channel will automatically bypass when in a force fight with good channels.
- Launch with one of these RPCs failed combined with an FA1, FA2 or FA3 failure would require the three good FCS channels to be placed in _override_ (Panel C3, FCS Channel switches in the OVERRIDE position), to prevent bypassing good channels.
  - Failure of one of the three good channels could result in a 2 on 2 force fight (an uncertified condition) until the bad channels are isolated.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Loss of two-fault tolerance for maintaining a certified FCS channel configuration.

CAUSES OF EXCEEDING REDLINE:

(12) Wiring failure.
(13) RPC failure.
(14) Switch failure.
(15) Instrumentation failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 9.11	SHEET 1 of 1	ZONE 2-7/S,R
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-971102	SHEET 71FA,FB	ZONE 16,17
	DWG NO VS70-971099	SHEET 71FC,FD	ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

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SSIDs GNC-33 thru GNC-37 Reserved

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LCC VIOLATION CALL: Flight Control System Channel Failure Indication | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V72X4550X	Flight Control Channel Failure	(2)	0	NA	Event	CI

TIME PERIOD:

(1) From APU Start (T-5 minutes) to Go for SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES: 34-01

PREPLANNED CONTINGENCY PROCEDURE:

(2) If FCS CHANNEL FAIL occurs before T-31 seconds, perform all of the following: (Ref. S0007 Vol 5)
   A. Place FCS CHANNEL switch on PNL C3 to OVRD.
      If secondary delta pressure is within the following limits, proceed to Step B.

	All channels (psid)	Summation per actuator (psid)
Aerosurfaces	+/- 850	-440 to +370
SSME-TVC	+/- 1050	-440 to +370

      Otherwise compare polarity of secondary delta pressure to driver current in affected channel:
      1. If secondary delta pressure and driver current are both extend or both retract, electronics failed. LCC violation confirmed, No Go for launch.
      2. If secondary delta pressure and driver current are one extend and one retract and a secondary delta pressure force fight exists with the other three channels opposing the failed channel, repeat slew test until above limits are satisfied. If problem does not clear, LCC violation confirmed, No Go for launch.
   B. Place FCS CHANNEL switch on PNL C3 to AUTO. Perform actuators slew test. Confirm no channel fail indications. If data evaluation indicates that the initial channel failure was caused by suspected transient hydraulic contamination which is now cleared, LCC violation cleared, continue countdown.

NOTES:

(3) Fail event is latching in ASA and ATVC.
(4) Reference Table 34-01 for FCS Channel Fail indications.
(5) SSME override reset commands applied by flight software from OPS 1 transition (T-20 minutes) until MPS slew profile start (T-3 minutes 30 seconds).

REDLINE DERIVATION: CRITICALITY: 1R

(6) Pressure-time integration in ASA and ATVC establishes failure criteria.

REDLINE DERIVATION: (Continued)

(7) All channels of all actuators required for launch. This redline verifies that no channel has been bypassed.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Flight control system would not be two-fault tolerant with a channel failure.

CAUSES OF EXCEEDING REDLINE:

(9) Power supply failure.
(10) Delta P fault detection.
(11) Actuator failure.
(12) Electronics failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	Event								
V72X4550X				0					

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 9.11 SHEET ZONE 7B
DWG NO 9.15 SHEET ZONE 7B
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

SUPPORTING DATA:

Table 34-01 FCS CHANNEL FAIL INDICATIONS:

MSID	TITLE	MSID	TITLE
V79X3275X	R Otboard Elevon Actr 1 Fail	*V79X1270X	MPS Eng 2 P Actr A Fail
V79X3276X	R Otboard Elevon Actr 2 Fail	*V79X1273X	MPS Eng 2 P Actr B Fail
V79X3277X	R Otboard Elevon Actr 3 Fail	*V79X1276X	MPS Eng 2 P Actr C Fail
V79X3278X	R Otboard Elevon Actr 4 Fail	*V79X1278X	MPS Eng 2 P Actr D Fail
V79X3270X	R Inboard Elevon Actr 1 Fail	*V79X1271X	MPS Eng 2 Y Actr A Fail
V79X3271X	R Inboard Elevon Actr 2 Fail	*V79X1274X	MPS Eng 2 Y Actr B Fail
V79X3272X	R Inboard Elevon Actr 3 Fail	*V79X1277X	MPS Eng 2 Y Actr C Fail
V79X3273X	R Inboard Elevon Actr 4 Fail	*V79X1279X	MPS Eng 2 Y Actr D Fail
V79X3265X	L Otboard Elevon Actr 1 Fail	*V79X1370X	MPS Eng 3 P Actr A Fail
V79X3266X	L Otboard Elevon Actr 2 Fail	*V79X1373X	MPS Eng 3 P Actr B Fail
V79X3267X	L Otboard Elevon Actr 3 Fail	*V79X1376X	MPS Eng 3 P Actr C Fail
V79X3268X	L Otboard Elevon Actr 4 Fail	*V79X1378X	MPS Eng 3 P Actr D Fail
V79X3260X	L Inboard Elevon Actr 1 Fail	*V79X1371X	MPS Eng 3 Y Actr A Fail
V79X3261X	L Inboard Elevon Actr 2 Fail	*V79X1374X	MPS Eng 3 Y Actr B Fail
V79X3262X	L Inboard Elevon Actr 3 Fail	*V79X1377X	MPS Eng 3 Y Actr C Fail
V79X3263X	L Inboard Elevon Actr 4 Fail	*V79X1379X	MPS Eng 3 Y Actr D Fail
V79X3336X	Speed Brake Actr 1 Fail	V79X5101X	LH SRB Tilt Actr A Fail
V79X3337X	Speed Brake Actr 2 Fail	V79X5106X	LH SRB Tilt Actr B Fail
V79X3338X	Speed Brake Actr 3 Fail	V79X5111X	LH SRB Tilt Actr C Fail
V79X3339X	Speed Brake Actr 4 Fail	V79X5116X	LH SRB Tilt Actr D Fail
V79X3331X	Rudder Actr 1 Fail Output	V79X5100X	LH SRB Rock Actr A Fail
V79X3332X	Rudder Actr 2 Fail Output	V79X5105X	LH SRB Rock Actr B Fail
V79X3333X	Rudder Actr 3 Fail Output	V79X5110X	LH SRB Rock Actr C Fail
V79X3334X	Rudder Actr 4 Fail Output	V79X5115X	LH SRB Rock Actr D Fail
*V79X1170X	MPS Eng 1 P Actr A Fail	V79X5151X	RH SRB Tilt Actr A Fail
*V79X1173X	MPS Eng 1 P Actr B Fail	V79X5156X	RH SRB Tilt Actr B Fail
*V79X1176X	MPS Eng 1 P Actr C Fail	V79X5161X	RH SRB Tilt Actr C Fail
*V79X1178X	MPS Eng 1 P Actr D Fail	V79X5166X	RH SRB Tilt Actr D Fail
*V79X1171X	MPS Eng 1 Y Actr A Fail	V79X5150X	RH SRB Rock Actr A Fail
*V79X1174X	MPS Eng 1 Y Actr B Fail	V79X5155X	RH SRB Rock Actr B Fail
*V79X1177X	MPS Eng 1 Y Actr C Fail	V79X5160X	RH SRB Rock Actr C Fail
*V79X1179X	MPS Eng 1 Y Actr D Fail	V79X5165X	RH SRB Rock Actr D Fail

*SSME TVC ACTUATOR CHANNEL FAILS Monitored by redundant set after engine at 90% thrust to T-0.

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LCC VIOLATION CALL: Orbiter ATVC Power Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76X4285E	PCA Flt Cont ATVC 1 RPC A On		ON	NA	Event	CI
V76X4286E	PCA Flt Cont ATVC 1 RPC B On		ON	NA	Event	CI
V76X4287E	PCA Flt Cont ATVC 2 RPC B On		ON	NA	Event	CI
V76X4288E	PCA Flt Cont ATVC 2 RPC C On		ON	NA	Event	CI
V76X4289E	PCA Flt Cont ATVC 3 RPC A On		ON	NA	Event	CI
V76X4290E	PCA Flt Cont ATVC 3 RPC C On		ON	NA	Event	CI
V76X4291E	PCA Flt Cont ATVC 4 RPC C On		ON	NA	Event	CI
V76X4292E	PCA FLt Cont ATVC 4 RPC A On		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 Seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Loss of ATVC RPC ON indication requires evaluation. (3,4)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Verify FCS and ATVC power switches are configured correctly (ref S0007 Vol 5). If switch repositioning clears problem, LCC violation is cleared, continue countdown.

(4) To confirm instrumentation failure, drop specified control bus (ref OMRS S00GEN.780) and verify that channel does not bypass with redundant RPC unpowered (Ref S0007 Vol 5).
  For PCA Flt Cont ATVC 1 RPC A; Drop CNTL BC1.
  For PCA Flt Cont ATVC 1 RPC B; Drop CNTL AB1.
  For PCA Flt Cont ATVC 2 RPC B; Drop CNTL CA3.
  For PCA Flt Cont ATVC 2 RPC C; Drop CNTL BC2.
  For PCA Flt Cont ATVC 3 RPC A; Drop CNTL CA1.
  For PCA Flt Cont ATVC 3 RPC C; Drop CNTL AB2.
  For PCA Flt Cont ATVC 4 RPC A; Drop CNTL CA2.
  For PCA Flt Cont ATVC 4 RPC C; Drop CNTL AB3.
  For confirmed instrumentation failure, LCC violation cleared, continue countdown.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(5) Off (logic 0) indicates power failure at point under test. All RPCs are required for two-fault tolerance. An RPC failure prelaunch combined with the in-flight loss of two main buses results in an uncertified FCS channel configuration. All RPC and bus failure combinations result in either (A) the good channel against one channel with null driver output and not

REDLINE DERIVATION: (Continued)

isolable, or (B) two good channels against one null channel not isolable. The minimum certified configuration is two good channels with the two failed channels isolated (bypassed).

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Loss of two-fault tolerance for maintaining a certified FCS channel configuration.

CAUSES OF EXCEEDING REDLINE:

(7) Wiring failure.
(8) RPC failure.
(9) Switch failure.
(10) Instrumentation failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 9.15	SHEET 1 of 1	ZONE 2-7/T
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: MPS TVC Actuator Position Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V58H1100A	MPS Eng 1 P Actr Posn	(2)	-1.12	+0.48	Deg	CI
V58H1150A	MPS Eng 1 Y Actr Posn	(2)	+0.77	-0.43	Deg	CI
V58H1200A	MPS Eng 2 P Actr Posn	(2)	+1.12	-0.48	Deg	CI
V58H1250A	MPS Eng 2 Y Actr Posn	(2)	+0.81	-0.39	Deg	CI
V58H1300A	MPS Eng 3 P Actr Posn	(2)	-1.12	+0.48	Deg	CI
V58H1350A	MPS Eng 3 Y Actr Posn	(2)	+0.81	-0.39	Deg	CI

TIME PERIOD:

(1) Postgimbal Profile (approximately T-3 minutes) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 5 of 6 acceptable for confirmed instrumentation failure.
(3) Confirm engine start configuration (launch configuration for 1P, 1Y, 2P, 3P, prior to SSME Start T-10 seconds).

PREPLANNED CONTINGENCY PROCEDURE:

(4) For instrumentation failure, use driver current output and secondary delta pressures to verify proper operation during slew.
(5) Failure of one transducer requires monitoring eight additional measurements. Reference Table 34-02, Backup Measurements for MPS Engine Actuator Position, for the parameters that must be monitored if an MPS Engine Actuator Position measurement is lost.

NOTES:

(6) Engine movement frequently occurs at engine start.
(7) RSLS will move 2Y and 3Y to launch position after main engine thrust is greater than 90 percent.

REDLINE DERIVATION: CRITICALITY: 1R

(8) Redlines confirm launch configuration, except for 2Y and 3Y which are in the SSME Start Configuration.
(9) Instrumentation is used for verification of ME Gimbal positions prior to lift-off, for required engine movement during powered flight, for engine movement pre-MECO (engine out) and post-MECO (engine to dump and/or stow positions).

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Structural damage because of improper launch configuration.
(11) Actuator not responding as design requires.

CAUSES OF EXCEEDING REDLINE:

(12) ATVC failure.
(13) Actuator failure.
(14) DPS command problem.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	deg								
V58H1100A	0.084	-10.5	+10.5						
V58H1300A	0.084	-10.5	+10.5						
V58H1200A	-0.084	+10.5	-10.5						
n = 1, 2, AND 3 FOR ENGINE 1, 2, AND 3 RESPECTIVELY									
V58H1n50A	-0.068	+8.5	-8.5						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 9.15 SHEET 1 of 1 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-971102 SHEET 71AA ZONE C,F
DWG NO VS70-971099 SHEET 71AA ZONE C,F

ELEMENT: Orbiter SUBSYSTEM: GNC

SUPPORTING DATA:

Table 34-02 Backup Measurements for MPS Engine Actuator Position

Meas. No.	Measurement Description	Min	Max	Units	Slew Posn
Backup Measurements for V58H1100A MPS Eng 1 P Actr Posn					
V58P1181A	MPS Eng 1 Pitch Sec Delta Press A	-1050	+1050	psid	All (2)
V58P1182A	MPS Eng 1 Pitch Sec Delta Press B	-1050	+1050	psid	All (2)
V58P1183A	MPS Eng 1 Pitch Sec Delta Press C	-1050	+1050	psid	All (2)
V58P1184A	MPS Eng 1 Pitch Sec Delta Press D	-1050	+1050	psid	All (2)
V79H2150A	MPS Eng 1 Pitch Actr A Drive Out	-0.72	0.0	deg	initial, final
		+5.22	+6.12	deg	positive
		-6.77	-5.83	deg	negative
V79H2153A	MPS Eng 1 Pitch Actr B Drive Out	-0.72	0.0	deg	initial, final
		+5.22	+6.12	deg	positive
		-6.77	-5.83	deg	negative
V79H2156A	MPS Eng 1 Pitch Actr C Drive Out	-0.72	0.0	deg	initial, final
		+5.22	+6.12	deg	positive
		-6.77	-5.83	deg	negative
V79H2159A	MPS Eng 1 Pitch Actr D Drive Out	-0.72	0.0	deg	initial, final
		+5.22	+6.12	deg	positive
		-6.77	-5.83	deg	negative
Backup Measurements for V58H1150A MPS Eng 1 Y Actr Posn					
V58P1186A	MPS Eng 1 Yaw Sec Delta Press A	-1050	+1050	psid	All (2)
V58P1187A	MPS Eng 1 Yaw Sec Delta Press B	-1050	+1050	psid	All (2)
V58P1188A	MPS Eng 1 Yaw Sec Delta Press C	-1050	+1050	psid	All (2)
V58P1189A	MPS Eng 1 Yaw Sec Delta Press D	-1050	+1050	psid	All (2)
V79H2151A	MPS Eng 1 Yaw Actr A Drive Out	-0.09	+0.50	deg	initial, final
		+5.80	+6.56	deg	positive
		-6.22	-5.47	deg	negative
V79H2154A	MPS Eng 1 Yaw Actr B Drive Out	-0.09	+0.50	deg	initial, final
		+5.80	+6.56	deg	positive
		-6.22	-5.47	deg	negative
V79H2157A	MPS Eng 1 Yaw Actr C Drive Out	-0.09	+0.50	deg	initial, final
		+5.80	+6.56	deg	positive
		-6.22	-5.47	deg	negative
V79H2160A	MPS Eng 1 Yaw Actr D Drive Out	-0.09	+0.50	deg	initial, final
		+5.80	+6.56	deg	positive
		-6.22	-5.47	deg	negative

Table 34-02 Backup Measurements for MPS Engine Actuator Position (continued)

Meas. No.	Measurement Description	Min	Max	Units	Slew Posn
Backup Measurements for V58H1200A MPS Eng 2 P Actr Posn					
V58P1281A	MPS Eng 2 Pitch Sec Delta Press A	-1050	+1050	psid	All (2)
V58P1282A	MPS Eng 2 Pitch Sec Delta Press B	-1050	+1050	psid	All (2)
V58P1283A	MPS Eng 2 Pitch Sec Delta Press C	-1050	+1050	psid	All (2)
V58P1284A	MPS Eng 2 Pitch Sec Delta Press D	-1050	+1050	psid	All (2)
V79H2165A	MPS Eng 2 Pitch Actr A Drive Out	0.0	+0.72	deg	initial, final
		+5.83	+6.77	deg	positive
		-6.12	-5.22	deg	negative
V79H2168A	MPS Eng 2 Pitch Actr B Drive Out	0.0	+0.72	deg	initial, final
		+5.83	+6.77	deg	positive
		-6.12	-5.22	deg	negative
V79H2171A	MPS Eng 2 Pitch Actr C Drive Out	0.0	+0.72	deg	initial, final
		+5.83	+6.77	deg	positive
		-6.12	-5.22	deg	negative
V79H2174A	MPS Eng 2 Pitch Actr D Drive Out	0.0	+0.72	deg	initial, final
		+5.83	+6.77	deg	positive
		-6.12	-5.22	deg	negative
Backup Measurements for V58H1250A MPS Eng 2 Y Actr Posn					
V58P1286A	MPS Eng 2 Yaw Sec Delta Press A	-1050	+1050	psid	All (2)
V58P1287A	MPS Eng 2 Yaw Sec Delta Press B	-1050	+1050	psid	All (2)
V58P1288A	MPS Eng 2 Yaw Sec Delta Press C	-1050	+1050	psid	All (2)
V58P1289A	MPS Eng 2 Yaw Sec Delta Press D	-1050	+1050	psid	All (2)
V79H2166A	MPS Eng 2 Yaw Actr A Drive Out	-0.09	+0.50	deg	initial, final
		+5.88	+6.72	deg	positive
		-6.31	-5.55	deg	negative
V79H2169A	MPS Eng 2 Yaw Actr B Drive Out	-0.09	+0.50	deg	initial, final
		+5.88	+6.72	deg	positive
		-6.31	-5.55	deg	negative
V79H2172A	MPS Eng 2 Yaw Actr C Drive Out	-0.09	+0.50	deg	initial, final
		+5.88	+6.72	deg	positive
		-6.31	-5.55	deg	negative
V79H2175A	MPS Eng 2 Yaw Actr D Drive Out	-0.09	+0.50	deg	initial, final
		+5.88	+6.72	deg	positive
		-6.31	-5.55	deg	negative

Table 34-02 Backup Measurements for MPS Engine Actuator Position (concluded)

Meas. No.	Measurement Description	Min	Max	Units	Slew Posn
Backup Measurements for V58H1300A MPS Eng 3 P Actr Posn					
V58P1381A	MPS Eng 3 Pitch Sec Delta Press A	-1050	+1050	psid	All (2)
V58P1382A	MPS Eng 3 Pitch Sec Delta Press B	-1050	+1050	psid	All (2)
V58P1383A	MPS Eng 3 Pitch Sec Delta Press C	-1050	+1050	psid	All (2)
V58P1384A	MPS Eng 3 Pitch Sec Delta Press D	-1050	+1050	psid	All (2)
V79H2180A	MPS Eng 3 Pitch Actr A Drive Out	-0.72	0.0	deg	initial, final
		+5.22	+6.12	deg	positive
		-6.77	-5.83	deg	negative
V79H2183A	MPS Eng 3 Pitch Actr B Drive Out	-0.72	0.0	deg	initial, final
		+5.22	+6.12	deg	positive
		-6.77	-5.83	deg	negative
V79H2186A	MPS Eng 3 Pitch Actr C Drive Out	-0.72	0.0	deg	initial, final
		+5.22	+6.12	deg	positive
		-6.77	-5.83	deg	negative
V79H2189A	MPS Eng 3 Pitch Actr D Drive Out	-0.72	0.0	deg	initial, final
		+5.22	+6.12	deg	positive
		-6.77	-5.83	deg	negative
Backup Measurements for V58H1350A MPS Eng 3 Y Actr Posn					
V58P1386A	MPS Eng 3 Yaw Sec Delta Press A	-1050	+1050	psid	All (2)
V58P1387A	MPS Eng 3 Yaw Sec Delta Press B	-1050	+1050	psid	All (2)
V58P1388A	MPS Eng 3 Yaw Sec Delta Press C	-1050	+1050	psid	All (2)
V58P1389A	MPS Eng 3 Yaw Sec Delta Press D	-1050	+1050	psid	All (2)
V79H2181A	MPS Eng 3 Yaw Actr A Drive Out	-0.09	+0.50	deg	initial, final
		+5.72	+6.47	deg	positive
		+5.72	+6.47	deg	positive
		+5.72	+6.47	deg	positive
		+5.72	+6.47	deg	positive
		-6.06	-5.30	deg	negative
V79H2184A	MPS Eng 3 Yaw Actr B Drive Out	-0.09	+0.50	deg	initial, final
		+5.72	+6.47	deg	positive
		-6.06	-5.30	deg	negative
V79H2187A	MPS Eng 3 Yaw Actr C Drive Out	-0.09	+0.50	deg	initial, final
		+5.72	+6.47	deg	positive
		-6.06	-5.30	deg	negative
V79H2190A	MPS Eng 3 Yaw Actr D Drive Out	-0.09	+0.50	deg	initial, final
		+5.72	+6.47	deg	positive
		-6.06	-5.30	deg	negative

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LCC VIOLATION CALL: MPS TVC Actuator Secondary Delta Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V58P1181A	MPS Eng 1 Pitch Sec Delta Press A	(4)	-1050	+1050	psid	CI
V58P1182A	MPS Eng 1 Pitch Sec Delta Press B	(4)	-1050	+1050	psid	CI
V58P1183A	MPS Eng 1 Pitch Sec Delta Press C	(4)	-1050	+1050	psid	CI
V58P1184A	MPS Eng 1 Pitch Sec Delta Press D	(4)	-1050	+1050	psid	CI
V58P1186A	MPS Eng 1 Yaw Sec Delta Press A	(4)	-1050	+1050	psid	CI
V58P1187A	MPS Eng 1 Yaw Sec Delta Press B	(4)	-1050	+1050	psid	CI
V58P1188A	MPS Eng 1 Yaw Sec Delta Press C	(4)	-1050	+1050	psid	CI
V58P1189A	MPS Eng 1 Yaw Sec Delta Press D	(4)	-1050	+1050	psid	CI
V58P1281A	MPS Eng 2 Pitch Sec Delta Press A	(4)	-1050	+1050	psid	CI
V58P1282A	MPS Eng 2 Pitch Sec Delta Press B	(4)	-1050	+1050	psid	CI
V58P1283A	MPS Eng 2 Pitch Sec Delta Press C	(4)	-1050	+1050	psid	CI
V58P1284A	MPS Eng 2 Pitch Sec Delta Press D	(4)	-1050	+1050	psid	CI
V58P1286A	MPS Eng 2 Yaw Sec Delta Press A	(4)	-1050	+1050	psid	CI
V58P1287A	MPS Eng 2 Yaw Sec Delta Press B	(4)	-1050	+1050	psid	CI
V58P1288A	MPS Eng 2 Yaw Sec Delta Press C	(4)	-1050	+1050	psid	CI
V58P1289A	MPS Eng 2 Yaw Sec Delta Press D	(4)	-1050	+1050	psid	CI
V58P1381A	MPS Eng 3 Pitch Sec Delta Press A	(4)	-1050	+1050	psid	CI
V58P1382A	MPS Eng 3 Pitch Sec Delta Press B	(4)	-1050	+1050	psid	CI
V58P1383A	MPS Eng 3 Pitch Sec Delta Press C	(4)	-1050	+1050	psid	CI
V58P1384A	MPS Eng 3 Pitch Sec Delta Press D	(4)	-1050	+1050	psid	CI
V58P1386A	MPS Eng 3 Yaw Sec Delta Press A	(4)	-1050	+1050	psid	CI
V58P1387A	MPS Eng 3 Yaw Sec Delta Press B	(4)	-1050	+1050	psid	CI
V58P1388A	MPS Eng 3 Yaw Sec Delta Press C	(4)	-1050	+1050	psid	CI
V58P1389A	MPS Eng 3 Yaw Sec Delta Press D	(4)	-1050	+1050	psid	CI

TIME PERIOD:

(1) Postgimbal Profile (approximately T-3 minutes) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) The algebraic sum of the four secondary actuator delta pressure measurements for each of the SSME-TVC actuators must equal 0 plus 370 or minus 440 psid.
(3) Redlines valid at engine actuator position 0.0 deg plus or minus 2.0 deg.
(4) 3 of 4 acceptable for confirmed instrumentation failure (exclusive of transducer).

PREPLANNED CONTINGENCY PROCEDURE:

(5) If 4 of 4 delta pressures are not within +/- 1050 psid, hold at T-31 seconds. If not clear at T-31 seconds, rerun MPS slew to attempt to clear. If clear, LCC violation cleared, continue countdown. If not clear, LCC violation confirmed, No Go for launch.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(6) Redline limits were established as hardware RSS on system performance tolerance based on testing. The limits are set as high as possible without risk of inadvertent port bypass, but below the equalization pressure limits of plus or minus 1175 psid.

(7) Derivation of the algebraic sum in Requirement (2) is as follows:
Sum of four secondary pressure measurements (Aerosurface Actuators).
Each Channel (Calculated at delta P of 1050 psid);

Pressure Transducer Error	179.6 psi
Power Supply Tolerance	24.2 psi
ATVC Pressure Monitor Output	31.5 psi
MDM Error	35.2 psi
Root Sum Square	187.3 psi

Sum of Four Delta Pressures;

Root Sum Square of 4 Channels (187.3 X the square root of 4)	374.6 psi
Power Valve Friction (50 lb max)	127.3 psi
Variation in Sum of Four Delta Pressures (RSS)	+395.6 psi
Bias Due to Truncation of Two Bits (8.982 psi/chan)	-35.9 psi

+395.6 - 35.9 = +359.7 psi +359.7/23.952 = +15.02
-395.6 - 35.9 = -431.5 psi -431.5/23.952 = -18.02
+15 X 23.952 = +359.28 Upper Limit = +370 psi
-18 X 23.952 = -431.14 Upper Limit = -440 psi

(8) The transducers are in the Equalization and Failure Detection circuitry.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Flight Control System would not be two-fault tolerant.

CAUSES OF EXCEEDING REDLINE:

(10) Electronics failure.
(11) Actuator failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1, 2, AND 3 FOR ENGINE 1, 2, AND 3 RESPECTIVELY									
UNITS-->	psid								
V58P1n81A	23.95	-2994	2994						
V58P1n82A	23.95	-2994	2994						
V58P1n83A	23.95	-2994	2994						
V58P1n84A	23.95	-2994	2994						
V58P1n86A	23.95	-2994	2994						
V58P1n87A	23.95	-2994	2994						
V58P1n88A	23.95	-2994	2994						
V58P1n89A	23.95	-2994	2994						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 9.15	SHEET 1 of 1	ZONE	
	DWG NO 9.14	SHEET	ZONE	V5
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-971102	SHEET 71AF,AG	ZONE	C
	DWG NO VS70-971099	SHEET AH	ZONE	C

ELEMENT: Orbiter SUBSYSTEM: GNC

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LCC VIOLATION CALL: MPS Engine TVC Actuator Profile Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V58H1100A	MPS eng 1 pitch ACTR posn	(4)	(2,3)	(2,3)	deg	DI
V58H1150A	MPS eng 1 yaw ACTR posn	(4)	(2,3,6)	(2,3,6)	deg	DI
V58H1200A	MPS eng 2 pitch ACTR posn	(4)	(2,3,6)	(2,3,6)	deg	DI
V58H1250A	MPS eng 3 yaw ACTR posn	(4)	(2,3,6)	(2,3,6)	deg	DI
V58H1300A	MPS eng 3 pitch ACTR posn	(4)	(2,3)	(2,3)	deg	DI
V58H1350A	MPS eng 3 yaw ACTR posn	(4)	(2,3,6)	(2,3,6)	deg	DI
Positive	(+) Slew Test = +6.0 nominal		+4.5	+7.5	deg	DI
Negative	(-) Slew Test = -6.0 nominal		-7.5	-4.5	deg	DI

TIME PERIOD:

(1) Approximately T-3 minutes, 18 seconds

REQUIREMENTS: FIGURES/TABLES:

(2) Verify positive (+) slew test MPS TVC actuator positions (minimum: +4.5 deg; maximum: +7.5 deg) when at the positive plateau (steady state).
(3) Verify negative (-) slew test MPS TVC actuator positions (minimum: -7.5 deg; maximum: -4.5 deg) when at the negative plateau (steady state).
(4) 5 of 6 acceptable for confirmed instrumentation failure.

PREPLANNED CONTINGENCY PROCEDURE:

(5) Use driver output and secondary delta pressures to verify proper operation during slew. Failure of one transducer requires monitoring eight additional measurements.

NOTES:

(6) Monitoring implementation for V58H1150A, 1200A, 1250A, and 1350A uses negative scale factor, thereby reversing the polarity.
(7) The nominal values for the slew test are: positive, +6.0 degrees; negative, -6.0 degrees.

REDLINE DERIVATION: CRITICALITY: 1R

CONSEQUENCES OF EXCEEDING REDLINE:

CAUSES OF EXCEEDING REDLINE:

(8) ATVC failure.
(9) Actuator failure.
(10) DPS command problem.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	deg								
V58H1100A	0.084	-10.5	+10.5						
V58H1300A	0.084	-10.5	+10.5						
V58H1200A	-0.084	+10.5	-10.5						
n = 1, 2, AND 3 FOR ENGINE 1, 2, AND 3 RESPECTIVELY									
V58H1n50A	-0.068	+8.5	-8.5						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 9.14	SHEET 1 of 1	ZONE W1
	DWG NO 9.15	SHEET 1 of 1	ZONE C7
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-971102	SHEET 71AA	ZONE C,F
	DWG NO VS70-971099	SHEET 71AA	ZONE C,F

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: OMS Actuator Launch Position Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V43H2500C	OMS-L Eng Actv P Actr Posn In		+5.14	+6.16	Deg	DI
V43H2504C	OMS-L Eng Stby P Actr Posn In		+5.14	+6.16	Deg	DI
V43H2502C	OMS-L Eng Actv Y Actr Posn In		+5.35	+6.67	Deg	DI
V43H2506C	OMS-L Eng Stby Y Actr Posn In		+5.35	+6.67	Deg	DI
V43H2550C	OMS-R Eng Actv P Actr Posn In		+5.14	+6.16	Deg	DI
V43H2554C	OMS-R Eng Stby P Actr Posn In		+5.14	+6.16	Deg	DI
V43H2552C	OMS-R Eng Actv Y Actr Posn In		-6.67	-5.35	Deg	DI
V43H2556C	OMS-R Eng Stby Y Actr Posn In		-6.67	-5.35	Deg	DI

TIME PERIOD:

(1) Verify prior to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) Active and standby positions must track within 0.25 deg of each other.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(3) The redlines reflect the OMS stow position plus or minus uncertainties caused by servo loop deadband, MDM tolerances, and transducer excitation.
(4) Instrumentation is required for in-flight operations to ensure that the engine nozzle does not enter the air stream during ascent. If the engine nozzle does protrude into the air stream more than 1.5 degrees, the engine must not be used.
(5) This verification ensures that the Flight Software (OPS 101) does not improperly command an OMS Engine actuator.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Propellant wasting during orbit insertion burn.
(7) If inboard or up, wind loads on OMS engines may be excessive.
(8) Indicative of an actuator failure.
(9) Lack of instrumentation.

CAUSES OF EXCEEDING REDLINE:

(10) Synchro failure.
(11) Transducer failure.
(12) Electronics failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	deg								
V43H2500C	.0164	-8.19	+8.19						
V43H2504C	.0164	-8.19	+8.19						
V43H2502C	.0164	-8.19	+8.19						
V43H2506C	.0164	-8.19	+8.19						
V43H2550C	.0164	-8.19	+8.19						
V43H2554C	.0164	-8.19	+8.19						
V43H2552C	-.0164	+8.19	-8.19						
V43H2556C	-.0164	+8.19	-8.19						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 9.13 SHEET 1 of 1 ZONE H6
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-943099 SHEET 43AE,BE ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: OMS Gimbal Profile Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V43H2500C	OMS-L Eng Actv P Actr Posn In		(2)	(2)	Deg	DI
V43H2504C	OMS-L Eng Stby P Actr Posn In		(2)	(2)	Deg	DI
V43H2502C	OMS-L Eng Actv Y Actr Posn In		(2)	(2)	Deg	DI
V43H2506C	OMS-L Eng Stby Y Actr Posn In		(2)	(2)	Deg	DI
V43H2550C	OMS-R Eng Actv P Actr Posn In		(2)	(2)	Deg	DI
V43H2554C	OMS-R Eng Stby P Actr Posn In		(2)	(2)	Deg	DI
V43H2552C	OMS-R Eng Actv Y Actr Posn In		(2)	(2)	Deg	DI
V43H2556C	OMS-R Eng Stby Y Actr Posn In		(2)	(2)	Deg	DI

TIME PERIOD:

(1) Verify at Go for ET Cryo Loading (T-6 hours)

REQUIREMENTS: FIGURES/TABLES:

(2) Positions at steady state shall equal commands plus or minus 0.25 deg. Drive rates shall be between 2.9 and 6 deg/sec with a delta from previous comparable test of less than 1 deg/sec.
(3) It is acceptable to launch with a failed primary or secondary channel (including the controller) if the failure is such that when selected the channel will not drive either the pitch or yaw actuator out of position by more than 1.5 degrees inward or upward from the stow position.
(4) The allowance to launch with certain channel failures assumes the no-back devices for the affected TVC held during the boost phase of its last flight and therefore provide a level of fault tolerance (Ref. SODB Vol. 1, Paragraph 4.3.3.1, 2nd Note b; OMRSD File 9).

PREPLANNED CONTINGENCY PROCEDURE:

(5) If OMS gimbal profile fails rate or delta criteria, rerun profile.

NOTES:

(6) Profile optional for countdown recycle operations to reduce actuator cycles.

REDLINE DERIVATION: CRITICALITY: 1R

(7) The lower drive rate specified is the minimum allowed by the hardware specification.
(8) The thrust vector control (TVC) system consists of four channels (two engines each with primary and secondary TVC). Control of an engine movement in both the pitch and yaw axes. Both the primary and secondary TVC hardware contain no-back devices which lock the TVC when it is unpowered. The flight software contains logic in OPS 1 which monitors pitch and yaw actuator positions and will power the TVC if the engine bells move from their stow position. The hardware and software are designed to

REDLINE DERIVATION: (Continued)

ensure that the bells are stowed during ascent for any single failure post lift-off. This requirement exists because both engines must be used for the OMS propellant dump on an RTLS abort. The dump is required to manage landing weight and vehicle center of gravity.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Loss of redundant OMS TVC control path.
(10) Loss of two-fault tolerance for deorbit capability.
(11) Loss of single fault tolerance for OMS abort dump capability for an engine.

CAUSES OF EXCEEDING REDLINE:

(12) Failure in the actuator/controller electronics.
(13) Failure in the GPC/MDM command path.
(14) Failure of logic or motor power paths.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
UNITS-->	deg								
V43H2500C	.0164	-8.19	+8.19						
V43H2504C	.0164	-8.19	+8.19						
V43H2502C	.0164	-8.19	+8.19						
V43H2506C	.0164	-8.19	+8.19						
V43H2550C	.0164	-8.19	+8.19						
V43H2554C	.0164	-8.19	+8.19						
V43H2552C	-.0164	+8.19	-8.19						
V43H2556C	-.0164	+8.19	-8.19						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 9.13 SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-943099 SHEET 43AE,BE ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: RJD Jet Chamber Pressure Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V79X2704X	RJDF 1 Jet F1D Chamber Press Ind	(2)	OFF	NA	Event	CI
V79X2708X	RJDF 1 Jet F2D Chamber Press Ind	(2)	OFF	NA	Event	CI
V79X2712X	RJDF 2 Jet F3D Chamber Press Ind	(2)	OFF	NA	Event	CI
V79X2714X	RJDF 2 Jet F4D Chamber Press Ind	(2)	OFF	NA	Event	CI
V79X2722X	RJDA 1 Jet L2D Chamber Press Ind	(3)	OFF	NA	Event	CI
V79X2725X	RJDA 2 Jet L3D Chamber Press Ind	(3)	OFF	NA	Event	CI
V79X2728X	RJDA 2 Jet L4D Chamber Press Ind	(3)	OFF	NA	Event	CI
V79X2736X	RJDA 1 Jet R2D Chamber Press Ind	(3)	OFF	NA	Event	CI
V79X2739X	RJDA 2 Jet R3D Chamber Press Ind	(3)	OFF	NA	Event	CI
V79X2742X	RJDA 2 Jet R4D Chamber Press Ind	(3)	OFF	NA	Event	CI
V79X2702X	RJDF 1 Jet F1L Chamber Press Ind	(4)	OFF	NA	Event	CI
V79X2710X	RJDF 2 Jet F3L Chamber Press Ind	(4)	OFF	NA	Event	CI
V79X2706X	RJDF 1 Jet F2R Chamber Press Ind	(4)	OFF	NA	Event	CI
V79X2713X	RJDF 2 Jet F4R Chamber Press Ind	(4)	OFF	NA	Event	CI
V79X2718X	RJDA 1 Jet L1L Chamber Press Ind	(2)	OFF	NA	Event	CI
V79X2720X	RJDA 1 Jet L2L Chamber Press Ind	(2)	OFF	NA	Event	CI
V79X2724X	RJDA 2 Jet L3L Chamber Press Ind	(2)	OFF	NA	Event	CI
V79X2726X	RJDA 2 Jet L4L Chamber Press Ind	(2)	OFF	NA	Event	CI
V79X2732X	RJDA 1 Jet R1R Chamber Press Ind	(2)	OFF	NA	Event	CI
V79X2734X	RJDA 1 Jet R2R Chamber Press Ind	(2)	OFF	NA	Event	CI
V79X2738X	RJDA 2 Jet R3R Chamber Press Ind	(2)	OFF	NA	Event	CI
V79X2740X	RJDA 2 Jet R4R Chamber Press Ind	(2)	OFF	NA	Event	CI
V79X2703X	RJDF 1 Jet F1U Chamber Press Ind	(5)	OFF	NA	Event	CI
V79X2707X	RJDF 1 Jet F2U Chamber Press Ind	(5)	OFF	NA	Event	CI
V79X2711X	RJDF 2 Jet F3U Chamber Press Ind	(5)	OFF	NA	Event	CI
V79X2719X	RJDA 1 Jet L1U Chamber Press Ind	(3)	OFF	NA	Event	CI
V79X2721X	RJDA 1 Jet L2U Chamber Press Ind	(3)	OFF	NA	Event	CI
V79X2727X	RJDA 2 Jet L4U Chamber Press Ind	(3)	OFF	NA	Event	CI
V79X2733X	RJDA 1 Jet R1U Chamber Press Ind	(3)	OFF	NA	Event	CI
V79X2735X	RJDA 1 Jet R2U Chamber Press Ind	(3)	OFF	NA	Event	CI
V79X2741X	RJDA 2 Jet R4U Chamber Press Ind	(3)	OFF	NA	Event	CI
V79X2717X	RJDA 1 Jet L1A Chamber Press Ind	(6)	OFF	NA	Event	CI
V79X2723X	RJDA 2 Jet L3A Chamber Press Ind	(6)	OFF	NA	Event	CI
V79X2731X	RJDA 1 Jet R1A Chamber Press Ind	(6)	OFF	NA	Event	CI
V79X2737X	RJDA 2 Jet R3A Chamber Press Ind	(6)	OFF	NA	Event	CI

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	(Concluded)					
V79X2701X	RJDF 1 Jet F1F Chamber Press Ind	(5)	OFF	NA	Event	CI
V79X2705X	RJDF 1 Jet F2F Chamber Press Ind	(5)	OFF	NA	Event	CI
V79X2709X	RJDF 2 Jet F3F Chamber Press Ind	(5)	OFF	NA	Event	CI

TIME PERIOD:

(1) From OPS 1 Transition (T-20 minutes) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) 3 of 4 acceptable only if (8) or (9) successfully completed.
(3) 2 of 3 acceptable only if (8) or (9) successfully completed.
(4) 1 of 2 acceptable only if (8) or (9) successfully completed.
(5) If indicator failed - LCC violation cleared, continue countdown. (10, 11)
(6) 1 of 2 indicators failed to zero (min) is acceptable. (10)

PREPLANNED CONTINGENCY PROCEDURE:

(7) All actions must be performed in OPS 1.
(8) If indicator failed to logical zero, deselect inhibit once-failed jet is required to keep jet in available table and to reprioritize jet with failure to last priority. (Except jets F1U, F2U, F3U, +X and -X jets.)
(9) If indicator failed to logical 1, deselect inhibit twice-failed jet is required to reprioritize jet with failure to last priority. (Except jets F1U, F2U, F3U and -X jets.)
(10) For an analog Pc or Pc event indication failed to zero (min) on jets F1U, F2U, F3U or the +X or -X jets deselect inhibit once-failed jet to keep jet in available table and to reprioritize jet with failure to last priority if action does not seriously impact countdown. Otherwise, LCC violation cleared, continue countdown.
(11) For an analog Pc or Pc event indication failed high (max) on jets F1U, F2U, F3U or the -X jets deselect inhibit twice-failed jet to reprioritize jet with failure to last priority if the action does not seriously impact the launch countdown. Otherwise, LCC violation cleared, continue countdown.

NOTES:

(12) Failure to logical zero cannot be detected during the launch countdown.
(13) RJD Pc receiver level detector threshold for indication of Pc event is an analog Pc measurement of 36 psia. Analog Pc transducer failure implies Pc event indication failure (reference SSID: RCS-08).
(14) The first deselect inhibit causes the jet to be placed at the bottom of the jet priority table and inhibits subsequent auto deselection but allows annunciation to take place. The second deselect inhibit regains the capability to auto deselect the jet and resets the jet fail counters but leaves the jet at the bottom of the jet priority table.

REDLINE DERIVATION: CRITICALITY: 1R

(15) Logical "1" indicates Pc event from Pc receiver level detector located in the RJD (13). Pc indication is necessary for operation of redundancy management.

CONSEQUENCES OF EXCEEDING REDLINE:

(16) Maximum (fail to logical "1"): DAP would not detect jet failed off. During RTLS mated coast and ET SEP, one real undetected jet failure may result in loss of control unless jet is in last priority. DAP would not recognize loss of control authority (not one-fault tolerant for RTLS). NOTE: BFS would indicate jet fail on.
(17) Minimum (fail to logical zero): Equivalent to jet failure since jet will fail OFF when first commanded. Override not available in ascent phase. RCS will not be one failure tolerant for RTLS.

CAUSES OF EXCEEDING REDLINE:

(18) Failed jet PC Transducers.
(19) Failed electronics (RJD, MDM).
(20) Data path failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

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LCC VIOLATION CALL: RCS Vernier Driver Out Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V79X2615X	RJDF 2 Jet F5L Driver		0	NA	Event	CI
V79X2616X	RJDF 2 Jet F5R Driver		0	NA	Event	CI
V79X2629X	RJDA 1 Jet L5D Driver		0	NA	Event	CI
V79X2630X	RJDA 1 Jet L5L Driver		0	NA	Event	CI
V79X2643X	RJDA 2 Jet R5R Driver		0	NA	Event	CI
V79X2644X	RJDA 2 Jet R5D Driver		0	NA	Event	CI

TIME PERIOD:

(1) From OPS 1 Transition (T-20 minutes) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) This SSID is dictated by mission requirements and may be waived if it is determined that verniers are not required.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) ON = logical 1, OFF = logical 0.

REDLINE DERIVATION: CRITICALITY: 1R

(4) Fail "ON" detection required for flight. Measurement should be logic 0 during countdown. Logic 1 without jet firing indicates instrumentation failure.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Has potential to compromise mission objectives.
(6) Min: Failed to zero cannot be detected.
(7) Max: Loss of fail "ON" detection, resulting in excessive propellant usage.

CAUSES OF EXCEEDING REDLINE:

(8) Failed electronics.
(9) Data path failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-943099	SHEET 43CJ,DJ	ZONE ARCS
	DWG NO VS70-942099	SHEET 42AY,AT	ZONE FRCS

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: RCS Vernier Logic RPC Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76X3257E	RJDF 2 Manf 4,5 Logic RPC C On Ind	(2)	ON	NA	Event	CI
V76X4237E	PCA FC RJDA 2 Logic 3 RPC B On	(2)	ON	NA	Event	CI
V76X4221E	PCA FC RJDA 1 Logic 1 RPC A On	(2)	ON	NA	Event	CI

TIME PERIOD:

(1) From RJD Power Up to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown. (4)
(3) This SSID is Mission Dependent.

PREPLANNED CONTINGENCY PROCEDURE:

(4) If logic RPC goes to OFF after RJD power up, turn on associated driver switch; RPC driver ON indicates instrumentation failure - LCC violation cleared, continue countdown.

NOTES:

(5) ON = logical 1, OFF = logical 0.

REDLINE DERIVATION: CRITICALITY: 1R

(6) Measurement should be Logic "1" during countdown (after RJD power up). Logic "0" indicates instrumentation failure or loss of RPC power.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Verniers will not operate on orbit.
(8) Increased propellant consumption for attitude hold.
(9) Degradation of payload pointing function.
(10) Potential to compromise mission objectives.

CAUSES OF EXCEEDING REDLINE:

(11) Failed electronics.
(12) Failed data path.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 11.10	SHEET 1, 2	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-942099	SHEET 42AJ,AN	ZONE FRCS
	DWG NO VS70-943099	SHEET 43CP	ZONE ARCS

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: RCS Driver Power Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76X3252E	RJDF 1 Manf 1 Drvr RPC A On Ind	(2)	ON	NA	Event	CI
V76X3254E	RJDF 1 Manf 2 Drvr RPC B On Ind	(2)	ON	NA	Event	CI
V76X3256E	RJDF 2 Manf 3 Drvr RPC C On Ind	(2)	ON	NA	Event	CI
V76X3260E	RJDF 2 Manf 3 Drvr RPC A On Ind	(2)	ON	NA	Event	CI
V76X3258E	RJDF 2 Manf 4,5 Drvr RPC C On Ind	(2)	ON	NA	Event	CI
V76X4233E	PCA FC RJDA 1 RCS 2 RPC A On	(2,3	ON	NA	Event	CI
V76X4234E	PCA FC RJDA 1 RCS 2 RPC C On	(2,3	ON	NA	Event	CI
V76X4224E	PCA FC RJDA 1 RCS 1 RPC B On	(2,3	ON	NA	Event	CI
V76X4223E	PCA FC RJDA 1 RCS 1 RPC A On	(2,3	ON	NA	Event	CI
V76X4244E	PCA FC RJDA 2 RCS 4 RPC C On	(2,3	ON	NA	Event	CI
V76X4243E	PCA FC RJDA 2 RCS 4 RPC A On	(2,3	ON	NA	Event	CI
V76X4239E	PCA FC RJDA 2 RCS 3 RPC B On	(2,3	ON	NA	Event	CI
V76X4240E	PCA FC RJDA 2 RCS 3 RPC C On	(2,3	ON	NA	Event	CI

TIME PERIOD:

(1) From Driver Power Up (T-2 hr) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown.
(3) 7 of 8 functions are acceptable.

PREPLANNED CONTINGENCY PROCEDURE:

(4) Power down associated logic switch; if RPC logic shows "1", instrumentation failure - LCC violation cleared, continue countdown.

NOTES:

(5) ON = Logical 1, OFF = Logical 0.

REDLINE DERIVATION: CRITICALITY: 1R

(6) Measurement should be Logic "1" after driver power up. Logic "0" indicates instrumentation failure or loss of RPC power.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Single bus loss prevents safe RTLS ET sep and vehicle is no longer fail-safe on entry.

CAUSES OF EXCEEDING REDLINE:

(8) Failed electronics.
(9) Failed data path.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 11.10	SHEET 1, 2	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-942099	SHEET 42AJ,AH	ZONE FRCS
	DWG NO VS70-943099	SHEET 43CP	ZONE ARCS

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: RJD Trickle Current Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V79X2345X	RJDF 1 Trickle Cur Continuity 1		ON	NA	Event	CI
V79X2347X	RJDF 1 Trickle Cur Continuity 2		ON	NA	Event	CI
V79X2355X	RJDF 2 Trickle Cur Continuity 4,5		ON	NA	Event	CI
V79X2357X	RJDF 2 Trickle Cur Continuity 3		ON	NA	Event	CI
V79X2365X	RJDA 1 Trickle Cur Continuity 1,5L		ON	NA	Event	CI
V79X2367X	RJDA 1 Trickle Cur Continuity 2		ON	NA	Event	CI
V79X2375X	RJDA 2 Trickle Cur Continuity 3,5R		ON	NA	Event	CI
V79X2377X	RJDA 2 Trickle Cur Continuity 4		ON	NA	Event	CI

TIME PERIOD:

(1) From Driver Power Up (T-2 hours) to OPS 1 Transition (T-20 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown. (4)
(3) Transients at Driver power up are acceptable.

PREPLANNED CONTINGENCY PROCEDURE:

(4) To confirm instrumentation failure, cycle RJD Driver power OFF/ON and verify proper RPC indication response. If Trickle current indication remains OFF, perform RCS Single Command Test. If Trickle current still remains OFF, instrumentation failure is confirmed, re-establish ascent configuration, LCC violation cleared, continue countdown. Reference OMI S0007 Volume 5.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(5) Measurement should be logic "1" after driver power up. Logic "0" indicates instrumentation failure or BITE circuit failure, or loss of RCS driver power.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) If RCS driver power is lost on RJDF, safe RTLS ET Sep is lost and vehicle is no longer fail-safe on entry.
(7) If RCS driver power is lost on RJDA, vehicle is no longer two-fault tolerant for entry.

CAUSES OF EXCEEDING REDLINE:

(8) Failed electronics in BITE circuitry.
(9) Failed data path.
(10) Failed power path.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 11.10	SHEET 1,2,3	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-942099	SHEET 42AT,	ZONE FRCS
	DWG NO	SHEET 42AY	ZONE
	DWG NO VS70-943099	SHEET 43CJ,	ZONE ARCS
	DWG NO	SHEET 43DJ	ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

SSIDs GNC-50 thru GNC-55 Reserved

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LCC VIOLATION CALL: IMU Hardware Bite Indication | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V71X2021B	IMU-1 Good		ON	NA	Event	CI
V71X3021B	IMU-2 Good		ON	NA	Event	CI
V71X4021B	IMU-3 Good		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 sec)

REQUIREMENTS: FIGURES/TABLES:

(2) Three operational IMUs are required to remain two-fault tolerant.

PREPLANNED CONTINGENCY PROCEDURE:

(3) If any of these individual measurements go "ON" (1) with the "IMU Good" BITE remaining "ON" (1), then the indication is that of a "BITE-on-BITE" failure within the IMU, and the IMU may be presumed to be functional unless other abnormalities are observed. This note applicable to KT-70 IMU.

(4) For a one-time IMU Good "OFF," perform preflight cal and alignment. If all criteria of the preflight cal and alignment are met and there is no subsequent BITE indication, LCC violation cleared, continue countdown.

NOTES:

(5) "ON" = Logical 1.

REDLINE DERIVATION: CRITICALITY: 1R

(6) "IMU Good" discretes are set "OFF" (0) if built-in hardware test detects a failed function. These functions are "nor'ed" together as listed below:

IMU Function	HAINS Function	IMU 1	IMU 2	IMU 3
I/O Fail	MUX Fail	V71X2022B	V71X3022B	V71X4022B
A/D Fail	A/D Fail	V71X2023B	V71X3023B	V71X4023B
Platform Fail (3)	Platform Fail	V71X2024B	V71X3024B	V71X4024B
Pwr Contlr Fail (3)	Digital Subsystem Fail	V71X2025B	V71X3025B	V71X4025B
DC/DC No 1 Fail (3)	DC/DC Fail	V71X2026B	V71X3026B	V71X4026B
Filter/DC No 2 Fail (3)	Disc Pwr Sply Fail	V71X2027B	V71X3027B	V71X4027B
RX Current Fail	RX Fail	V71X2028B	V71X3028B	V71X4028B
Pwr Cond Over Temp	Circuit Card Over Temp	V71X2029B	V71X3029B	V71X4029B

CONSEQUENCES OF EXCEEDING REDLINE:

(7) An IMU Good "OFF" (0) forces an assumption of a hardware failure in the IMU until trouble shooting results indicate otherwise. A continuous or intermittent IMU Good "OFF" indicates a possible hardware failure.

CAUSES OF EXCEEDING REDLINE:

(8) Failure of one or more of the IMU internal circuits.
(9) Failure of the BITE logic.
(10) Transient indication (4).

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 9.7	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS72-900099	SHEET 56-64	ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: Orbiter IMU Power Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76X4250E	PCA IMU No 1 RPC No A On	5	ON	NA	Event	CI
V76X4251E	PCA IMU No 1 RPC No B On		ON	NA	Event	CI
V76X4253E	PCA IMU No 2 RPC No B On	of	ON	NA	Event	CI
V76X4254E	PCA IMU No 2 RPC No C On		ON	NA	Event	CI
V76X4256E	PCA IMU No 3 RPC No C On	6	ON	NA	Event	CI
V76X4257E	PCA IMU No 3 RPC No A On		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Any more than one OFF indication shall warrant confirmation that no more than one RPC is functionally failed (3,4,5).

PREPLANNED CONTINGENCY PROCEDURE:

(3) Verify IMU power switches configured to ON (ref S0007 Vol 5). If switch is OFF and repositioning to ON clears problem, LCC violation cleared, continue countdown.

(4) If both RPCs for an IMU indicate OFF and the IMU is not bypassed by FCOS (Flight Computer Operating System), at least one of the failures is confirmed to be instrumentation only; LCC violation cleared, continue countdown.

(5) To confirm instrumentation failure, drop the specified control bus (ref OMRS S00GEN.780) and verify that an IMU element bypass does not occur with redundant RPC unpowered (Ref S0007 Vol 5).
For PCA IMU No 1 RPC No A On; drop CNTL AB2.
For PCA IMU No 1 RPC No B On; drop CNTL AB1.
For PCA IMU No 2 RPC No B On; drop CNTL BC1.
For PCA IMU No 2 RPC No C On; drop CNTL BC2.
For PCA IMU No 3 RPC No C On; drop CNTL CA2.
For PCA IMU No 3 RPC No A On; drop CNTL CA3.
For confirmed instrumentation failure, LCC violation cleared, continue countdown.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(6) An OFF indicates power failure at the point under test. 5 of 6 RPCs powered ensures IMU two-fault tolerance to two main bus failures. With any one RPC failed, the loss of any two main busses will result in the loss of no more than two IMUs. If a redline violation is due to a confirmed instrumentation failure, then the RPC is good and only insight is lost.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Loss of Orbiter IMU two-fault tolerance.

CAUSES OF EXCEEDING REDLINE:

(8) Wiring failure.
(9) RPC failure.
(10) Switch failure.
(11) Instrumentation failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 9.7	SHEET 1 of 1	ZONE 2/U,V,W
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-971099	SHEET 56,59	ZONE 19
	DWG NO	SHEET 62	ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: IMU Temperature Ready Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V71X2404X	IMU 1 Platform Temp Ready		ON	NA	Event	CI
V71X2406X	IMU 1 CAPRI Temp Ready		ON	NA	Event	CI
V71X3404X	IMU 2 Platform Temp Ready		ON	NA	Event	CI
V71X3406X	IMU 2 CAPRI Temp Ready		ON	NA	Event	CI
V71X4404X	IMU 3 Platform Temp Ready		ON	NA	Event	CI
V71X4406X	IMU 3 CAPRI Temp Ready		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) For transient indication, perform preflight cal and alignment. If all criteria of the preflight cal and alignment are met and there is no subsequent BITE indication, LCC violation cleared, continue countdown.

NOTES:

(3) Three operational IMUs are required to remain two-fault tolerant.
(4) The HAINS does not have a CAPRI and the CAPRI Temp Ready measurement is set "ON" internal to the HAINS.
(5) IMU performance degradation may not be immediately evident when an out-of-temp condition occurs. For the Platform Temp Ready indications only, thermal lag within the inertial elements will cause a delay in performance degradation.

REDLINE DERIVATION: CRITICALITY: 1R

(6) Instrumentation is necessary for redundancy management.
(7) Platform Temp Ready (V71X2404X, V71X3404X, & V71X4404X). When this measurement changes from "ON" (1) to "OFF" (0), it indicates that the IMU stable member heater is unable to supply sufficient heat to maintain proper temperature. IMU performance is expected to degrade and a malfunction may occur. For the KT-70 IMU, the desired temperature of 160.0 +/-0.1 deg F has dropped below 155 plus or minus 3 deg F. For the HAINS, the temperature of the vertical gyro has dropped below 146.5 plus or minus 3 deg F or the temperature of the azimuth gyro has dropped below 150 plus or minus 3 deg F.

REDLINE DERIVATION: (Continued)

(8) CAPRI Temp Ready (V71X2406X, 3406X, & 4406X). This is only applicable to the KT-70. When this measurement changes from "ON" (1) to "OFF" (0) for the KT-70 it indicates that the IMU heater is unable to supply sufficient heat to maintain proper temperature. IMU performance is expected to degrade and a malfunction may occur. The desired temperature of 149 plus or minus 0.9 deg F has dropped below 144 plus 1 or minus 2 deg F. For the HAINS, it indicates a problem in the power supply.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) IMU performance will degrade.
(10) Two-fault tolerance is not maintained since two-level redundancy management treats this BITE as real and will downmode the IMU in a dilemma situation.

CAUSES OF EXCEEDING REDLINE:

(11) Shorted or open heater circuit in either the platform or CAPRI oven system.
(12) Heater circuit component malfunction (temperature control amps, thermistor, etc.)
(13) Failure of bite logic.
(14) Transient indication (2).
(15) Failure of the HAINS internal power supply.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 9.7 SHEET 1 of 1 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS72-900099 SHEET 56-64 ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: IMU Over Temperature Indication | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V71X2405X	IMU 1 Platform Temp Safe		ON (2)	NA	Event	CI
V71X2407X	IMU 1 CAPRI Temp Safe		ON (2)	NA	Event	CI
V71X3405X	IMU 2 Platform Temp Safe		ON (2)	NA	Event	CI
V71X3407X	IMU 2 CAPRI Temp Safe		ON (2)	NA	Event	CI
V71X4405X	IMU 3 Platform Temp Safe		ON (2)	NA	Event	CI
V71X4407X	IMU 3 CAPRI Temp Safe		ON (2)	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) If the Temp Safe indication goes from "ON" (1) to "OFF" (0) the IMU should be powered down immediately to prevent potential damage due to overheating.
(3) For transient indication, perform preflight cal and alignment. If all criteria of the preflight cal and alignment are met and there is no subsequent BITE indication, LCC violation cleared, continue countdown.

NOTES:

(4) Three operational IMUs are required to remain two-fault tolerant.
(5) The HAINS does not have a CAPRI and the CAPRI Temp Safe measurement is set "ON" internal to the HAINS.
(6) IMU performance degradation may not be immediately evident when an out-of-temp condition occurs.
(7) Because of IMU RM software logic, failure of BITE logic will result in loss of two-fault tolerance.

REDLINE DERIVATION: CRITICALITY: 1R

(8) A Platform Temp Safe change from "ON" (1) to "OFF" (0) indicates that the IMU stable member temperature for the KT-70 exceeds 165 plus or minus 3 deg F or for the HAINS exceeds 156.5 plus or minus 3 deg F. This indicates a malfunction has occurred and IMU (gyro and accelerometer) performance will degrade. The inner roll thermostat opens at 170 deg F and the stable member thermostat opens at 178 deg F for the KT-70.
(9) A CAPRI Temp Safe change from "ON" (1) to "OFF" (0) for the KT-70 indicates that the CAPRI oven temperature exceeds 156 plus 2 or minus 1 deg F. This indicates a malfunction has occurred and IMU velocity performance will degrade. The CAPRI oven temp thermostat opens at 203 deg F. For the HAINS it indicates a problem in the IMU power supply.
(10) Instrumentation is necessary for redundancy management.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) IMU performance will degrade.
(12) IMU overheating and possible damage.
(13) Two-fault tolerance is not maintained since two-level redundancy management treats this BITE as real and will downmode the IMU in a dilemma situation.

CAUSES OF EXCEEDING REDLINE:

(14) Shorted heater circuit in either the platform or CAPRI oven systems.
(15) Heater circuit component malfunction (temperature control amps, thermistor, etc.).
(16) Failure of BITE logic.
(17) Loss of cooling air.
(18) Transient indication (3).
(19) Failure of the HAINS internal power supply.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 9.7 SHEET 1 of 1 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS72-900099 SHEET 56-64 ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: Redundancy Management IMU Failure Indication | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V90X2601X	IMU 1 Fail		OFF	NA	Event	CI
V90X2701X	IMU 2 Fail		OFF	NA	Event	CI
V90X2801X	IMU 3 Fail		OFF	NA	Event	CI

TIME PERIOD:

(1) From Platform Release (T-4 minutes) to Go For RSLS Start (T-31 sec)

REQUIREMENTS: FIGURES/TABLES:

(2) Three operational IMUs are required to remain two-fault tolerant.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(3) IMU 1 fail - This discrete is set to "ON" (1) whenever IMU 1 failure has been voted by RM in either of two ways:
   A. Three (3) successive trips (covering 48 sec of FDI processing) of a relative velocity error threshold of 1.31 ft/sec for IMU pair 1-2 and IMU pair 1-3.
   B. Three (3) successive trips (covering 48 sec of FDI processing) of a relative attitude whole angle error threshold of 865 + 0.0875*T arcsec (where T is the elapsed time in seconds from Platform Release) for IMU pair 1-2 and IMU pair 1-3. The 865 arcsec constant is based on 3 sigma GC-ALIGN and GC-ALIGN1 errors. The ramp of 0.0875 arcsec/sec is the rss of the 3 sigma KT-70 IMU restraint and mass unbalance drift terms (0.045 deg/hr and 0.075 deg/hr, respectively).

(4) IMU 2 fail - Same as IMU 1 fail (above) except that the IMU failed pairs are IMU pair 1-2 and IMU pair 2-3.

(5) IMU 3 fail - Same as IMU 1 fail (above) except that the IMU failed pairs are IMU pair 1-3 and IMU pair 2-3.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) IMU failure.

CAUSES OF EXCEEDING REDLINE:

(7) Loss of accelerometer or gyro channel on IMU.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS72-900099	SHEET 56-64	ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: IMU Software BITE Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V95X0030X	IMU 1 Word 13 Echo Fail		OFF	NA	Event	CI
V95X0031X	IMU 1 Word 14 Echo Fail		OFF	NA	Event	CI
V95X0033X	IMU 1 Redundant Rate Fail		OFF	NA	Event	CI
V95X0034X	IMU 1 Inner Resolver Null Fail		OFF	NA	Event	CI
V95X0035X	IMU 1 Velocity Limit Fail		OFF	NA	Event	CI
V95X0037X	IMU 1 Resolver Limit Fail		OFF	NA	Event	CI
V95X0081X	IMU 1 Acc/CAPRI SF Fail		OFF	NA	Event	CI
V95X1030X	IMU 2 Word 13 Echo Fail		OFF	NA	Event	CI
V95X1031X	IMU 2 Word 14 Echo Fail		OFF	NA	Event	CI
V95X1033X	IMU 2 Redundant Rate Fail		OFF	NA	Event	CI
V95X1034X	IMU 2 Inner Resolver Null Fail		OFF	NA	Event	CI
V95X1035X	IMU 2 Velocity Limit Fail		OFF	NA	Event	CI
V95X1037X	IMU 2 Resolver Limit Fail		OFF	NA	Event	CI
V95X1081X	IMU 2 Acc/CAPRI SF Fail		OFF	NA	Event	CI
V95X2030X	IMU 3 Word 13 Echo Fail		OFF	NA	Event	CI
V95X2031X	IMU 3 Word 14 Echo Fail		OFF	NA	Event	CI
V95X2033X	IMU 3 Redundant Rate Fail		OFF	NA	Event	CI
V95X2034X	IMU 3 Inner Resolver Null Fail		OFF	NA	Event	CI
V95X2035X	IMU 3 Velocity Limit Fail		OFF	NA	Event	CI
V95X2037X	IMU 3 Resolver Limit Fail		OFF	NA	Event	CI
V95X2081X	IMU 3 Acc/CAPRI SF Fail		OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 sec)

REQUIREMENTS: FIGURES/TABLES:

(2) For transients after T-5 min, LCC violation confirmed, No Go for launch.

PREPLANNED CONTINGENCY PROCEDURE:

(3) If transient indication occurs prior to T-5 minutes, perform analysis of data. If there is no indication of failure (substantiated by data), LCC violation cleared, continue countdown.

NOTES:

(4) Three operational IMUs are required to remain two-fault tolerant.
(5) CAPRI = capacitive reset integrator.

REDLINE DERIVATION: CRITICALITY: 1R

(6) Word 13 Echo Fail - This discrete is set to "ON" (1) whenever IMU output word 13 does not compare with the previously GPC-transmitted command. Word 1 and bit 9 (the trans-1-fail bit) of IMU output word 1 is a zero (0).

REDLINE DERIVATION: (Continued)

(7) Word 14 Echo Fail - This discrete is set to "ON" (1) whenever IMU output word 14 does not compare with the previously GPC-transmitted command. Word 2 and bit 10 (the trans-2-fail bit) of IMU output word 1 is a zero (0).
(8) Redundant Rate Fail - This discrete is set to "ON" (1) whenever an IMU platform rate exceeds an I-loaded threshold of 0.7 deg/hr.
(9) Inner Resolver Null Fail- This discrete is set to "ON" (1) when the 8X Inner Resolver angle is between plus 24 deg and plus 336 deg and the IMU is not in the gimbal flip region.
(10) Velocity Limit Fail - This discrete is set to "ON" (1) when the RSS of the X, Y, and Z delta velocities over a major cycle for this IMU (and only this IMU) is less than 0.656 ft/sec or if the accumulation of velocity pulses in any accelerometer channel is greater than the appropriate I-loaded limit.
(11) Resolver Limit Fail - This discrete is set to "ON" (1) when the difference between any 1X gimbal angle and the corresponding computed gimbal angle (utilizing both 1X and 8X angle data) is greater than a calculated reasonableness test limit.
(12) Acc/CAPRI SF Fail - This discrete is set to "ON" (1) when the D1/D8 bit (V71X2032B1-IMU 1, V71X3032B1-IMU 2, V71X4032B1-IMU 3) of the IMU output word 1 is not equal to the last transmitted accelerometer/CAPRI gain setting. The HAINS does not have a CAPRI but does support the gain setting.

CONSEQUENCES OF EXCEEDING REDLINE:

(13) IMU failure.

CAUSES OF EXCEEDING REDLINE:

(14) Words 13 and 14 Echo Fails are caused by the improper communications between the IMU and the GPC. Redundant Rate Fail is caused by a gyro failure in any channel. Inner Resolver Null Fail is caused by a malfunction of the servo that usually maintains the pitch gimbal axis normal to the azimuth axis of the Inner Resolver gimbal by using the 1X Inner Resolver signal to torque the Outer Resolver gimbal. Velocity limit fail is caused by a accelerometer channel failure of the IMU. Resolver limit fail is caused by a malfunction of the gimbal-angle read circuitry, such as a resolver failure.
(15) Transient indication (2, 3).

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS72-900099	SHEET 56-64	ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: IMU Gyrocompass Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V99U3262C	G/C Failed IMU 1,2 Pair		OFF	NA	Event	DI
V99U3263C	G/C Failed IMU 1,3 Pair		OFF	NA	Event	DI
V99U3264C	G/C Failed IMU 2,3 Pair		OFF	NA	Event	DI

TIME PERIOD:

(1) Verify at Alignment Complete (approx. 38 minutes after start of Preflight Alignment)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) Repeat the preflight gyrocompass alignment. If the repeat gyrocompass alignment fails, allow preflight alignment to continue with GC_ALIGN1. Perform realtime analysis to determine if alignment and IMU performance are acceptable.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(3) Failed IMU 1,2 pair discrete is set to "ON" (1) when the relative misalignment between IMU 1 and IMU 2 (at the end of gyrocompass) has exceeded the following limits in body axis:

		(with zero MB Terms)	(with non-zero MB terms- avail in LPS)
Body axis:	X	360 arc sec	268 arc sec
	Y	268 arc sec	119 arc sec
	Z	268 arc sec	268 arc sec

These limits are I-Loads which protect for 3 sigmaKT-70 IMU performance.

(4) Failed IMU 1,3 Pair discrete is set the same as above except the relative misalignment between IMU 1 and IMU 3 has exceeded the limits.

(5) Failed IMU 2,3 Pair discrete is set the same as above except the relative misalignment between IMU 2 and IMU 3 has exceeded the limits.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Proceeding with IMUs that failed gyrocompass can cause excessive IMU misalignment at launch. This can result in large navigation errors at MECO and allowable errors at entry interface for an AOA.

CAUSES OF EXCEEDING REDLINE:

(7) Misalignment of IMU platform caused by internal hardware failure.

CAUSES OF EXCEEDING REDLINE: (Continued)

(8) Y-axis or Z-axis fail likely caused by accelerometer channel performance failure.
(9) X-axis likely caused by gyro drift performance failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS72-900099	SHEET 56-64	ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: IMU Gyrocompass Alignment 1 Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V95X0777X	IMU 1 Alignment Correction Limited		OFF	NA	Event	CI
V95X0778X	IMU 2 Alignment Correction Limited		OFF	NA	Event	CI
V95X0779X	IMU 3 Alignment Correction Limited		OFF	NA	Event	CI

TIME PERIOD:

(1) Verify at completion of each filter pass of IMU Gyrocompass Alignment 1 (GC-ALIGN1) until platform release (T-4 minutes)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) Continue preflight alignment GC-ALIGN1 while evaluating the downlisted misalignment corrections, the IMU to IMU relative misalignment data and the IRAMS determined misalignments. If during subsequent GC-ALIGN1 filter passes the alignment correction limited discrete is "off", accelerometer and gyro health monitor measurements are acceptable, the mission misalignment redlines are not exceeded, and there is adequate margin relative to IMU RM thresholds, LCC violation cleared, continue countdown.

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(3) IMU ALIGNMENT CORRECTION LIMITED discrete is set to "ON" (binary 1) indicating that a misalignment correction torque out value has been limited to the TILT LIMIT or AZIMUTH LIMIT rather than the measured value. The limits are based on accelerometer and gyro 3-sigma performance specifications and maximum expected time between misalignment torque out (2 cycles of GC-ALIGN1).

CONSEQUENCES OF EXCEEDING REDLINE:

(4) If the contingency conditions are met, no consequences are anticipated; Otherwise the following could occur:
   (a) If the misalignments are excessive, large navigation errors could occur during ascent which could result in unallowable errors at entry interface for an AOA.
   (b) A MDF per flight rule 2-201 may be required because the IMU performance may not be acceptable to support entry.

CAUSES OF EXCEEDING REDLINE:

(5) Gyro drift randomness or drift level shift.
(6) Accelerometer scale factor or bias instability.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: IMU Requirements When IRAMS In Use | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
(a)	Accelerometer Fail		-228	228	uG	CI
(a)	Gyro Drift Fail (N-Axis)		-.090	.090	D/H	CI
(a)	(W-Axis)		-.090	.090	D/H	CI
(a)	(U-Axis)		-.160	.160	D/H	CI
(b)	Align Test Fail (N-Axis)		-134	134	arcs	CI
(c)	(N-Axis)		-190	190	arcs	CI
(b)	(W-Axis)		-134	134	arcs	CI
(c)	(W-Axis)		-190	190	arcs	CI
(d)	(U-Axis)		-228	228	arcs	CI
(e)	(U-Axis)		-284	284	arcs	CI
(f)	(U-Axis)		-530	530	arcs	CI
(g)	Misalignment A Axis Fail	(2)	-287	NA	arcs	CI
(g)	Misalignment B Axis Fail	(2)	NA	373	arcs	CI
(g)	Misalignment C Axis Fail	(2)	-855	855	arcs	CI

TIME PERIOD:

(1) From the end of the first position of the flight gyrocompass (approximately T-1 hour 34 minutes) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Misalignment Minimum and Maximum values (g) are specific to Space Station (51.6 degree inclination) launches. For a Hubble mission (28.5 degree inclination), the redline limits are:

	MINIMUM	MAXIMUM
Misalignment A Axis Fail	-243	N/A
Misalignment B Axis Fail	N/A	330
Misalignment C Axis Fail	-821	821

For other launch inclinations refer to MOD Flight Rule A8-57, Prelaunch IMU Hold for specific misalignment redlines.

(3) If data analysis review confirms limits were exceeded, then LCC violation confirmed, No Go for launch.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) In the event the Inertial Reference Alignment Monitor System (IRAMS) is not working at JSC and KSC, refer to Prelaunch IMU Hold Flight Rule (A8-57).

(5) IRAMS has additional detailed engineering displays at JSC for evaluation of a failure. The data should be evaluated completely to determine if a true IMU hardware anomaly exists.

NOTES: (Continued)

(6) The specific update times for each of the measurements are as follows:

MEASUREMENT	MODE	MEASUREMENT TIME
(a,b,d)	GCA POS 1 & 2	At the end of each of the 10 min filter passes.
(a,b,e)	GC-ALIGN1	At the end of each 8 min. pass beginning at Align Complete.
(a,c,f,g)	Inertial	At the end of each 8 minute IRAMS filter pass.

(7) uG = Micro - G.
(8) D/H = Degrees per hour.
(9) arcs = Arc seconds.

REDLINE DERIVATION: CRITICALITY: 1R

(10) a. SSID Intent Summary - The intent of this SSID is to ensure that the IMUs are within acceptable limits to support a safe launch and if required, an abort. The AOA is the constraining abort. IRAMS monitors for accelerometer, gyro and resolver failures by utilizing IMU downlisted and mission I-load parameters. Downlisted paramaters, such as resolver and velocity data for each IMU, are used to calculate the IMU alignment measurement values which are an indicator of expected performance. The IRAMS provides estimated launch hold times based on misalignments and launch inclinations once the IMUs are in Inertial mode. Failure to meet any of these limits would make the IMU unreliable for AOA success. The IMUs are 3 of 3 for launch so that they can remain 2 fault tolerant in Redundancy Management (RM).

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - Redlines are based on the Root Sum Square of 3-sigma (spec) IMU (KT-70) errors and 3-sigma measurement errors. KT-70 (legacy IMU) limits are still used in IMU RM. Exception: Misalignment Axis (g) redlines are for a Space Station launch. For other missions, the redline values used are flight inclination dependent and are installed in the IRAMS via I-load prior to each mission. Mission specific redlines are defined to achieve a 99.74% probability of success for an AOA. Performance near the flight software RM limits is out of family for a High Accuracy Inertial Navigation System (HAINS). Preflight vehicle recalibration would not be sufficient to clear a verified HAINS LCC violation.

d. Time Period - The gyrocompass is started at T-1 hour 47 minutes. It takes a few minutes to get into the first position and 10 minutes for the first position to complete. Therefore, the redlines are in effect from approximately T-1 hour 34 minutes until the system is committed to launch at T-31 seconds.

e. Requirements - Proper IMU performance for all three IMUs maintains the requirement of IMU two-fault tolerance.

f. Preplanned Contingency Procedures - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Reduced probability of a safe mission abort, most significantly AOA.

CAUSES OF EXCEEDING REDLINE:

(12) (a) Gyro and/or accelerometer performance, and/or resolver performance in (U-AXIS) only.
(b,c) Accelerometer and/or resolver performance.
(d,e) Gyro, accelerometer and/or resolver performance.
(f,g) Alignment incorrect or hold time capability of IMU was exceeded.
(13) IRAMS I-Load

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS70-971099	SHEET 56-64	ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

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IMU Transition Time to OPS 1 Exceeded

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LCC VIOLATION CALL: IMU Transmission Word Failure | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V71X2030B	IMU-1 Trans WD1 Fail		OFF	NA	Event	CI
V71X3030B	IMU-2 Trans WD1 Fail		OFF	NA	Event	CI
V71X4030B	IMU-3 Trans WD1 Fail		OFF	NA	Event	CI
V71X2031B	IMU-1 Trans WD2 Fail		OFF	NA	Event	CI
V71X3031B	IMU-2 Trans WD2 Fail		OFF	NA	Event	CI
V71X4031B	IMU-3 Trans WD2 Fail		OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) For transient indication, perform preflight cal and alignment. If all criteria of the preflight cal and alignment are met and there is no subsequent BITE indication, LCC violation cleared, continue countdown.

NOTES:

(3) Three operational IMUs required to remain two-fault tolerant.
(4) Because of IMU RM software logic, failure of BITE logic will result in degradation of two-fault tolerance.

REDLINE DERIVATION: CRITICALITY: 1R

(5) Transmission Word 1 Fail - This discrete is set to a logic "ON" (1) if a failure of parity, gap, or Manchester coding occurs in IMU input word no. 1.
(6) Transmission Word 2 Fail - This discrete is set to a logic "ON" (1) if a failure of parity, gap, or Manchester coding occurs in IMU input word no. 2.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Transmission Word 1 Fail - Loss of IMU pulse torquing capability.
(8) Transmission Word 2 Fail - Loss of IMU slew capability.

CAUSES OF EXCEEDING REDLINE:

(9) Failure of parity, gap, or Manchester coding in IMU input words no. 1 or 2.
(10) Failure of the BITE logic.
(11) Transient indication (2).

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO VS72-900099	SHEET 56-64	ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: IMU PRESSURE/COMMUNICATION ANOMALY | EMERG COND:

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V71X2401X1	IMU 1 Pressure/Communication Good		ON	NA	Event	CI
V71X3401X1	IMU 2 Pressure/Communication Good		ON	NA	Event	CI
V71X4401X1	IMU 3 Pressure/Communication Good		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) For transient indication, perform preflight calibration and alignment. If all criteria of the preflight calibration and alignment are met and there is no subsequent BITE indication, LCC violation cleared, continue countdown.

NOTES:

(3) For the KT-70 IMU this measurement is Pressure Good and this LCC is not applicable. For the HAINS IMU this measurement is Communication Good and this LCC is applicable. (The measurement description nomenclature is effective for OI-21 and subs. Prior to that it is Pressure Good only.)
(4) Three operational IMUs required to remain two-fault tolerant.

REDLINE DERIVATION: CRITICALITY:

(5) The communication from the MDM to the HAINS is monitored by the HAINS to determine if the timing gap between the message-in discrete and the word discrete is within limits. The OFF state of Communication Good indicates that an error condition has been detected during the message-in serial data transfer from the MDM to the HAINS.
(6) Loss of HAINS Communication Good by itself indicates an MDM problem. Loss of the Communication Good with any combination of the following software bites, Word 13 Echo Fail, Word 14 Echo Fail, Inner Resolver Null Fail, and Resolver Limit Fail indicates a problem with the HAINS.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Loss of MDM to HAINS communications, resulting in loss of HAINS and two-fault tolerance.

CAUSES OF EXCEEDING REDLINE:

(8) Bad timing gap between the message-in discrete and/or the word discrete from the MDM to the HAINS.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

SSIDs GNC-68 thru GNC-72 Reserved

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LCC VIOLATION CALL: Air Data Transducer Assembly BITE Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V71M7020P	ADTA 1 Mode Status WD1		(2)	NA	HEX	CI
V71M7520P	ADTA 2 Mode Status WD1		(2)	NA	HEX	CI
V71M8020P	ADTA 3 Mode Status WD1		(2)	NA	HEX	CI
V71M8520P	ADTA 4 Mode Status WD1		(2)	NA	HEX	CI

TIME PERIOD:

(1) From start of ET Cryo Tanking (T-6 hours) to OPS-1 Transition (T-20 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) Nominal hexadecimal pattern is 8FFC.
(3) Discrete Inputs Good failures are acceptable and are represented by pattern 0FF8 (5).
(4) A-D Converter Good failures are acceptable and are represented by pattern 0F7C.

PREPLANNED CONTINGENCY PROCEDURE:

(5) Confirm correct ambient pressure data for Discrete Inputs Good failures. After confirmation of expected ambient pressure, LCC violation cleared, continue count.

NOTES:

(6) ADTA measurements valid in downlist formats 23, 42, 44, and 60 only.
(7) ADTA-1 and ADTA-3 are on LH side; ADTA-2 and ADTA-4 on RH side.
(8) V71Xnm22B (Radiate Circuit Good WD1B1), V71Xnm35B (RAM Memory Good WD1B14), and V71Xnm36B (F/D Good WD1B15) will not be in the downlist until OI-29. All other measurements are downlisted.
(9) Loss of V71Xnm29B (A-D Converter Good WD1B8) will affect Total Temperature and BITE capability only. Total Temperature measurements are not used in PASS or BFS air data calculations and are therefore not an impact to flight operations. The execution of a self test is considered a conservative action to verify electronics monitored via the A-D converter. The expected hex patterns during a self test are 9FFC or AFFC. Self test option is only available in G9. While a self test is desirable, it is not a constraint to launch.
(10) For OI 28 only, presence of the A-D Converter BITE will downmode the affected ADTA, and result in a loss of LRU fault tolerance in the BFS only. For OI-29, and subsequent OI loads, the A-D Converter BITE will no longer downmode the affected LRU in the BFS, however it will result in loss of some BITE capability. The crew is trained to evaluate air data prior to accepting the data into flight control and navigation software, so no additional risk is incurred in accepting the A-D Converter BITE condition.

NOTES: (Continued)

(11) Loss of V71Xnm34B (Discrete Inputs Good WD1B13) will affect self-test mode only and will not affect flight operations.

(12) The following measurements make up the ADTA Mode Status parent word:

MEAS. NO.	MEASUREMENT DESCRIPTION		NOMINAL VALUE
V71Xnm21B	ADTA i Good	WD1B0	1
V71Xnm22B	ADTA i Radiate Circuit Good	WD1B1	0
V71Xnm23B	ADTA i High Test Mode	WD1B2	0
V71Xnm24B	ADTA i Low Test Mode	WD1B3	0
V71Xnm25B	ADTA i Alpha 1 Xdcr Good	WD1B4	1
V71Xnm26B	ADTA i Alpha 2 Xdcr Good	WD1B5	1
V71Xnm27B	ADTA i Tot Press Xdcr Good	WD1B6	1
V71Xnm28B	ADTA i St Press Xdcr Good	WD1B7	1
V71Xnm29B	ADTA i A-D Converter Good	WD1B8	1
V71Xnm30B	ADTA i Electronics Good	WD1B9	1
V71Xnm31B	ADTA i Temp Circuit Good	WD1B10	1
V71Xnm32B	ADTA i Sum Check Good	WD1B11	1
V71Xnm33B	ADTA i Power Supply Good	WD1B12	1
V71Xnm34B	ADTA i Discrete Inputs Good	WD1B13	1
V71Xnm35B	ADTA i RAM Memory Good	WD1B14	0
V71Xnm36B	ADTA i F/D Good	WD1B15	0

Where i = 1, 2, 3 or 4. For i = 1, nm = 70, for i = 2, nm = 75, for i = 3, nm = 80, and for i = 4, nm = 85.

REDLINE DERIVATION: CRITICALITY: 1R

(13) Presence of the V71Xnm29B (A-D Converter Good BITE WD1B8) will inhibit voltage derived inputs for built-in tests, effectively masking the V71Xnm22B (Radiate Circuit Good WD1B1), V71Xnm33B (Power Supply Good WD1B12), and V71Xnm30B (Electronics Good WD1B9), however, LRU performance is not affected. The Non Volatile Memory (NVM) built-in test remains valid and will continue to drive the V71Xnm30B (Electronics Good WD1B9). Verification of ADTA performance with inhibited built-in test can be performed through self-test and evaluation of pressure data.

(14) The V71Xnm34B (Discrete Inputs Good WD1B13) results in a loss of self-test capability only. BFS does not have the capability to command self-test; therefore, it is no impact to BFS. PASS RM will detect an erroneous ADTA at the four LRU level, so there is no additional risk to PASS from launching with this BITE condition. The only impact to PASS occurs during FCS checkout on-orbit. Self-test will not be available for the affected LRU.

CONSEQUENCES OF EXCEEDING REDLINE:

(15) Loss of ADTA two-fault tolerance.

CAUSES OF EXCEEDING REDLINE:

(16) ADTA electronics.
(17) Transducer failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO		SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	VS70-971099	SHEET 71BR,BS	ZONE
	DWG NO	VS70-971102	SHEET 71BT,BU	ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

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LCC VIOLATION CALL: Air Data Transducer Assembly (ADTA) Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V71P7040B	ADTA 1 Static Press	WD2	(2,3)	(2,3)	in Hg	CI
V71P7540B	ADTA 2 Static Press	WD2	(2,3)	(2,3)	in Hg	CI
V71P8040B	ADTA 3 Static Press	WD2	(2,3)	(2,3)	in Hg	CI
V71P8540B	ADTA 4 Static Press	WD2	(2,3)	(2,3)	in Hg	CI
V71P7080B	ADTA 1 Ctr Alpha Press(PAC)	WD3	(2,3)	(2,3)	in Hg	CI
V71P7580B	ADTA 2 Ctr Alpha Press(PAC)	WD3	(2,3)	(2,3)	in Hg	CI
V71P8080B	ADTA 3 Ctr Alpha Press(PAC)	WD3	(2,3)	(2,3)	in Hg	CI
V71P8580B	ADTA 4 Ctr Alpha Press(PAC)	WD3	(2,3)	(2,3)	in Hg	CI
V71P7120B	ADTA 1 Lwr Alpha Press(PAL)	WD5	(2,3)	(2,3)	in Hg	CI
V71P7620B	ADTA 2 Lwr Alpha Press(PAL)	WD5	(2,3)	(2,3)	in Hg	CI
V71P8120B	ADTA 3 Lwr Alpha Press(PAL)	WD5	(2,3)	(2,3)	in Hg	CI
V71P8620B	ADTA 4 Lwr Alpha Press(PAL)	WD5	(2,3)	(2,3)	in Hg	CI
V71P7140B	ADTA 1 Upr Alpha Press(PAU)	WD6	(2,3)	(2,3)	in Hg	CI
V71P7640B	ADTA 2 Upr Alpha Press(PAU)	WD6	(2,3)	(2,3)	in Hg	CI
V71P8140B	ADTA 3 Upr Alpha Press(PAU)	WD6	(2,3)	(2,3)	in Hg	CI
V71P8640B	ADTA 4 Upr Alpha Press(PAU)	WD6	(2,3)	(2,3)	in Hg	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to OPS-1 Transition (T-20 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) Verify that the pressure measurements from the four ADTA fall within the limits of Quad Mid-Value Select (QMVS) plus or minus 0.064 in. Hg.
(3) Pressure excursions outside requirement limits are acceptable if the cause can be attributed to any of the following:

- ADTA Self test.
- Wind turbulence.
- Water intrusion resulting in port blockage due to rainy conditions provided that both ADTA pressure measurements associated with the port suspected of water blockage show similar responses.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) ADTA-1 and ADTA-3 are on LH side; ADTA-2 and ADTA-4 are on RH side.
(5) The QMVS output value is the second highest value of the four input signals. This value is compared with the four input values to determine ADTA pressure transducer performance.

REDLINE DERIVATION: CRITICALITY: 1R

(6) a. SSID Intent Summary - The Air Data system provides information relative to the movement of the orbiter through the lower atmosphere. This data may be used by the orbiter for the guidance, navigation, and flight control (GN&C) system to point and translate the orbiter during landing. There are two air data probes, one on each side of the orbiter. Each probe has four pressure ports, which sense four pressures: Static Pressure (Ps), Center (or Total) Alpha Pressure (PAC), Lower Alpha Pressure (PAL), and Upper Alpha Pressure (PAU). Pneumatic lines connect the probes to the ADTAs. There are four ADTAs, two for each probe. Each ADTA has four transducers that send the four pressure readings to onboard computers to update parameters used in GN&C. The system is zero fault tolerant prelaunch in order to preserve dual fault tolerance during landing. Use of a single ADTA is restricted by Flight Rule A8-111 to specific conditions.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - Minimum and maximum redlines are based on the QMVS value as described in Requirement (2). The redlines are determined by calculating the QMVS among the 4 ADTAs for like pressure functions (Ps, PAC, PAL, and PAU). Each pressure is compared to the corresponding QMVS output pressure to within +/- 0.064 in. Hg. The QMVS output pressures are dynamic and will depend on how each ADTA responds to the changing environmental conditions which are experienced even with the ADP stowed for flight. The +/- 0.064 in. Hg tolerance was selected from the tightest of the ADTA Redundancy Management (RM) Subsystem Operating Program (SOP) same-side comparison test tolerances. The QMVS scheme is used in lieu of the ADTA RM SOP scheme for simplicity. The ADTA RM SOP runs in OPS 3 and 6 only and is designed to account for vehicle flight dynamics. The QMVS is better suited for the pad non flight environment. Any redline violations are automatically flagged by the GNC GOAL (Ground Operations Aerospace Language) LCC monitor.

d. Time Period - Redline is in effect from T-6 hours until Ops-1 Transition (approx. T-20 minutes and counting) when ADTA data becomes unavailable. This time period ensures that the system is up until the loss of visibility has been functionally stable and is committed for flight. Changes because of environmental effects after termination of monitoring are transitory and will not affect operation of the ADTAs during approach and landing.

e. Requirements - The requirements serve to ensure the ADTA health and two fault tolerance for flight operations. Requirement (3) allows for pressure excursions while performing self test, if attributed to wind turbulence, or if there is probe port blockage caused by rain water. The self test will cause a redline violation because the self test performs a comparison of onboard limits with a set of ADTA stored pressure values. A self test on each ADTA lasts approximately 10 seconds, therefore this condition is momentary.

REDLINE DERIVATION: (Continued)

If there are windy conditions, it is possible to observe momentary pressure spikes on the various pressure transducers. This will be dependent on wind speed and wind direction. This is a launch pad environment issue and will be a non-factor during ascent and also when ADTAs are used during entry.

In order for pressure excursions that are indicative of rain water intrusion to be considered acceptable the ADTA pressures on the same probe port must show similar behavior typical of rainwater blockage, this confirms rainwater blockage of the port. Water blocking the probe ports may dislodge prior to launch, however if it remains attached the water blocking the probe port will be forced out as air evacuates the air data lines during ascent. The landing environment will clear any remaining moisture during probe deployment allowing for nominal ADTA performance.

f. Preplanned Contingency Procedures - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Loss of ADTA two-fault tolerance in flight.
(8) Ref. Hazard Report ORBI-211.

CAUSES OF EXCEEDING REDLINE:

(9) Malfunction of the ADTA electronics.
(10) Transducer failure.
(11) Day of launch operational and environmental conditions that do not affect flight ADTA performance such as ADTA self test, wind gusts, and wind driven rain blockage of an Air Data Probe Port.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	in.Hg								
V71P7040B	.0011	-35.2	35.2						
V71P7540B	.0011	-35.2	35.2						
V71P8040B	.0011	-35.2	35.2						
V71P8540B	.0011	-35.2	35.2						
V71P7080B	.0016	-50.8	50.8						
V71P7580B	.0016	-50.8	50.8						
V71P8080B	.0016	-50.8	50.8						
V71P8580B	.0016	-50.8	50.8						
V71P7120B	.0016	-50.8	50.8						
V71P7620B	.0016	-50.8	50.8						
V71P8120B	.0016	-50.8	50.8						
V71P8620B	.0016	-50.8	50.8						
V71P7140B	.0016	-50.8	50.8						
V71P7640B	.0016	-50.8	50.8						
V71P8140B	.0016	-50.8	50.8						
V71P8640B	.0016	-50.8	50.8						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 9.9 SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-971099 SHEET 71BR,BU ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

Air Data Transducer Assembly Temperature Anomaly

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SSIDs GNC-76 thru GNC-78 Reserved

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LCC VIOLATION CALL: Brake Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V51P0722A	Ldg Gr LH Outbd Brake Press No 2A		NA	156	psia	CI
V51P0728A	Ldg Gr LH Inbd Brake Press No 1A		NA	156	psia	CI
V51P0724A	Ldg Gr LH Outbd Brake Press No 4A		NA	156	psia	CI
V51P0726A	Ldg Gr LH Inbd Brake Press No 3A		NA	156	psia	CI
V51P0742A	Ldg Gr RH Outbd Brake Press No 2A		NA	156	psia	CI
V51P0748A	Ldg Gr RH Inbd Brake Press No 1A		NA	156	psia	CI
V51P0744A	Ldg Gr RH Outbd Brake Press No 4A		NA	156	psia	CI
V51P0746A	Ldg Gr RH Inbd Brake Press No 3A		NA	156	psia	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown (3).

PREPLANNED CONTINGENCY PROCEDURE:

(3) If brake pressure is greater than 2250 PSIA or the associated hydraulic system pressure, for confirmed instrumentation failure, LCC violation cleared, continue countdown. If brake pressure is between 156 and 2250 PSIA and less than the associated hydraulic system pressure, LCC violation confirmed, No Go for launch.

NOTES:

(4) This SSID checks the ambient value to detect instrumentation failed off-scale high.

REDLINE DERIVATION: CRITICALITY: 1R

(5) To detect failure mode during entry (uncommanded brake pressure).
(6) 180 psia maximum allowable brake pressure for landing. Normal operating range is 0-156 psia.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Uncommanded brake pressure resulting in blown tire at wheel touchdown.

CAUSES OF EXCEEDING REDLINE:

(8) Instrumentation failure, hydraulic line blockage or brake/skid control system failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	psia								
OV-102, OV-104, AND OV-105									
V51P0722A	12.0	0	3000						180
V51P0728A	12.0	0	3000						180
V51P0724A	12.0	0	3000						180
V51P0726A	12.0	0	3000						180
V51P0742A	12.0	0	3000						180
V51P0748A	12.0	0	3000						180
V51P0744A	12.0	0	3000						180
V51P0746A	12.0	0	3000						180
OV-103									
V51P0722A	13.2159	0	3000						180
V51P0728A	13.2159	0	3000						180
V51P0724A	13.2159	0	3000						180
V51P0726A	13.2159	0	3000						180
V51P0742A	13.2159	0	3000						180
V51P0748A	13.2159	0	3000						180
V51P0744A	13.2159	0	3000						180
V51P0746A	13.2159	0	3000						180

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 13.2 SHEET 1 of 1 ZONE E-H
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: Brake Power Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76X5800E	Brake/Skid Sub Bus C/A RPC Pwr A	(2)	1	NA	Event	CI
V76X5805E	Brake/Skid Sub Bus B/C RPC Pwr B	(2)	1	NA	Event	CI
V76X5806E	Brake/Skid Sub Bus B/C RPC Pwr C	(2)	1	NA	Event	CI
V76X5811E	Brake/Skid Sub Bus C/A RPC Pwr C	(2)	1	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For APU Start (T-5 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) For confirmed instrumentation failure, LCC violation cleared, continue countdown.

PREPLANNED CONTINGENCY PROCEDURE:

(3) To detect instrumentation failure of RPC power indication - turn OFF redundant power switch and observe brake/skid control box circuit indications.
RPC A: Turn off Brake MNC, Panel O16 - verify Box A indications.
RPC B: Turn off Brake MNC, Panel O16 - verify Box B indications.
RPC C: Turn off Brake MNA/MNB - verify Box A & B indications.

NOTES:

(4) Logical 0 = OFF, Logical 1 = ON

(5) A. Box A Indications:
V51X0412E LH Skid Control No 3 Box A.
V51X0413E LH Skid Control No 4 Box A.
V51X0416E RH Skid Control No 3 Box A.
V51X0417E RH Skid Control No 4 Box A.
V51X0430E Ldg Gr LH Outbd Skid Control No 4.
V51X0433E Ldg Gr LH Inbd Skid Control No 3.
V51X0441E Ldg Gr RH Inbd Skid Control No 3.
V51X0442E Ldg Gr RH Outbd Skid Control No 4.

B. Box B Indications:
V51X0410E LH Skid Control No 1 Box B.
V51X0411E LH Skid Control No 2 Box B.
V51X0414E RH Skid Control No 1 Box B.
V51X0415E RH Skid Control No 2 Box B.
V51X0431E Ldg Gr LH Outbd Skid Control No 2.
V51X0432E Ldg Gr LH Inbd Skid Control No 1.
V51X0440E Ldg Gr RH Inbd Skid Control No 1.
V51X0443E Ldg Gr RH Outbd Skid Control No 2.

C. The above MSID nomenclature was taken from an OI measurement listing and the titles shown in the LCC Mandatory Instrumentation List, page I-07.11, may be used as substitutes.

REDLINE DERIVATION: CRITICALITY: 1R

(6) Brake power required ON for abort/landing.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Loss of brake two-fault tolerance.

CAUSES OF EXCEEDING REDLINE:

(8) Open or short in power wiring.
(9) Loss of power source.
(10) Instrumentation failure.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 13.2 SHEET 1 of 1 ZONE S-T
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-958102 SHEET FA ZONE FA

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: Landing Gear Anti-Skid Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V51X0410E	LH Skid Control No 1 Box B	(2,3)	ON	NA	Event	CI
V51X0432E	Ldg Gr LH Inbd Skid Control No 1	(2,3)	ON	NA	Event	CI
V51X0412E	LH Skid Control No 3 Box A	(2,3)	ON	NA	Event	CI
V51X0433E	Ldg Gr LH Inbd Skid Control No 3	(2,3)	ON	NA	Event	CI
V51X0411E	LH Skid Control No 2 Box B	(2,3)	ON	NA	Event	CI
V51X0431E	Ldg Gr LH Outbd Skid Control No 2	(2,3)	ON	NA	Event	CI
V51X0413E	LH Skid Control No 4 Box A	(2,3)	ON	NA	Event	CI
V51X0430E	Ldg Gr LH Outbd Skid Control No 4	(2,3)	ON	NA	Event	CI
V51X0414E	RH Skid Control No 1 Box B	(2,3)	ON	NA	Event	CI
V51X0440E	Ldg Gr RH Inbd Skid Control No 1	(2,3)	ON	NA	Event	CI
V51X0416E	RH Skid Control No 3 Box A	(2,3)	ON	NA	Event	CI
V51X0441E	Ldg Gr RH Inbd Skid Control No 3	(2,3)	ON	NA	Event	CI
V51X0415E	RH Skid Control No 2 Box B	(2,3)	ON	NA	Event	CI
V51X0443E	Ldg Gr RH Outbd Skid Control No 2	(2,3)	ON	NA	Event	CI
V51X0417E	RH Skid Control No 4 Box A	(2,3)	ON	NA	Event	CI
V51X0442E	Ldg Gr RH Outbd Skid Control No 4	(2,3)	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) If prime abort runways are dry (exception: KSC allowed to be wet), 15 of 16 measurements are acceptable, or 14 of 16 measurements are acceptable if both failures are in the same measurement pair, i.e., same box, same wheel (e.g., V51X0410E and V51X0432E LH #1 BOX B).
(3) For confirmed instrumentation failure, LCC violation cleared, continue countdown. (4)

PREPLANNED CONTINGENCY PROCEDURE:

(4) If failed indication is not verified by ANTI-SKID FAIL light ON, then cycle ANTI-SKID switch OFF to verify operation of ANTI-SKID FAIL light. If ANTI-SKID FAIL light is operational, the failed discrete is due to instrumentation. For confirmed instrumentation failure, turn ANTI-SKID switch back ON, LCC violation cleared, continue countdown.

NOTES:

(5) Failure indication could result in partial brake loss or partial skid protection loss, which cannot be determined realtime.

REDLINE DERIVATION: CRITICALITY: 1R

(6) 15 of 16 functions ensure:
   A. The vehicle has a minimum of 7 out of 8 skid control cards operating properly.
   B. A minimum of 87.5% braking capability with anti-skid protection is available.
   C. Total skid protection on 3 wheels and half skid protection on one wheel is available.

(7) Two failures in the same box and wheel has the same impact as one failure.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Less than 15 of 16 functions can indicate:
   A. Loss of capability to stop the vehicle within the predicted rollout distance with anti-skid ON.
   B. Increased reduction of skid/locked wheel and touchdown protection.
   C. General box failures may be present that could cause brake failures in addition to anti-skid failures.

CAUSES OF EXCEEDING REDLINE:

(9) Self test failures or power losses will cause self test failed measurements OFF.

(10) Skid valve open or short circuits will cause a skid valve failed indications.

(11) Instrumentation failure.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 13.2 SHEET 1 of 1 ZONE I-O
INTEGRATED SYSTEMS SCHEMATIC: DWG NO 58 SHEET FA-FW ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: ANTI-SKID FAIL Light Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	ANTI-SKID FAIL Light	(2)	OFF		Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 Minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) An ON indication is acceptable if anti-skid box is within LCC limits (Reference SSID GNC-81) and the primary Abort runways are DRY, with the exception of the KSC runway, which may be WET.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) ANTI-SKID FAIL light is visible to Crew only (panel F3).
(4) Failure indication could result in partial brake loss or partial skid protection loss, which cannot be determined realtime.
(5) When the ANTI-SKID FAIL light is ON, but no skid valve failure indications or self test failure indications are present, the ANTI-SKID FAIL light is assumed to be due a wheel speed sensor circuit failure.
(6) A single wheel speed sensor fault will light the ANTI-SKID FAIL light; consequently, subsequent failures cannot be detected. Therefore, if the ANTI-SKID FAIL light comes ON and there are no other failure indications, a single failure is assumed.

REDLINE DERIVATION: CRITICALITY: 1R

(7) A single wheel speed sensor failure causing the ANTI-SKID FAIL light to go ON indicates:
    A. A minimum of 87.5% braking capability with anti-skid protection is available.
    B. Total skid protection of 3 wheels and half skid protection on one wheel is available.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) More than one wheel speed sensor failure can cause:
    A. Loss of capability to stop the vehicle within the predicted rollout distance with anti-skid ON.
    B. Increased reduction of skid and locked wheel protection.

CAUSES OF EXCEEDING REDLINE:

(9) Anti-skid has open or short circuits in the wheel speed sensors(s).
(10) Instrumentation failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 13.2	SHEET 1 of 1	ZONE I-O
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO 58	SHEET FA-FW	ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: Nose Wheel Steering Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
N/A	NWS Fail Light		OFF	NA	Event	CI
V51X0645E1	N/W Steering Failed		OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Either NWS-1 or NWS-2 is required. It is acceptable to launch with a failed channel by placing the NWS switch to select the good channel.
(3) 1 of 2 measurements acceptable on selected system for confirmed instrumentation failure. (4)

PREPLANNED CONTINGENCY PROCEDURE:

(4) A. For confirmed power configuration problem that is not associated with an overload and if either NWS mode (1 or 2) is recovered, LCC violation cleared, continue countdown (Ref. S0007, Vol 5).
B. For telemetry or indication ON (not both): Set the NWS system to OFF. If respective parameter remains ON, confirmed instrumentation failure, LCC violation cleared, continue countdown. Otherwise, confirmed respective NWS mode (1 or 2) failure (Ref. S0007, Vol 5).
C. For both telemetry and indication ON: Set the NWS system to OFF. If both telemetry and indication go OFF, confirmed respective NWS mode (1 or 2) failure (Ref. S0007, Vol 5).
D. For confirmed respective NWS mode (1 or 2) failure: Set the NWS system to the alternate mode (1 or 2). If telemetry and indication are OFF, LCC violation cleared, continue countdown (Ref. S0007, Vol 5).
E. For confirmed NWS mode failure in 1 and 2 simultaneously, LCC violation confirmed, No Go for Launch (Ref. S0007, Vol 5).

NOTES:

(5) NWS FAIL light in cockpit duplicates downlink measurement. Light should be OFF for normal operation.
(6) NWS FAIL is not a BITE check of NWS circuitry. The NWS FAIL light and V51X0645E1 are activated by the NWS switch and are held off by the steering control box pre-enable logic or the hydraulic pressure switch post enable. The light and V51X0645E1 will come on if there is an instrumentation failure, a lack of power to the control box, or an enable command on (no hydraulic pressure).
(7) Logical 1 = ON, Logical 0 = OFF.
(8) An alternate path to turn on NWS FAIL light is provided through FF4.

REDLINE DERIVATION: CRITICALITY: 1R

(9) Steering required for RTLS, TAL, AOA, or KSC end of mission landing.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Possibility of no NWS capability during landing.

CAUSES OF EXCEEDING REDLINE:

(11) Instrumentation failure.
(12) NWS control box failure (internal power or logic failure - not health test).
(13) Control box power circuit breaker (Panel O14) open.
(14) MDM failure (enable command on without hydraulic pressure).

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 13.3	SHEET 2 of 2	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: Nosewheel Position Signal Path Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V51V0550C	Nose Wheel Position A	2 of	-0.70	-0.14	Volts	CI
V51V0551C	Nose Wheel Position B	3	-0.70	-0.14	Volts	CI
V51V0552C	Nose Wheel Position C		-0.70	-0.14	Volts	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to OPS-1 Transition (T-20 minutes)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(2) Nominal Value: -0.42 +/- 0.28 Volts.
(3) Measurement required for RTLS, TAL, or KSC end of mission landing.

CONSEQUENCES OF EXCEEDING REDLINE:

(4) Nosewheel steering position feedback to flight software would not be one-fault tolerant if one feedback is missing.

CAUSES OF EXCEEDING REDLINE:

(5) Steering position transducer (SPT) failure.
(6) Steering position sensor assembly (SPA) failure.
(7) Open/shorted wire.
(8) Mechanical failure.
(9) MDM failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	Vdc								
V51V0550C	0.01	-5.0	5.0						
V51V0551C	0.01	-5.0	5.0						
V51V0552C	0.01	-5.0	5.0						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 13.3 SHEET 1 of 1 ZONE G1,S8
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-958102 SHEET DH ZONE 20-24
DWG NO VS70-958099 SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

LCC VIOLATION CALL: DDU Power Supply Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V73X3001X	LH DDU Pwr Sply A Good		ON	NA	Event	CI
V73X3002X	LH DDU Pwr Sply B Good		ON	NA	Event	CI
V73X3003X	LH DDU Pwr Sply C Good		ON	NA	Event	CI
V73X3011X	RH DDU Pwr Sply A Good		ON	NA	Event	CI
V73X3012X	RH DDU Pwr Sply B Good		ON	NA	Event	CI
V73X3013X	RH DDU Pwr Sply C Good		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) Move applicable station's RHC out of detent through the full range of motion, in the plus and minus directions, and verify all 9 RHC channels are tracking. If all channels track through the full range of motion, LCC violation cleared, continue countdown (Ref. S0007 VL 5).

NOTES:

(3) Reference SSID GNC-01 for the respective RHC MSIDs.
(4) In G9, all RHC outputs are available via the onboard SPEC 106, Manual Controls Display, via downlist format 42, or via LDB read. In G1, all RHC outputs are available via downlist format 21, or via LDB read.

REDLINE DERIVATION: CRITICALITY:

(5) These redlines ensure proper DDU Power Supply voltage. An OFF indicates that the associated DDU power supply voltage has gone out of tolerance, resulting in a degraded power supply output to the manual flight controllers and BFS engage drivers.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Loss of power to one channel of all manual flight controllers at one crew station.
(7) Loss of BFS engage capability at one crew station (three power supplies required).

CAUSES OF EXCEEDING REDLINE:

(8) Hardware anomaly in DDU power supply.
(9) Hardware anomaly in DDU power supply monitor.

CAUSES OF EXCEEDING REDLINE: (Continued)

(10) Instrumentation failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 9.17	SHEET 1	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: GNC

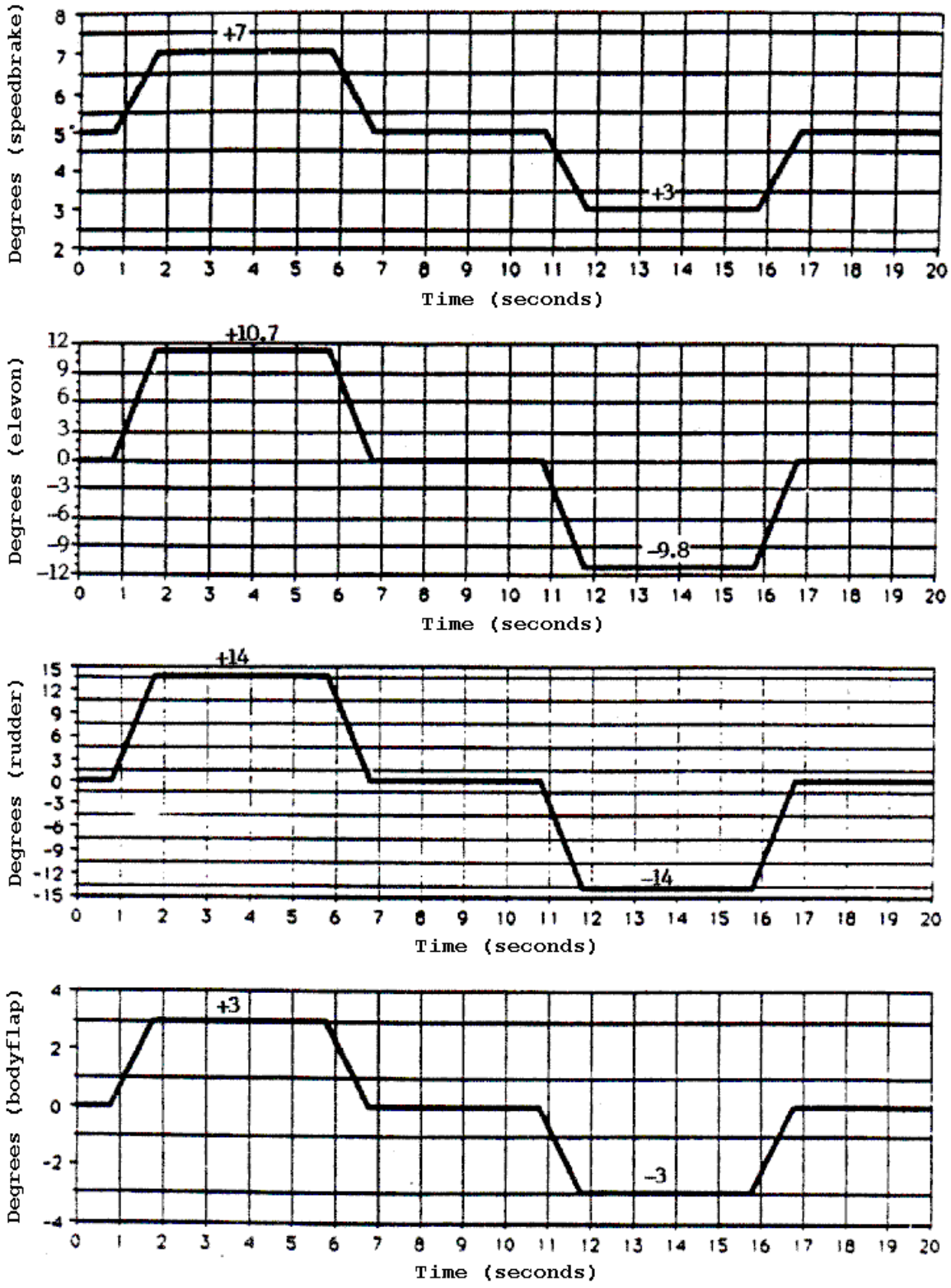

Figure 34-02 Aerosurface Gimbal Profiles

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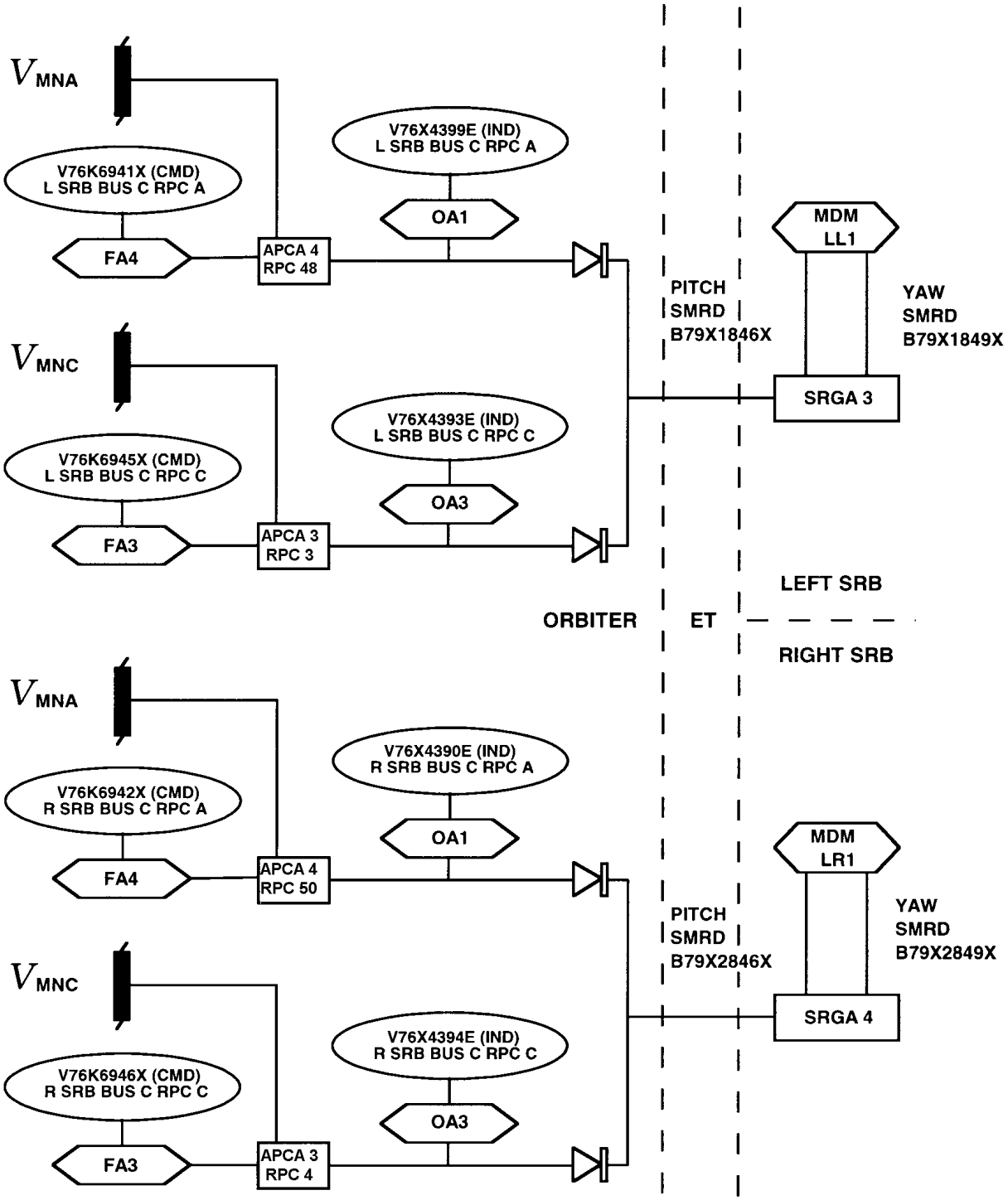

Figure 34-03 SRB Bus C Power

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SECTION 35

BACKUP FLIGHT CONTROL SYSTEM

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SECTION 35: BACKUP FLIGHT CONTROL SYSTEM

SSID No.	Description/Violation Call	Page
BFS-01	BFS Input/Output Terminate B Anomaly	35-01.1
BFS-02	BFS Engage Discrete Anomaly	35-02.1
BFS-03	BFS Time Source Faultdown	35-03.1
BFS-04	BFS GPC BITE Anomaly	35-04.1
BFS-05	BFS GPC Error Count Anomaly	35-05.1
BFS-06	BFS Tracking PASS Anomaly	35-06.1
BFS-07	BFS Ascent Digital Auto Pilot (DAP) Anomaly (REQUIREMENT DELETED)	35-07.1
BFS-08	BFS GPC Fail Indication	35-08.1
BFS-09	BFS Payload MDM Bypass Indication	35-09.1
BFS-10	BFS Multifunction CRT Display System Anomaly (REQUIREMENT DELETED)	35-10.1
BFS-10a	BFS Multifunction Electronic Display Subsystem (MEDS) Anomaly	35-10a.1
BFS-11	BFS IMU Initialization Data Anomaly	35-11.1
BFS-12	BFS I/O Error Log	35-12.1
BFS-13	BFS Transmitter Anomaly (REQUIREMENT DELETED)	35-13.1
BFS-14	GPC Soft Error Counter Anomaly	35-14.1
BFS-15	BFS I/O Error PCM Anomaly	35-15.1
BFS-16	BFS Battery Backup Unit (BBU) Anomaly	35-16.1

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LCC VIOLATION CALL: BFS Input/Output Terminate B Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V98X0594X	I/O Terminate B		1 (On)	NA	Event	CI

TIME PERIOD:

(1) From Post Ingress Switch Reconfiguration (approximately T-2 hours 10 minutes) to Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) Measurement is required to engage BFS.
(3) There is no crew annunciation for violation of this redline (i.e., logic "1" to logic "0").
(4) "0"=Off (KSC), Off (Master Measurement List(MML)); "1"=On (KSC), On (MML).

REDLINE DERIVATION: CRITICALITY: 1R

(5) a. SSID Intent Summary - The purpose of this requirement is to ensure the ability to engage the Backup Flight System (BFS) General Purpose Computer (GPC). This is accomplished by monitoring the downlisted BFS I/O Terminate B discrete for the proper pre-engaged state. BFS engage requires I/O Terminate B discrete = 0 and 2 of 3 BFS engage discretes = 1 (ref SSID BFS-02). The proper pre-launch state of the BFS I/O Terminate B command discrete is ON (1). For information purposes, the BFS engaged/pre-engaged discrete statuses are as follows:
   1. Pre-engage Operation:
      I/O Terminate B = 1 and Engage 1-3 = 0 for BFS (backup).
      I/O Terminate B = 0 and Engage 1-3 = 0 for Primary Avionics Software System (PASS) (primary).
   2. BFS Engage Operation:
      I/O Terminate B = 0 and Engage 1-3 (2 of 3) = 1 for BFS.
      I/O Terminate B = 1 and Engage 1-3 = 1 for PASS.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - The minimum redline limit of ON insures that the Backup Flight Controller (BFC) hardware is capable of generating the pre-engage state of the I/O Terminate B discrete, and the GPC discrete receiver is able to receive the discrete. There is no maximum redline limit.

d. Time Period - Detection of a BFS I/O Terminate B discrete anomaly is

REDLINE DERIVATION: (Continued)

possible whenever BFS is active with its Output switch in Backup. Therefore, the time period extends from the positioning of the Output Switch to Backup during the Post-Ingress Switch Reconfiguration (approximately T-2 hours 10 minutes) until commit for flight at Go for SSME Start (T-10 seconds).

e. Requirements - An I/O Terminate B discrete controls whether a GPC can transmit on the Flight Critical (FC) data busses (Bus Control Elements (BCEs) 14-17 and 20-23). During the post-ingress switch configuration, the crew positions the GPC 5 Output Switch to BACKUP. This identifies the GPC as the BFS GPC, sets the BFS I/O Terminate B discrete to ON, and prevents the BFS GPC from transmitting on the FC busses. The I/O Terminate B discrete ON along with the three BFS engage discretes OFF is the pre-engage configuration for BFS. If the BFS I/O Terminate B is failed OFF pre-launch and later a BFS engage is attempted, PASS computers would go to software halt, but BFS may not engage. This could lead to loss of vehicle control. Crew procedures require use of BFS if primary control is lost. Any configuration of the I/O Terminate B and BFS Engage 1-3 discretes other than the nominal engage or pre-engage states will result in the logging of a BFS GPC error code 41 -"ILLEGAL ENGAGE/TERM B".

f. Preplanned Contingency Procedure - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Potential loss of BFS engage capability.
(7) Loss of hardware protection against BFS improperly transmitting on FC busses pre-engaged.

CAUSES OF EXCEEDING REDLINE:

(8) Panel O6 GPC 5 Output Switch not in BACKUP position.
(9) Panel O6 GPC 5 Output Switch failure.
(10) ESS3AB fuse failure.
(11) BFC hardware failure.
(12) GPC 5 Discrete Input receiver failure.
(13) Wiring anomaly.
(14) Forward Power Control Assembly (FPCA) 2 to BFC Module 2B fuse failure.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: BFS

LCC VIOLATION CALL: BFS Engage Discrete Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V98X0604X	BFS Engage 1		0 (Off)	NA	Event	CI
V98X0605X	BFS Engage 2		0 (Off)	NA	Event	CI
V98X0606X	BFS Engage 3		0 (Off)	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) "0"=Off (KSC), Off (Master Measurement List (MML)), "1"=On (KSC), On (MML).

REDLINE DERIVATION: CRITICALITY: 1R

(3) a. SSID Intent Summary - The purpose of this requirement is to ensure the ability to engage the Backup Flight System (BFS) General Purpose Computer (GPC). This is accomplished by monitoring the three downlisted BFS Engage discretes for the proper pre-engaged state.

BFS engage requires 2 of 3 BFS engage discretes = 1 and I/O Terminate B discrete = 0 (ref SSID BFS-01). The proper pre-launch state of the BFS Engage 1-3 discretes is OFF (0). For information purposes, the BFS engaged/pre-engaged discrete statuses are as follows:

1. Pre-engage Operation:
   I/O Terminate B = 1 and Engage 1-3 = 0 for BFS (backup).
   I/O Terminate B = 0 and Engage 1-3 = 0 for Primary Avionics Software System (PASS) (primary).
2. BFS Engage Operation:
   I/O Terminate B = 0 and Engage 1-3 (2 of 3) = 1 for BFS.
   I/O Terminate B = 1 and Engage 1-3 = 1 for PASS.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - The minimum redline limit of OFF insures that the Backup Flight Controller (BFC) hardware is capable of generating the pre-engage state of the Engage 1, 2 and 3 discretes, and the GPC Discrete Receivers are able to receive the discretes. There is no maximum redline limit.

d. Time Period - Detection of a BFS Engage discrete anomaly is possible at

REDLINE DERIVATION: (Continued)

any time BFS is active. Therefore, the time period extends from the start of ET Cryo Tanking (T-6 hours) until commit for flight at Go for SSME Start (T-10 seconds).

e. Requirements - Engage discretes are used to indicate a crew request for BFS engage. There are three engage discretes available from each Rotational Hand Controller (RHC) - Left A, B and C and Right A, B and C. In order to set these discretes, the crew must depress the BFS Engage switch atop either RHC. Prelaunch, there should be no crew request for a BFS engage and these discretes should remain OFF. All three BFS Engage discretes OFF along with the BFS I/O Terminate B discrete equal to ON is the pre-engage configuration for BFS. One or more BFS Engage discretes ON indicates the BFS GPC is not in the proper configuration for engage, or an inadvertent BFS engage has occurred. Any configuration of the I/O Terminate B and BFS Engage 1-3 discretes other than the nominal engage or pre-engage states will result in the logging of a BFS GPC error code 41 - "ILLEGAL ENGAGE/TERM B".

f. Preplanned Contingency Procedure - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(4) Potential loss of BFS engage capability.
(5) Additional failure may result in premature BFS engage and thus loss of primary control.

CAUSES OF EXCEEDING REDLINE:

(6) RHC BFS Engage Switch failure.
(7) BFC hardware failure.
(8) GPC 5 Discrete Input receiver failure.
(9) Wiring anomaly.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: BFS

LCC VIOLATION CALL: BFS Time Source Faultdown | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V98J0615C	MTU Accumulator Source		(2)	NA	(5)	CI

TIME PERIOD:

(1) From "BFS Transition into OPS 101 plus 1 Second" (approximately T-18 minutes) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Must indicate source 1, 2, or 3.
(3) It is acceptable for the Backup Flight System (BFS) General Purpose Computer (GPC) to be on internal time for 2 seconds or less during an automatic BFS accumulator switchover.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) There are a total of three Master Timing Unit (MTU) accumulators, but only one is used at any time. When BFS transitions into G1, it may come up on any accumulator due to midvalue select (MVS) logic.
(5) Binary number.

REDLINE DERIVATION: CRITICALITY: 1R

(6) a. SSID Intent Summary - The purpose of this requirement is to insure that the BFS GPC is acquiring Greenwich Mean Time (GMT) from an MTU accumulator time source. This is accomplished by monitoring the downlisted BFS GPC time source Measurement Stimulus Identification (MSID). The BFS is initialized to MTU GMT during the OPS 101 transition. While BFS may select any of the three MTU accumulators due to the MVS logic, it will fault to its internal GPC clock if BFS does not receive valid GMT from an MTU source. The use of the internal GPC clock instead of an MTU accumulator may result in inaccurate navigation calculations. Once an MTU source is selected, BFS will remain on that source unless the MTU GMT received does not pass a reasonableness check.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - The minimum redline limit of 1, 2 or 3 insures that an MTU accumulator has been selected as the time source by the BFS GPC. BFS will continually retry the MTU accumulators for a time source, but will remain on internal time until one is found that is within tolerance of the BFS internal clock. While on internal time, the MTU accumulator source will indicate "0" (zero). There is no maximum redline limit.

REDLINE DERIVATION: (Continued)

d. Time Period - Detection of a BFS time source anomaly is possible whenever BFS is tracking the Primary Avionics Software System (PASS) (i.e., OPS 1). Therefore, the time period extends from the BFS OPS 101 transition (approximately T-18 minutes) until commit for flight at Go for RSLS Start (T-31 seconds).

e. Requirements - If GMT is not received from the MTU, the software faults down to internal time and uses the GPC clock for updating the values of GMT and Mission Elapsed Time (MET). Due to GPC oscillator drift, the utilization of the GPC internal clock may result in inaccurate BFS navigation calculations. BFS will fault off an accumulator if the difference between the GPC internal time and the MTU accumulator time is greater than 800 microseconds, or if the accumulator is commfaulted. The BFS will remain on internal time for 960 milliseconds before selecting the next MTU accumulator available, in the order 1, 2, 3, 1... . If only two MTU accumulators are available, BFS will substitute its internal time for the missing accumulator, and then select one of the three as its time source using MVS criteria. Problems with MTU accumulator I/O may result in the logging of a BFS I/O error code 10 - "I/O ERROR MTU". Two consecutive I/O errors will result in an accumulator bypass, and annunciation of fault summary message code 256(7,8) - "BCE STRG 1(2,3) MTU".

f. Preplanned Contingency Procedure - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Decreased BFS navigation accuracy.
(8) Loss of MTU GMT/MET.

CAUSES OF EXCEEDING REDLINE:

(9) MTU anomaly.
(10) Multiplexer/demultiplexer (MDM) anomaly.
(11) GPC anomaly.
(12) PASS/BFS interface problem.

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SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: BFS

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LCC VIOLATION CALL: BFS GPC BITE Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA FSM	Fault Summary Message GPC 5 BITE		(2)	NA	NA	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) No error occurrence.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) Fault Summary Message (FSM) is downlisted with Error Code 289. The Error Code is derived from downlist by multiplying the MAJOR field by four and adding the MINOR field. MAJOR and MINOR fields for the five downlisted FSMs are:

	MAJOR	MINOR
1.	V98U1301C	V98U1302C
2.	V98U1306C	V98U1307C
3.	V98U1311C	V98U1312C
4.	V98U1316C	V98U1317C
5.	V98U1321C	V98U1322C

REDLINE DERIVATION: CRITICALITY: 1R

(4) a. SSID Intent Summary - The purpose of this requirement is to ensure that the Backup Flight System (BFS) General Purpose Computer (GPC) is operable for flight. This is accomplished by monitoring for the occurrence of a BFS GPC BITE FSM. BFS GPC failures are collectively monitored via downlist validity, the downlisted BFS GPC error log, and BFS FSMs. BFS GPC BITE FSM is annunciated for any of several GPC error conditions. These GPC errors may result from a BFS hardware or software anomaly that could affect BFS's ability to control the vehicle if engaged.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - The minimum redline limit of no occurrence insures that BFS has not encountered any of twenty unique GPC error conditions that drive this fault summary message. There is no maximum redline limit.

REDLINE DERIVATION: (Continued)

d. Time Period - Detection of a BFS GPC 5 BITE fault summary message is possible at any time BFS is active. Therefore, the time period extends from the start of ET Cryo Tanking (T-6 hours) until commit for flight at Go for SSME Start (T-10 seconds).

e. Requirements - BFS will annunciate a "GPC BITE" fault summary message for any of twenty unique GPC error conditions. The cause and response depend solely on which error condition was encountered. The fault message indicates that a GPC error has occurred which has resulted in a software-initiated restart. Continuous restarts will result in the BFS displays showing BIG "X"/POLL FAIL, momentary interruption of BFS downlist, and a GPC 5 I-Fail indication (GPC 5 I-Fail downlink indicator ON (V72X7015E), the GPC 5 I-Fail light illuminated on Panel O1, and a Caution and Warning alarm annunciated (parameter 045) with the "GPC" light illuminated on Panel F7).

f. Preplanned Contingency Procedure - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(5) BFS may not be operable for flight.

CAUSES OF EXCEEDING REDLINE:

(6) GPC 5 hardware failure.
(7) BFS software anomaly.
(8) Improper procedure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: BFS

LCC VIOLATION CALL: BFS GPC Error Count Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V98J2299C	GPC Error Count		(2)	NA	NA	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) No error occurrence. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) All errors will be evaluated. If analysis determines errors occurred due to explainable phenomena documented in Space Shuttle Program approved documentation, and do not affect General Purpose Computer (GPC) or flight software functionality or system redundancy, LCC violation cleared, continue countdown.

NOTES:

(4) GPC error count will increment upon occurrence of a GPC error.
V98J2509C GPC Error Log 1 Error Code.
V98J2525C GPC Error Log 2 Error Code.
V98J2541C GPC Error Log 3 Error Code.
V98J2557C GPC Error Log 4 Error Code.
V98J2573C GPC Error Log 5 Error Code.

REDLINE DERIVATION: CRITICALITY: 1R

(5) a. SSID Intent Summary - The purpose of this requirement is to ensure that the Backup Flight System (BFS) GPC is operable for flight. This is accomplished by monitoring the downlisted BFS GPC error counter for the occurrence of unexpected GPC errors. The counter will increment upon the occurrence of any GPC error. BFS GPC failures are collectively monitored via downlist validity, the downlisted BFS GPC error log, and BFS fault summary messages. Unexpected BFS GPC errors may be indicative of a BFS hardware or software anomaly that could preclude the ability to control the vehicle if engaged.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - The minimum redline limit of no occurrence insures that BFS has not detected any of forty unique GPC error conditions. There is no maximum redline limit.

d. Time Period - Detection of a BFS GPC error is possible at any time BFS

REDLINE DERIVATION: (Continued)

is active. Therefore, the time period extends from the start of ET Cryo Tanking (T-6 hours) until commit for flight at Go for SSME Start (T-10 seconds).

e. Requirements - BFS will log a GPC error and increment the GPC error count for any of forty unique error conditions. The cause and response depend solely on which error condition was encountered. All BFS GPC errors must be evaluated, since none are expected during nominal software operation. However, due to software timing considerations and periods of high applications processing, there are some GPC errors that are acceptable for continuing the countdown. These exceptions are outlined in OPS and User Notes.

f. Preplanned Contingency Procedure - The intent of the Preplanned Contingency Procedure is to discriminate between errors that may occur due to known software conditions (i.e., program note conditions), and those that occur due to software anomalies. This is accomplished by evaluating all errors. If analysis determines the errors resulted from explainable conditions as documented in Space Shuttle Program approved documentation, and do not affect the GPC or flight software functionality or system redundancy, the error is not a constraint to launch.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) BFS is questionable for flight.

CAUSES OF EXCEEDING REDLINE:

(7) Primary Avionics Software System (PASS)/BFS interface problem.
(8) Improper procedure.
(9) GPC 5 hardware failure.
(10) BFS software anomaly.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: BFS

LCC VIOLATION CALL: BFS Tracking PASS Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V98X2752X	Trkg Pass Stat-Trkg FC Stng 1		ON (2)	NA	Event	CI
V98X2753X	Trkg Pass Stat-Trkg FC Stng 2		ON (2)	NA	Event	CI
V98X2754X	Trkg Pass Stat-Trkg FC Stng 3		ON (2)	NA	Event	CI
V98X2755X	Trkg Pass Stat-Trkg FC Stng 4		ON (2)	NA	Event	CI

TIME PERIOD:

(1) From "BFS Transition into OPS101" (approximately T-18 minutes) to Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) AN "OFF" in place of an "ON" indicates that the backup computer is no longer tracking the Primary Avionics Software System (PASS) General Purpose Computer (GPC) commanding the corresponding string. This indicates that either the bus commander or the backup computer has a problem.

(3) "0"=OFF (KSC), OFF (Master Measurement List (MML)); "1"=ON (KSC), ON (MML).

REDLINE DERIVATION: CRITICALITY: 1R

(4) a. SSID Intent Summary - The purpose of this requirement is to ensure that the Backup Flight System (BFS) GPC is tracking the PASS GPCs on all four of the Flight Critical (FC) strings. Tracking of PASS is required for BFS to determine the vehicle state pre-engage. BFS awareness of vehicle state is required in order to successfully assume control of the vehicle post-engage. BFS is required to track PASS on all four FC strings pre-engage in order to acquire redundant Line Replaceable Unit (LRU) data. If BFS is unable to track one or more of the strings, it indicates there is an interface problem with the PASS on that string (e.g., BFS is unable to hear PASS listen commands, BFS disagrees with PASS Bus Control Element (BCE) bypass data, data on one string disagrees with data on the other three strings, or there is some other problem internal to the BFS).

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - The minimum redline limit of ON insures that the BFS GPC is tracking the PASS GPCs on each of the four FC strings. Tracking of PASS is required for BFS to successfully control the vehicle post engage. There is no maximum redline limit.

REDLINE DERIVATION: (Continued)

d. Time Period - Detection of a BFS Tracking PASS anomaly is possible whenever PASS and BFS are operating in OPS 1. Therefore, the time period extends from the BFS OPS 101 transition (approximately T-18 minutes) until commit for flight at Go for SSME Start (T-10 seconds).

e. Requirements - Tracking is the process by which the BFS acquires FC data pre-engage. If BFS fails to track the PASS FC I/O on at least two of the four FC strings, it no longer has access to the necessary FC data to perform a successful engage. If tracking is lost on a given string, BFS will downmode the string, disable the Bus Control Elements (BCEs) and mark all string elements bypassed for that string. For a string downmode, BFS will annunciate a fault message "BCE STRG 1(2,3,4) PASS" (fault codes 268-271) against the affected string(s) as well as any of several GPC and I/O errors.

f. Preplanned Contingency Procedure - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(5) BFS operating with limited or no FC data.
(6) BFS is questionable for flight.

CAUSES OF EXCEEDING REDLINE:

(7) PASS/BFS interface problem.
(8) BFS hardware failure.
(9) Data bus anomaly.
(10) PASS hardware failure.
(11) BFS software anomaly.
(12) PASS software anomaly.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: BFS

BFS Ascent Digital Auto Pilot (DAP) Anomaly

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LCC VIOLATION CALL: BFS GPC Fail Indication | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
SGPCAREA2	Downlist Validity Check Area 2		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) Backup Flight System (BFS) General Purpose Computer (GPC) failure is monitored via downlist validity, BFS GPC error logs and BFS fault summary messages (reference SSID: BFS-04 and BFS-05). Separate monitoring of GPC 5 fail indicator is not required.

(3) While BFS is on internal time (i.e., prior to tracking pass), one downlist frame may be lost approximately every 2 hours due to BFS GPC & Pulse Code Modulation Master Unit (PCMMU) timing differences (reference BFS User Note B08062).

REDLINE DERIVATION: CRITICALITY: 1R

(4) a. SSID Intent Summary - The purpose of this requirement is to ensure that the BFS GPC is operating properly and providing downlist data to the ground. This is accomplished by monitoring for valid BFS downlist via the GPC Front End Processor (FEP) Area 2 status. Monitoring for the presence of valid BFS downlist serves as a health check of the BFS, and enables monitoring of other BFS LCCs. BFS GPC failures are collectively monitored via downlist validity, the downlisted BFS GPC error log, and BFS fault summary messages. Loss of downlist data may be indicative of a BFS hardware or software anomaly that could preclude the ability to control the vehicle if engaged.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - The minimum redline limit of ON insures that the BFS GPC is active and providing downlist data to the ground. This serves as a health check of the BFS, and enables monitoring of the remaining BFS LCCs. There is no maximum redline limit.

d. Time Period - Detection of a BFS downlist loss is possible at any time BFS is active. Therefore, the time period extends from the start of ET Cryo Tanking (T-6 hours) until commit for flight at Go for SSME Start

REDLINE DERIVATION: (Continued)

(T-10 seconds).

e. Requirements - BFS downlist format 12 is generated by the BFS GPC from BFS activation through ascent, and is required to monitor for BFS redline violations. In addition, loss of BFS downlist is one means used to detect BFS GPC failures. While BFS is on internal time (i.e., prior to tracking PASS), one downlist frame may be lost approximately every 2 hours due to BFS GPC & PCMMU timing differences (reference BFS User Note B08062).

f. Preplanned Contingency Procedure - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Launch with a failed BFS GPC.
(6) Launch with undetected BFS redline violations.

CAUSES OF EXCEEDING REDLINE:

(7) GPC FEP failure.
(8) PCMMU failure.
(9) BFS hardware failure.
(10) GPC 5 Instrumentation Pulse Code Modulation (IP) bus anomaly.
(11) BFS software anomaly.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: BFS

LCC VIOLATION CALL: BFS Payload MDM Bypass Indication | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V98X0961X	Payload 1B PF1		OFF	NA	Event	CI
V98X0965X	Payload 1B PF2		OFF	NA	Event	CI

TIME PERIOD:

(1) From BFS transition into RUN (approximately T-18 minutes) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES: Figure 35-01

PREPLANNED CONTINGENCY PROCEDURE:

(2) Reference Figure 35-01, BFS Payload MDM Bypass Recovery Flow Diagram, for a preplanned contingency procedure.

NOTES:

(3) "0"=Off (KSC), Off (Master Measurement List MML)); "1"=On (KSC), On (MML).
(4) Violation will result in fault summary message "I/O ERROR PL1" (fault code 260) or "I/O ERROR PL2" (fault code 264).

REDLINE DERIVATION: CRITICALITY: 1R

(5) a. SSID Intent Summary - The purpose of this requirement is to ensure that the Backup Flight System (BFS) General Purpose Computer (GPC) to Payload Multiplexer/Demultiplexer (MDM) interfaces are functional. This is accomplished by monitoring the Payload (PL) MDM bypass discretes for a bypass condition. PL MDM communication is required for BFS to successfully perform System Management functions during ascent/entry, and for cycling payload bay doors on orbit.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - The minimum redline limit of OFF insures that the BFS GPC has not bypassed the associated Payload Forward (PF) MDM. An MDM bypass condition signifies a loss of communication between the BFS GPC and the MDM. There is no maximum redline limit.

d. Time Period - Detection of a PL MDM bypass is possible whenever the BFS GPC commands the PL data busses. BFS assumes command of the PL busses when it is moded to RUN (approximately T-18 minutes). Therefore, the time period extends from the BFS transition into RUN (approximately T-18 minutes) until commit for flight at Go for RSLS Start (T-31 seconds).

e. Requirements - BFS reads non-mission dependent input data from the

REDLINE DERIVATION: (Continued)

Payload MDMs at a rate of once per major cycle (every 960 milliseconds). Output commands and/or data to the Payload MDMs are transmitted at a rate of 6.25 times per second. When necessary, BFS can be updated to read and process up to 50, 16-bit analog or discrete payload support data words on a mission-by-mission basis. These parameters can be read in any combination from the PL MDMs and/or the Pulse Code Modulation Master Unit (PCMMU) (source Payload Data Interleaver (PDI)). A PF MDM bypass discrete ON indicates the BFS has received two consecutive I/O errors on the data read for the associated PF MDM. This will result in loss of the above mentioned I/O data and annunciation of BFS fault message code 260 - "I/O ERROR PL1", or 264 - "I/O ERROR PL2".

f. Preplanned Contingency Procedure - The intent of the Preplanned Contingency Procedure is to attempt to restore communication with the affected PL MDM on the redundant port. This is accomplished by port moding the PL MDMs via a Primary Avionics Software System (PASS) item entry, and performing an I/O Reset on the BFS to attempt to upmode the bypassed MDM. If functionality is restored by port moding, the fault is isolated to a single MDM port (e.g., MDM Sequence Control Unit (SCU) or Multiplexer Interface Adapter (MIA)). Loss of a single MDM port has been deemed acceptable by the program, and is not a constraint to launch if the function is restored by port moding.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Loss of one payload MDM will cause a minimum duration mission because of loss of redundancy in payload bay door operations.

CAUSES OF EXCEEDING REDLINE:

(7) Panel O6 GPC 5 Mode Switch not in RUN position.
(8) MDM anomaly.
(9) Data bus anomaly.
(10) Panel O6 GPC 5 Mode Switch failure.
(11) GPC 5 hardware failure.

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SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: BFS

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SUPPORTING DATA:

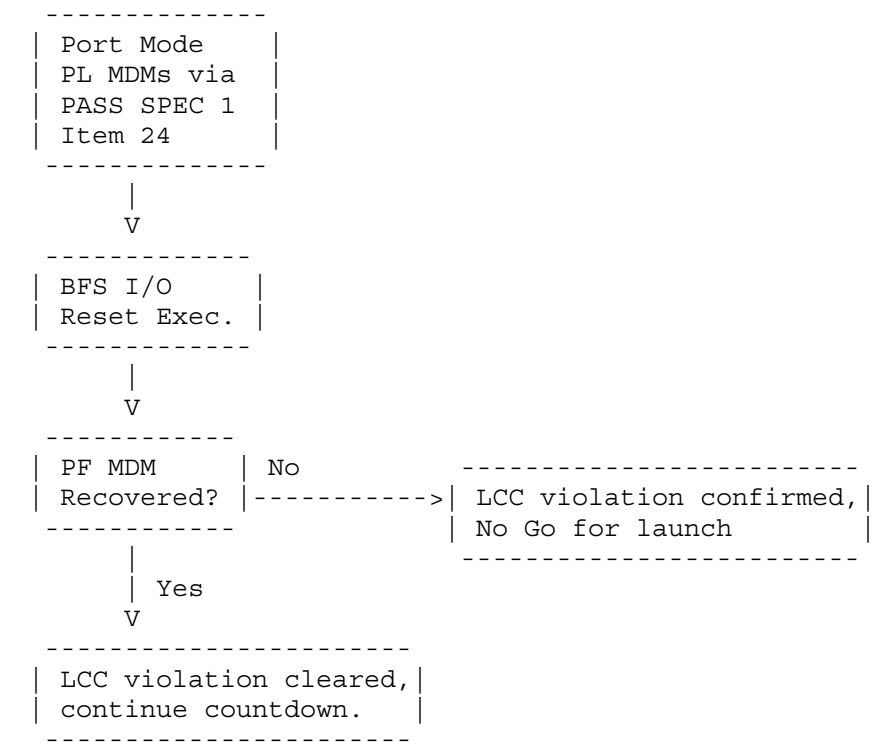

Figure 35-01 BFS Payload MDM Bypass Recovery Flow Diagram

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BFS Multifunction CRT Display System Anomaly

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LCC VIOLATION CALL: BFS Multifunction Electronic Display Subsystem (MEDS) Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	Fault Summary Messages (FSM)					
	(Downlisted BFS)					
FSM	I/O ERROR CRT x		(2,5,6)	NA	Error	CI
FSM	CRT BITE x		(2,5,6)	NA	Error	CI
	MEDS Status Word Errors					
V98M4864P	IDP MEDS Status Wd 1 BFS		(3,5,6)	NA	HEX	CI
V98M4862P	IDP MEDS Status Wd 2 BFS		(3,5,6)	NA	HEX	CI
V98M4863P	IDP MEDS Status Wd 3 BFS		(3,5,6)	NA	HEX	CI
	Crew indication of MEDS Anomaly		(4,5,6)	NA	NA	

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES: See Note 8

(2) No Fault Summary Message occurrence. (7)
(3) The following MEDS Status Word (SW) 1-3 reported conditions are redline violations (7):
- MEDS Errors (SW1 Bits 5-7 = '001')
- MEDS Operational Self Test (OST) and Power On Self Test (POST) Summary Built In Test (BIT) indications (SW1 Bits 5-7 = '010')
- Display/Format Fill error (SW3 Bit 0 = '1')
- Checksum Error (SW3 Bit 11 = '1').

(4) Crew is backup to the downlist and should notify the ground upon detection of any of the following MEDS anomalies (7):
- MEDS FSM
- "I/O ERROR CRT x" or "CRT BITE x" GPC FSM
- "BIG X"
- "Poll Fail"
- Unexpected invalid indications (i.e., missing data or red outlined boxes)
- Blank or unreadable MDU screen
- Keyboard or edge key anomalies
- Multiple IDPs responding to the same keyboard entry.

(5) The following minimum MEDS hardware is required to be functional: (6)
- 3 of 3 forward IDPs
- 3 of 3 forward CRT MDUs
- 5 of 6 forward non-CRT MDUs, if all ADCs and ADC ports are functional, or 6 of 6 otherwise
- 3 of 4 ADCs, if all MDUs and MDU ports are functional, or 4 of 4 otherwise
- 2 of 2 forward keyboards.

REQUIREMENTS: (Continued)

(6) IDP4 and aft MDU (CRT4, Aft Flight Deck (AFD)1) effectivities are mission unique. Reference MEL for current mission requirements.

PREPLANNED CONTINGENCY PROCEDURE:

(7) Evaluate MEDS anomaly per Figure BFS-10a.01, Flow Diagram for BFS MEDS Anomaly.

NOTES:

(8) The following Figure and Tables are included in this SSID: Figure BFS-10a.01, Tables BFS-10a.01, BFS-10a.02, BFS-10a.03, BFS-10a.04, BFS-10a.05.
(9) The Status Words of all four IDPs are submultiplexed into a single error buffer in the BFS downlist. The IDP ID reporting Status Word 1-3 content in the error buffer is determined via V98J4388C, ER BU - DEU ID BFS.
(10) For "I/O ERROR CRT x" and "CRT BITE x" FSM, x = 1, 2, 3, 4 since crew may assign any CRT to BFS, and BFS listens to PASS DK bus transactions.
(11) "I/O ERROR CRT x" FSM will be annunciated on the first occurrence of any of the following GPC detected anomalies:
- BCE I/O error
- MSC timeout
- IDP Poll Response checksum error
- Keyboard Message Present bit set in the IDP poll response header word with no keycodes present
- No EXEC keycode detected when processing an ITEM keystroke message

(12) "CRT BITE x" FSM will be annunciated upon GPC notification of any of the following IDP detected anomalies:
- Keyboard channel A fail
- Keyboard channel B fail
- Error Detection and Correction (EDAC) failure in Data Entry and Display (DED) card of IDP
- Keyboard Stack Underflow
- Initialization Performed (IDP S/W Start Up).

(13) Bit numbers used in this SSID are referenced from bit 0 being the leftmost bit, and bit 15 being the rightmost bit.
(14) MEDS Error event is indicated if SW1 Bits 5-7 = '001'. Specific error code will be reported in SW2 Bits 8-15, and the reporting LRU in SW3 (reference Table BFS-10a.05).
(15) MEDS OST/POST BIT event is indicated by the occurrence of a Summary BIT (SW1 Bits 5-7 = '010') followed by one or more Detailed BIT (SW1 Bits 5-7 = '100'). Specific BIT codes for each will be reported in SW2 Bits 0-15, and the reporting LRU in SW3 (reference Table BFS-10a.05).

REDLINE DERIVATION: CRITICALITY: 1

(16) a. SSID Intent Summary - The intent of this SSID is to ensure the MEDS system is functional and capable of supporting all critical flight and mission support operations. Launching with a latent MEDS system anomaly or reduced functionality may put the crew and vehicle at risk due to loss of critical display information required for the

REDLINE DERIVATION: (Continued)

crew to fly the vehicle, maintain situational awareness, respond to contingencies, and enter keyboard commands to the GPCs. Refer to paragraph (16)e5. for information on fault tolerance.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - Redline criteria is intended to detect the occurrence of MEDS error conditions that may indicate a loss of functionality, or aberrant behavior of a critical system component.

Monitored parameters consist of error codes, fault messages, and aberrant conditions observed by the crew. These parameters do not have quantifiable Max/Min redline limits. Violation of LCC exists upon the occurrence of any of the specified error conditions.

d. Time Period - The MEDS is operating in flight configuration throughout the terminal count period, and errors may be reported at any time through T-0. The chosen time period ensures continuous health monitoring from the start of tanking phase at T-6 hours until commitment for launch at T-31 seconds. Committing the system for flight at T-31 seconds enables monitoring for certain Crit 1/1 failure modes that are only detectable during preflight use of the system by the crew.

e. Requirements -

e1. Reference Measurement Description Table.

The parameters defined in the Measurement Description Table are intended to monitor the MEDS for anomalous conditions that may degrade system operability or fault tolerance. This includes monitoring for all of the following conditions.

- BFS GPC Fault Summary Messages:
  Required for detection of GPC/IDP interface issues.
- MEDS Status Word Indications:
  Required for detection of MEDS internal fault conditions and interface issues.
- Crew Detected Anomalies:
  Required to detect display anomalies and keyboard interface issues that may not be reported via the downlist.

e2. Reference Requirement (2).

BFS Fault Summary Messages are annunciated by the GPC upon detection of an error in receipt of response data from the IDP. GPC FSMs are reported in the downlist, and displayed onboard on the CRT message line, and Fault Summary Page. The occurrence of either of the following FSMs is a redline violation:

- I/O ERROR CRT x FSM - The GPC will report an "I/O Error CRT x" FSM

REDLINE DERIVATION: (Continued)

upon the first occurrence of an I/O error in communication with the IDP. It will also report this error for any of the following IDP Poll Response data anomalies:

- o IDP Poll Response checksum error
- o Keyboard Message Present bit set in the IDP poll response header word with no keycodes present
- o No EXEC keycode detected when processing an ITEM keystroke message

Occurrence of this fault signifies a potential loss of keyboard data from the IDP, as well as a potential loss of GPC display data to the IDP.

- CRT BITE x FSM - The GPC will report a "CRT BITE x" FSM if the Critical Built In Test Equipment (BITE) bit in the IDP response header word is set. This bit is set by the IDP upon detection of certain internal critical faults that may compromise keystroke data integrity. Occurrence of this fault signifies a potential loss of keyboard data from the IDP.

e3. Reference Requirement (3).

IDP Status Words 1, 2 and 3 are downlisted digital patterns used to report MEDS status and error conditions. The SWs contain a mix of discrete error, BIT, and status indications, and submultiplexed error and edge key identification codes. The occurrence of any of the following Status Word reported error conditions is a redline violation:

- MEDS Errors

MEDS errors signify the occurrence of certain IDP detected system abnormalities, and may indicate a loss of function of the IDP or one of its associated MDUs or ADCs. MEDS errors require evaluation to determine system effects.

- OST/POST BIT Summary Errors

IDP Operational Self Test (OST) Built In Test (BIT)/Power On Self Test (POST) summary errors represent a roll up of fault indications detected internally by the IDP, MDU or ADC OST/POST routines. The occurrence of an OST/POST BIT summary indication will be accompanied by one or more detailed BIT fault codes that provide more specificity as to the source of the fault. It will also be accompanied by an LRU fail bit in SW3 that will remain set for as long as self test is detecting the anomalous condition.

The occurrence of an OST/POST BIT failure signifies a possible loss of function of the associated Line Replaceable Unit (LRU). OST/POST BIT summary errors require evaluation in order to determine system effects. The associated detailed BIT and SW3 LRU

REDLINE DERIVATION: (Continued)

fail indications are not required to be monitored for redline violation since they supplement the Summary BIT.

- Display Format Fill Error

  The occurrence of a Display Format Fill error is reported by the IDP via a bit in IDP status word 3 upon detection of any of the following DK bus message errors. Occurrence requires evaluation to determine system effects.

  - o Word Error: The IDP Multiplexer Interface Adapter (MIA) has detected an incoming Manchester, bit count, or parity error.
  - o Check Bit Error: The SEV check bit pattern on a data word received from the GPC was not '101'.
  - o Address Miscompare: The address of a data word received by the IDP did not match the address of the preceding command word.
  - o Message Timeout Error: The IDP did not receive all data words in the message within 36 ms of the command word.
  - o Invalid Word Count: The number of display/format fill words received by the IDP does not match the word count sent by the GPC.
  - o Invalid Address: The received display/format fill start or end address is outside the valid address range for the Display, Critical Format, and Message Line buffers.

- Checksum Error

  The occurrence of a Checksum error is reported by the IDP via a bit in IDP status word 3 if the Critical Format Buffer checksum value computed by the IDP does not match the checksum value sent by the GPC. Occurrence requires evaluation to determine system effects.

Certain other IDP Status Word 1-3 contents, such as MDU Command bits, Virtual Memory Load bits, Downlist Required bit, Non-Critical Error bit, spare bits, Edge Key data, Initialization Performed bit, and LRU ID bits, are information only and therefore, do not constitute redline violations.

e4. Reference Requirement (4).

Certain failure conditions may not appear in the downlist, and can only be detected and reported by the crew. Therefore, the crew is a backup to the ground for monitoring of system performance, and should report any anomalous conditions noted during operation of the MEDS:

- MEDS Fault Summary Messages, which appear on the MEDS message line of the MDU displays. These signify MEDS detected anomalies that may affect the crew's use of the system.
- "I/O ERROR CRT x" and "CRT x BITE" GPC Fault Summary Messages,

REDLINE DERIVATION: (Continued)

which appear on the GPC FSM message line of the DPS displays. These signify GPC detected anomalies that may affect the crew's use of the system.
- Big X, which signifies that the active DPS display (Spec, Display, or Ops Display) is no longer being updated by the GPC.
- Poll Fail, which indicates the IDP is no longer receiving GPC polls for keystroke and status information.
- Unexpected invalid data indications, such as missing parameters or red-outlined data fields, which signifies that the IDP is not properly receiving the associated parameter.
- Display abnormalities, such as blank screen, malformed or unreadable characters, brightness issues, etc., which may affect readability of the display. Loss of display capabilities affects the crew's ability to monitor vehicle performance and respond to fault conditions.
- Keyboard anomalies, such as failed open/failed closed keys, or no response from the keyboard, which signify a loss of function from the associated keyboard, and impair the crew's ability to issue GPC commands and invoke DPS displays.
- MDU edge key anomalies, which affect the crew's ability to invoke MEDS displays and change MEDS configuration from the affected MDU.
- Multiple IDPs responding to the same keyboard entry, which presents a risk of unintended keyboard commands being executed by the GPC, with unpredictable results.

e5. Reference Requirement (5).

The minimum set of MEDS hardware specified is intended to provide Fail Operational/Fail Safe capability during flight by ensuring the minimum set of IDPs, MDUs, ADCs, and keyboards needed to fly and land the vehicle remain available following the worst case combination of two component or power bus failures. This is based on the crew's assessment that a minimum of one IDP, one forward keyboard, one CRT MDU and one other forward MDU are needed to successfully fly the vehicle. For proper operation, this remaining set of hardware must reside on the same hardware string.

Integrated Display Processors generate the critical display information for presentation on an MDU display. They also provide crew keystroke command data to the GPCs. Loss of an IDP also results in loss of a CRT MDU, loss of one port of several non-CRT MDUs and ADCs, and loss of one or two keyboard interfaces. All three forward IDPs must be functional at liftoff to meet the specified Fail Operational/Fail Safe criteria during flight.

Each IDP contains an internal Mass Storage Unit (MSU) used to store event logs and backup copies of IDP and MDU operating software. The MSU function is considered Crit 3 since the primary copy of IDP and MDU operating programs are stored in Electrically Erasable Programmable Read Only Memory (EEPROM). Therefore, loss of the MSU is not considered a constraint to launch.

REDLINE DERIVATION: (Continued)

Multifunction Display Units display the critical information provided by the IDPs to the crew. 3 of 3 forward CRT MDUs and 5 of 6 forward non-CRT MDUs must be functional at liftoff to ensure adequate visibility of critical flight information to the crew. Launching with all three forward CRT MDUs and 5 of 6 non-CRT MDUs functional ensures the system can still meet the minimum display requirements established by the crew following any combination of two failures of MDUs, IDPs, and power busses during flight. Loss of a single forward non-CRT MDU, or MDU port, is not a constraint to flight if all remaining IDPs, MDUs and ADCs are operating nominally.

Analog to Digital Converters (ADCs) provide OMS, MPS, APU, Hydraulics, and Surface Position Indicator (SPI) subsystem measurement data to the IDPs for display on the MDUs. Three of four ADCs are required for flight. Loss of a single ADC, or ADC port, is not a constraint to launch as long as the remaining IDPs, MDUs and ADCs are operating nominally. This is acceptable because redundancy for most ADC parameters is provided on PASS or BFS GPC displays (GNC SYS SUMM 1/2, VERT SIT 1, MANEUVER for ADC1; SM SYS SUMM 2 for ADC2).

Keyboards provide the crew with GPC command capability. Both forward keyboards are required in order to provide command/control from both CDR and PLT flight stations, and meet FOFS safety criteria.

e6. Reference Requirement (6).

The aft MEDS components (IDP4, aft keyboard, CRT4, AFD1) may support mission operations, but are not critical for ascent/entry ops. Therefore, the requirements for these components are mission dependent, and are specified in the MEL.

f. Preplanned Contingency Procedure -

The intent of the Preplanned Contingency Procedure is to evaluate the occurrence of MEDS anomalies for their impact on the performance and redundancy of the system. The Figure BFS-10a.01 flowchart and accompanying notes and data tables are provided to facilitate this evaluation. Highlights of this evaluation are as follows:

- Acceptable Errors:
  The MEDS errors and OST/POST BIT indications identified in Tables BFS-01a.01 through BFS-01a.04 represent fault indications which have previously been evaluated and determined not to have an adverse impact on system performance or redundancy. In general, these errors relate to unused or non-critical functions of the LRU. Occurrence of these errors is therefore acceptable for flight. Note that the IDP/MDU OST/POST Summary BIT errors listed are only acceptable for flight if the Summary BIT occurs as a result of the specified Detailed BIT.

REDLINE DERIVATION: (Continued)

- MEDS Program Notes:
  MEDS program notes, such as User Notes and Ops Notes, document hardware/software behaviors that may be expected to occur under certain operational conditions. They generally represent explainable phenomena that do not adversely affect system performance or redundancy, as opposed to actual system failures. Some user action may be specified on the note to confirm the error signature or reset the error condition. Following completion of any required user response, errors that are deemed acceptable by a program note are not a constraint to launch.

- Keyboard/Keyboard Interface Errors:
  Two of two forward keyboards are required for flight. Therefore, any keyboard or keyboard I/F anomalies, such as failed open/closed keys, multiple IDPs responding to the same keyboard entry, or CRT BITE FSM, are not acceptable.

- Transient Errors:
  One-time transient errors do not adversely affect system performance or redundancy. Therefore, these errors are acceptable for launch, as long as MEDS operation is confirmed. For MDUs and ADCs, confirmation of a transient condition may require power cycle of the LRU to force a reset of the hardware.

- Single Non-CRT MDU or ADC Errors:
  Errors that are not resolved by the above criteria and are isolated to a single non-CRT MDU, MDU port, ADC, or ADC port are accepted based on system redundancy levels. Any MDU display or ADC data lost as a result of the anomaly may be recovered by port moding or re-arranging MDU displays as necessary. Determination of display and port configuration is left to crew preference.

  Errors isolated to IDPs, CRT MDUs, or keyboards violate redundancy requirements, and are not acceptable. Similarly, combinations of IDP, MDU and ADC faults that would individually be acceptable may result in violation of redundancy requirements, and therefore, are also not acceptable.

CONSEQUENCES OF EXCEEDING REDLINE:

(17) Launching with a failed or suspect display system may result in loss of crew and vehicle due to any of the following conditions:

- Inadequate displays to provide crew situational awareness during critical flight phases and contingency operations.
- Erroneous display information resulting in the crew taking inappropriate action.
- Erroneous output of keystroke data to the GPCs resulting in unintended issuance of keyboard commands.
- Non-universal I/O errors on a Display/Keyboard (DK) bus resulting in breakup of the redundant set.

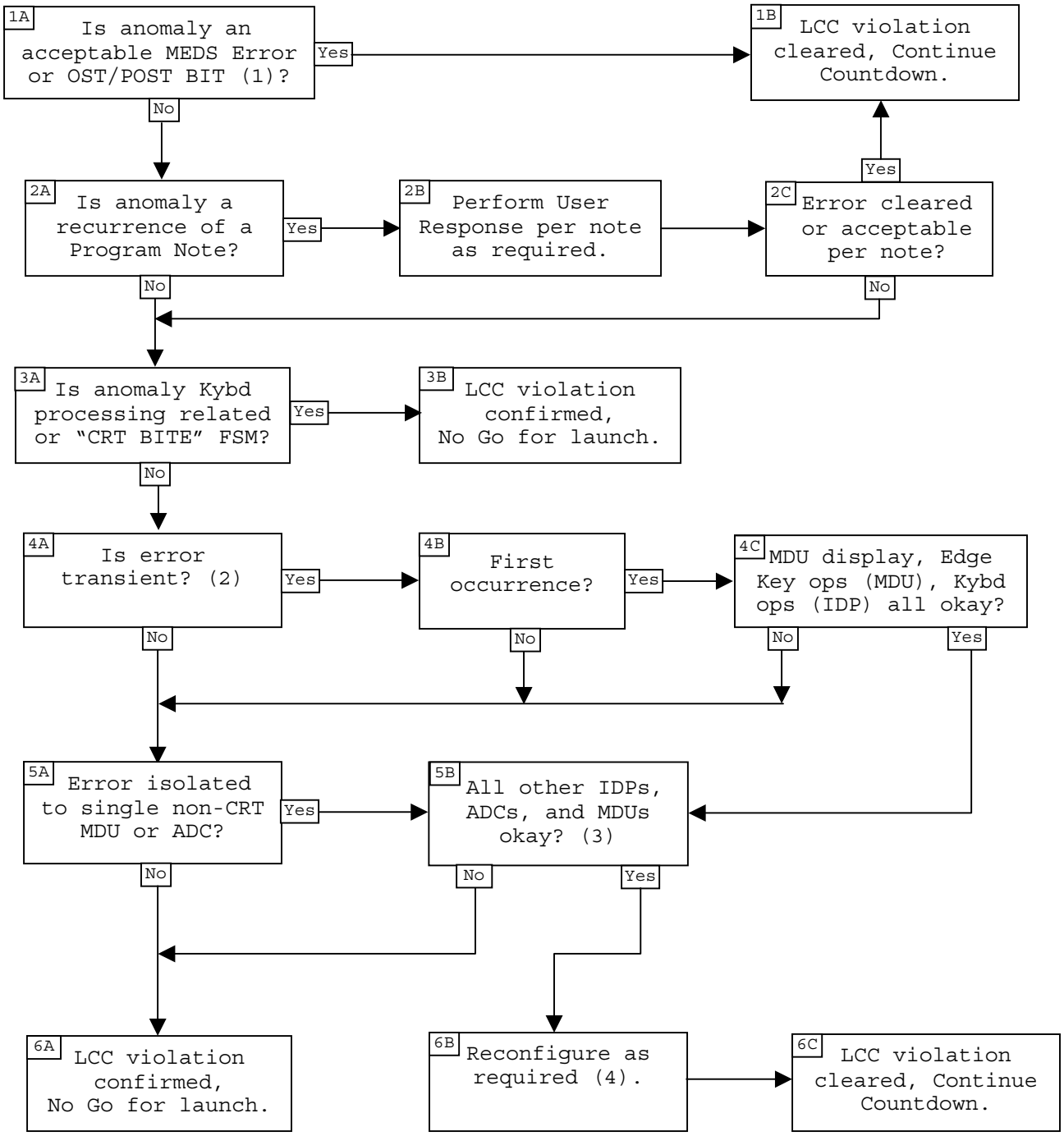
CAUSES OF EXCEEDING REDLINE:

(18) Hardware anomaly in IDP/MDU/ADC.
(19) Software anomaly in IDP/MDU/ADC.
(20) MEDS 1553 bus anomaly.
(21) MEDS power cycle.
(22) GPC hardware anomaly (e.g., MIA, Bus Control Element (BCE)).
(23) GPC software anomaly.
(24) DK bus anomaly.
(25) MEDS input power circuit fault (e.g., RPC, power switch, circuit breaker, wiring).
(26) MDM, DSC, or transducer in OMS, MPS, APU or Hydraulics subsystem analog signal path.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO 8.3	SHEET 1-3	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: BFS

SUPPORTING DATA:



(Numbers in parentheses refer to Supporting Notes on following page)

Figure BFS-10a.01 Flow Diagram For BFS MEDS Anomaly

SUPPORTING DATA:

Figure BFS-10a.01 Notes:

(1) The MEDS indications that have been deemed acceptable are as follows: (reference Table BFS-10a.05 to determine reporting LRU ID)

- MEDS errors specified in Table BFS-10a.01 are acceptable for flight.

- IDP OST/POST Summary BIT errors specified in Table BFS-10a.02 are acceptable for flight if they occur as a result of the associated Detailed BIT indications.

- MDU OST/POST Summary BIT errors defined in Table BFS-10a.03 are acceptable for flight if they occur as a result of the associated Detailed BIT indications.

- ADC OST/POST Summary BIT errors defined in Table BFS-10a.04 are acceptable for flight.

All other IDP/MDU/ADC OST/POST Summary BIT errors require evaluation.

(2) A transient error includes any of the following conditions:

- Single occurrence of an "I/O Error CRT x" FSM
- Single occurrence of a MEDS error*
- Single occurrence of a OST/POST BIT error that clears*
- Single occurrence of a crew reported display anomaly that clears*
- Single occurrence of a SW3 Display/Format Fill error or Checksum error that clears

* For MDUs and ADCs, an error condition that is cleared by power cycling the LRU is also considered a transient. If remaining hold time does not permit power cycle, the anomaly will be treated as hard failed.

(3) Only a single MEDS LRU anomaly is acceptable. Any transient or hard failed anomaly reported against any other IDP, MDU, ADC or MDU/ADC port, except for Excluded Errors, User Note conditions, or IDP/CRT 4 anomalies if excluded by the MEL, violates redundancy requirements.

(4) Crew may power off failed LRU and reconfigure displays, FC buses, and/or port mode MDUs as required to work around a single failed non-CRT MDU or ADC.

SUPPORTING DATA:

Table BFS-10a.01 Acceptable MEDS Errors*

ERROR CODE	MEDS ERROR DESCRIPTION
SW2 Hex^	
XX08	CST MM IN USE ERROR
XX11	DAS FOREGROUND EXTENDED
XX12	MSU SPIN-UP ERROR
XX4D	MSU I/O ERROR
XX50	OPERATOR REQUEST ERROR - MSU

* The MEDS Errors listed in this table are acceptable for flight. All other MEDS errors require evaluation.
^ XX = Don't Care

Table BFS-10a.02 Acceptable IDP BIT Errors*

OST/POST SUMMARY		DETAILED BIT	IDP SUMMARY/DETAILED BIT ERROR DESCRIPTION
SW2 Bit#	SW2 Hex	SW2 Hex	
08	0080	-	HDX Software Status
		F014	HDX SCSI Event Queue
		F015	HDX MSU Event Queue
15	0001	-	SCSI/MSU Fail
		F023	SCSI Failure 1
		F024	SCSI Failure 2
		F025	SCSI Failure 3
		F026	MSU Failure

* The IDP Summary BIT errors listed in this table are acceptable for flight if they occur as a result of the specified Detailed BIT indications. All other IDP Summary/Detailed BIT combinations require evaluation.

SUPPORTING DATA:

Table BFS-10a.03 Acceptable MDU BIT Errors*

OST/POST SUMMARY		DETAILED BIT	MDU SUMMARY/DETAILED BIT ERROR DESCRIPTION
SW2 Bit#	SW2 Hex	SW2 Hex	
01	4000	-	R3000 RAM Fail
		DD12	R3000 RAM Scrubber Fail
02	2000	-	EEPROM Fail
		DE03	EEPROM Write Fail
04	0800	-	Primary 1553B Fail
		DA12	Primary 1553B RAM Scrubber Fail
05	0400	-	Secondary 1553B Fail
		D712	Secondary 1553B RAM Scrubber Fail
07	0100	-	Spare (Unassigned)
		ALL	None defined - Disregard all
08	0080	-	Data Acquisition Fail
		DB04	Data Acquisition Backlight Sensor Fail
10	0020	-	GC RAM Fail
		D31A	GC CBIT Scrubber Fail
12	0008	-	Power Supply/Lamp Fail
		D905	Luminance Control Loop Fail
		DA05	Lamp Filament Fail
		DB05	Lamp TEC Fail
13	0004	-	Timer Fail
		DD07	Timer 1 Accuracy Fail
		DE07	Timer 1 Control Fail
		DF07	Timer 1 Interrupt Fail
14	0002	-	Miscellaneous Fail
		D503	UDI Interface Fail
15	0001	-	Overtemperature Sensor Fail
		D104	Ambient Temperature Sensor Fail
		D204	LCD Temperature Sensor Fail

* The MDU Summary BIT errors listed in this table are acceptable for flight if they occur as a result of the specified Detailed BIT indications. All other MDU Summary/Detailed BIT combinations require evaluation.

SUPPORTING DATA:

Table BFS-10a.04 Acceptable ADC BIT Errors*

OST/POST SUMMARY		ADC SUMMARY BIT ERROR DESCRIPTION
SW2 Bit#	SW2 Hex	
01	4000	Spare (Unassigned)
02	2000	Spare (Unassigned)
08	0080	Spare (Unassigned)
09	0040	Spare (Unassigned)
10	0020	Spare (Unassigned)

* The ADC Summary BIT errors listed in this table are acceptable for flight. All other ADC Summary BIT indications require evaluation.

Table BFS-10a.05 LRU ID Field Decode*

ID Field SW3 Binary	LRU Name	ID Field SW3 Binary	LRU Name
0001	IDP	0111	MFD1
0010	CRT	1000	MFD2
0011	CDR1	1001	AFD1
0100	CDR2	1010	ADC1
0101	PLT1	1011	ADC2
0110	PLT2	Other	Invalid

* LRU ID Field (SW3 Bits 12-15) identifies the LRU reporting status in SW2

LCC VIOLATION CALL: BFS IMU Initialization Data Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V98X0451X	QSMM50 Transfer Complete BFS		1	NA	Event	DI

TIME PERIOD:

(1) Snapshot After BFS NAV_START (approximately T-3 minutes, 50 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) "1"=ON (KSC), ON (Master Measurement List (MML)); "0"=OFF (KSC), OFF (MML).
(3) Failure of the discrete to be set to "ON", "1" following BFS NAV_START will result in RM FAIL XFER fault summary message annunciated on BFS CRT (Class 2, Code 44).

REDLINE DERIVATION: CRITICALITY: 1R

(4) a. SSID Intent Summary - The purpose of this requirement is to ensure that Backup Flight System (BFS) navigation has been properly initialized with Inertial Measurement Unit (IMU) quaternion transfer data from Primary Avionics Software System (PASS). This data is required for BFS to successfully control the vehicle post engage.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - The minimum redline limit of "1" (ON) insures that the BFS has successfully incorporated the PASS IMU quaternion data into its navigation. There is no maximum redline limit.

d. Time Period - Detection of a BFS IMU initialization data anomaly is possible at BFS NAV_START (T-3 minutes 57 seconds). The BFS QSMM50 Transfer Complete flag is set by a one-time software event that occurs at this time. Therefore, the time period is a one-time check following BFS NAV_START plus a few seconds of margin to allow for propagation and ground software delays (approximately T-3 minutes 50 seconds).

e. Requirements - When BFS is tracking PASS on the Flight Critical (FC) strings, PASS transfers Time Base Zero (TB0), identical copies of IMU quaternion data (one for each IMU) and an event flag (QREFS_RDY) to BFS on FC busses 5 through 8 as part of the 1hz FC MDM transfer data. BFS utilizes the transfer data from the lowest numbered FC bus available. When TB0 equals T-4 minutes, IMU platform release occurs and PASS calculates the quaternion data and sets QREFS_RDY to ON. This flag

REDLINE DERIVATION: (Continued)

indicates to BFS that the PASS IMU quaternion data has been calculated and is ready for incorporation into navigation (NAV) calculations. At BFS NAV_START, which occurs when TB0 equals T-3 minutes 57 seconds, BFS IMU initialization is performed. This initialization includes a check to determine if at least one set of FC transfer data is available for use and if QREFS_RDY for that bus is ON. If both these conditions are true, the PASS quaternion data for each IMU is subjected to a reasonableness check (i.e. that the components represent a unit quaternion). Each PASS quaternion that meets the reasonableness criteria will replace the corresponding BFS quaternion value and a flag will be set to indicate that this quaternion was incorporated into BFS NAV. If any PASS quaternion is not incorporated into BFS NAV, a flag will be set to indicate the failure to incorporate the value and the BFS quaternion value for that IMU will remain unchanged. After completion of the reasonableness check on the three IMU quaternions, if any fail flag is set, a BFS fault summary message code 44 - "RM FAIL XFER" will be annunciated. This also causes the QSMM50 Transfer Complete flag to be set OFF, resulting in violation of this LCC requirement.

f. Preplanned Contingency Procedure - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(5) BFS navigation is not properly initialized for flight.

CAUSES OF EXCEEDING REDLINE:

(6) BFS software anomaly.
(7) PASS software anomaly.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: BFS

LCC VIOLATION CALL: BFS I/O Error Log | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	BFS I/O Error Log - BCE Stat Reg					
NA	Bit 29: Illegal Opcode		(2)	NA	Event	CI
NA	Bit 28: Boundary Alignment Error		(2)	NA	Event	CI
NA	Bit 22: Self Test Error		(2)	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Occurrence of an I/O error with any of the indicated Bus Control Element (BCE) Status Register bits set ON constitutes a redline violation. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Evaluate error. If error is explainable based on conditions present at the time, and can be determined to have no effect on flight, LCC violation cleared, continue countdown.

NOTES:

(4) Indicated Status Register bits applicable for Bus Control Element (BCE) 1-24 only.

REDLINE DERIVATION: CRITICALITY: 1R

(5) a. SSID Intent Summary - The purpose of this requirement is to ensure that Backup Flight System (BFS) has not encountered any hardware or software anomaly that would result in annunciation of one of the specified I/O error conditions. This is accomplished by monitoring the downlisted BFS I/O error log for the occurrence of a Self Test, Boundary Alignment, or Illegal Opcode I/O error.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - The minimum redline limit of no occurrence insures that BFS has not detected any of the three specific I/O error conditions - Self Test Error, Boundary Alignment Error or Illegal Opcode. These I/O error conditions signify a potential BFS hardware or software problem as opposed to a communications problem with an external device. There is no maximum redline limit.

d. Time Period - Detection of one of the specified BFS I/O errors is possible at any time BFS is active. Therefore, the time period extends from the start of ET Cryo Tanking (T-6 hours) until commit for flight at

REDLINE DERIVATION: (Continued)

Go for RSLS Start (T-31 seconds).

e. Requirements -
Self-Test Error: An error has been detected by the BCE during execution of a Self Test (#STP) instruction. The capability exists to perform checks on BCE local store, BCE data flow, BCE memory read/write, Multiplexer Interface Adapter (MIA) wrap and MIA buffer. Any error encountered will set bit 22 and terminate self-test. This instruction is currently only used by the General Purpose Computer Initial Program Load (GPCIPL) software. This error should never occur when BFS is executing, and occurrence indicates a potential software anomaly (e.g., bad program branch).
Boundary Alignment Error: A BCE has attempted to execute a long format instruction that began on an odd half-word memory location. Each BCE is capable of executing 16-bit (short format) and 32-bit (long format) instructions. By hardware convention, the long format instructions must begin on an even half-word memory address. If an attempt is made to execute a long format instruction starting at an odd memory address, the BCE will not execute the erroneous instruction and will go to the wait state. The BCEs local store program counter will point to the offending instruction. Occurrence indicates a potential software anomaly (e.g., bad address reference).
Illegal Opcode: A BCE has attempted to execute an instruction with an illegal Opcode. If an attempt is made to execute an instruction with an illegal Opcode, the BCE will not execute the erroneous instruction and will go to the wait state. The BCEs local store program counter will point to the offending instruction. BFS intentionally forces execution of an illegal Opcode if an unexpected listen command appears on a flight critical bus. This is done to send the BCE to the wait state in the event of unexpected bus commands. Occurrence indicates a potential BFS software anomaly (e.g., memory corruption) or improper Primary Avionics Software System (PASS) listen command.

f. Preplanned Contingency Procedure - The intent of the Preplanned Contingency Procedure is to discriminate between errors that may occur due to known software conditions (i.e., program notes), and those that occur due to software anomalies. This is accomplished by evaluating all errors. If analysis determines errors occurred due to explainable conditions, and can be determined to have no effect on flight, the error is not a constraint to launch.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Possible loss of BFS.

CAUSES OF EXCEEDING REDLINE:

(7) BFS software anomaly.
(8) GPC 5 hardware failure.
(9) PASS listen command anomaly.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: BFS

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BFS Transmitter Anomaly

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LCC VIOLATION CALL: GPC Soft Error Counter Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V98Q2577B	GPC Soft Error Count 0-128K		NA	(2)	Cnts	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) More than two occurrences constitutes a redline violation.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(3) a. SSID Intent Summary - The purpose of this requirement is to ensure that Backup Flight System (BFS) General Purpose Computer (GPC) main memory has not encountered a memory cell (bit) failure or multi-bit error corruption. This is accomplished by monitoring the downlisted BFS lower core (0-128K) GPC Soft Error Counter (SEC) to ensure the GPC's Error Detection and Correction (EDAC) scrub logic has not detected and corrected more than two single bit errors in BFS GPC memory.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - The maximum redline limit of two occurrences insures that BFS is not launching with a GPC that may have some part(s) of memory that have failed or experienced uncorrectable multi-bit memory alterations. Multi-bit errors may result in loss of BFS software operation if the affected location is accessed during flight. Failed memory cells would make the GPC more susceptible to failure due to natural radiation induced memory alterations occurring during the mission. It is possible to have occurrences of single bit errors due to natural radiation while on the ground. Therefore, two occurrences of the soft error counter incrementing would most likely be attributed to natural radiation. More than two increments of the SEC would most likely be a result of a failed memory cell(s), or an uncorrectable multi-bit error somewhere in main memory. There is no minimum redline limit.

d. Time Period - Detection of a BFS GPC soft error counter (SEC) anomaly is possible at any time BFS is active. Therefore, the time period extends from the start of ET Cryo Tanking (T-6 hours) until commit for flight at

REDLINE DERIVATION: (Continued)

Go for RSLS Start (T-31 seconds).

e. Requirements - The AP101S GPCs have Complementary Metal Oxide Silicon (CMOS) technology main memory. CMOS has demonstrated a vulnerability to bit toggles in space caused by a greater exposure to natural radiation. Thus the GPCs main memory utilizes an EDAC design such that any GPC main memory read will be checked with a single bit error detect/correct and a multi-bit error detect functionality. Any single bit error detected during normal GPC software accesses is corrected before being sent to the Central Processing Unit (CPU) or Input/Ouput Processor (IOP), but the memory location is not corrected nor is the soft error counter incremented. A hardware process called "Scrub", which runs anytime the GPC is powered on, checks all memory every 1.7 seconds and corrects any single bit errors. A single bit error and a multi-bit error detected by Scrub increments the SEC. The failure of an entire 64K x 1 memory chip will result in the counter incrementing to 7F within two scrub cycles. A continuous incrementing counter is indicative of a single bit in memory hard-failed or a multi-bit error. A multi-bit error will cause a GPC BITE fault summary message (ref. SSID: BFS-04) when the GPC accesses that memory location. There are separate SECs for lower core (0-128K) and upper core (128-256K) memory. Since all of BFS operating software and data is contained in lower core memory, upper core memory anomalies are not a constraint to launch. Features of BFS that can cause the SEC to be reset are GPC Initial Program Load (IPL), GPC power cycle, store protect interrupt processing, a HALT-STBY transition (System Reset) and certain Machine Check interrupts.

f. Preplanned Contingency Procedure - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(4) Launching with a GPC that may have some part(s) of memory that has failed, thus the GPC is more susceptible to failure due to natural radiation induced memory alterations. Launching with a GPC that has a multi-bit error will cause a GPC BITE when the GPC accesses that memory location.

CAUSES OF EXCEEDING REDLINE:

(5) GPC hardware failure.
(6) Radiation causing single event upset (SEU).

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: BFS

LCC VIOLATION CALL: BFS I/O Error PCM Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
FSM	Fault Summary Message I/O ERROR PCM	(2)	NA	NA	CI	

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For APU Start (T-5 minutes)

REQUIREMENTS: FIGURES/TABLES: Figure 35-03

(2) Any error must be evaluated. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Reference Figure 35-03, BFS I/O Error PCM Recovery Flow Diagram, for a preplanned contingency procedure.

NOTES:

(4) I/O ERROR PCM fault summary message annunciated on the Backup Flight System (BFS) CRT upon detection of the second consecutive I/O error for the same element (OI MDM data).
(5) Fault message could be the only indication of a Pulse Code Modulation Master Unit (PCMMU) I/O buffer, PCMMU Multiplexer Interface Adapter (MIA) transmitter or General Purpose Computer (GPC) MIA receiver problem. Other PCMMU faults are covered in INS-01 and BFS-08.
(6) BFS I/O error would be logged (Error Code 51-58).

REDLINE DERIVATION: CRITICALITY: 1R

(7) a. SSID Intent Summary - The purpose of this requirement is to protect against the potential loss of Operational Instrumentation (OI) or Payload Data Interleaver (PDI) data to the Backup Flight System (BFS). This is accomplished by monitoring BFS fault summary messages for the occurrence of an I/O Error PCM fault message. OI/PDI data is acquired by the BFS via PCMMU Random Access Memory (RAM) reads, and used for Systems Management (SM) Fault Detection and Annunciation (FDA) and crew displays.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - The minimum redline limit of no occurrence insures that BFS has not detected any problem with the GPC/PCMMU interface. Occurrence of an error signifies a potential loss of OI/PDI data to the BFS. There is no maximum redline limit.

d. Time Period - Detection of a BFS I/O ERROR PCM fault summary message is possible at any time BFS is active. The data acquired by this process is

REDLINE DERIVATION: (Continued)

highly desirable, but not flight critical. Therefore, the time period extends from the start of ET Cryo Tanking (T-6 hours) until commit for flight at APU Start (T-5 minutes).

e. Requirements - PCMMU data RAM is divided up according to the data source for that area of RAM (i.e. PDI, OA01, OA02, OA03, OF01, OF02, OF03 OF04). BFS PDI data reads are mission-dependent. BFS reads each OI MDM RAM area once per major cycle (every 960 milliseconds) in all OPS. The data received is used to perform the required processing for each parameter as defined (e.g. scaling, display, fault detection and annunciation). The "I/O ERROR PCM" fault summary message will be annunciated on the second consecutive I/O error detected for the same OI MDM element (OI MDM data read from PCMMU RAM). The fault message could be the only indication of a PCMMU I/O buffer, PCMMU MIA transmitter or GPC MIA receiver problem. A BFS I/O error code 51-58 would also be logged. Loss of a BFS GPC MIA transmitter, PCMMU MIA receiver, or the IP5 bus would result in a loss of BFS downlist, which would violate SSID BFS-08.

f. Preplanned Contingency Procedure - The intent of the Preplanned Contingency Procedure is to verify functionality has not been affected for transient errors, and to attempt to restore functionality by switching to the alternate PCMMU for hard failures. Occurrences that also violate related LCCs (ref. SSID: BFS-08 and INS-01) will be dispositioned per those higher priority LCCs. Hard failures are determined by examining the BFS SM SYS SUMM2 display for commfault indications (over bright "M"). If there are no commfault indications and this is the first occurrence of the error, the problem is a one-time transient and is not a constraint to launch. If there are any commfaults present, or if this is not the first occurrence, this is not a transient condition, and a switch to the alternate PCMMU will be attempted to try and restore functionality. If the error condition can be cleared by switching PCMMUs, and a reload of the flight Telemetry Format Load (TFL) is completed, if required, the problem is not a constraint to launch. If a flight TFL reload is required and Primary Avionics System Software (PASS) is currently in OPS G1, a recycle to G9 will be required.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Possible loss of BFS SM and PDI data. Crew display data on BFS-Commanded CRT(s) would become static.

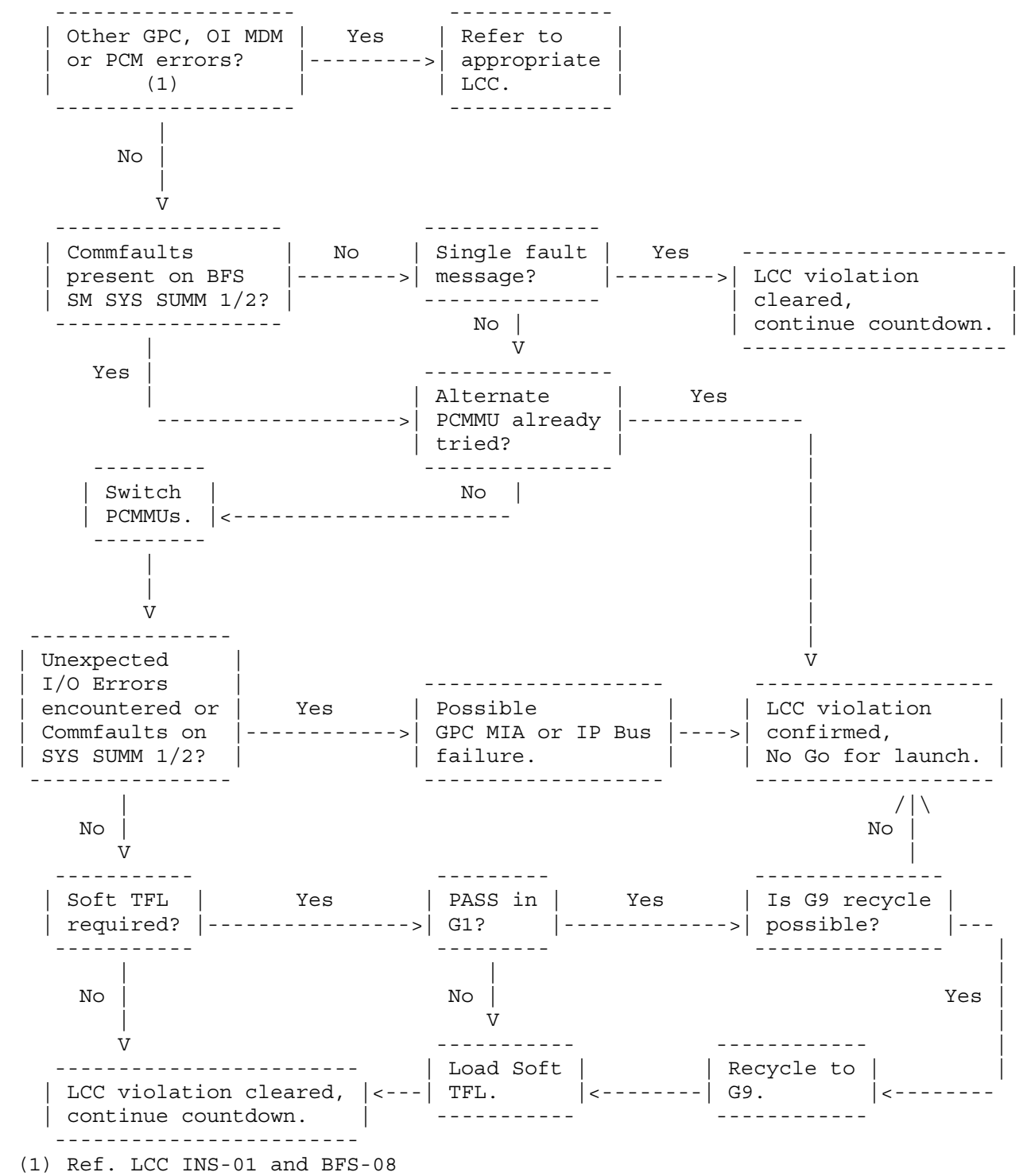
CAUSES OF EXCEEDING REDLINE:

(9) PCMMU hardware failure.
(10) Data bus anomaly.
(11) OI MDM anomaly.
(12) PDI anomaly.
(13) GPC hardware anomaly.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: BFS

SUPPORTING DATA:



(1) Ref. LCC INS-01 and BFS-08

Figure 35-03 BFS I/O Error PCM Recovery Flow Diagram

LCC VIOLATION CALL: BFS Battery Backup Unit (BBU) Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V98X2569X	GPC CHARGER BITE STATUS		0 (OFF)	NA	Event	CI
V98X2570X	GPC BATTERY BITE STATUS		0 (OFF)	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) The BBU is used to maintain GPC memory contents in the event of a loss of power to the GPC.
(3) There is no crew annunciation for violation of this redline.

REDLINE DERIVATION: CRITICALITY: 1R

(4) a. SSID Intent Summary - The intent of this LCC is to ensure that the GPC 5 BBU is capable of retaining GPC memory contents in event of a momentary power interruption to the BFS during flight. This requirement is verified by monitoring the GPC charger and battery BITE status indicators. AP-101S GPCs employ a volatile complementary metal oxide semiconductor (CMOS) main memory. This memory type requires a battery backup to maintain data integrity during periods of power loss. The BBU is designed to provide backup +5 VDC power to the CMOS main memory while GPC power is OFF. Without a properly functioning BBU, the BFS would not be capable of recovering from a power transient as documented in Backup System Services (BSS) Program Requirements Document (PRD) MG038101. A transient power interruption affecting the BFS GPC while it is engaged will result in loss of vehicle and crew if the BBU is unable to provide sufficient backup power to main memory.

b. Voting Logic - N/A

c. Redline Development - A GPC battery BITE status indicator set to ON indicates that at least one of the two 3-cell battery stacks in the GPC BBU is 3.1 volts or less when charging (i.e. while the GPC is powered ON). The BBU can maintain backup power to main memory as long as either of the two cell stacks is charged, but at a reduced amp-hour capacity. Since GPC 5 is powered ON for most of the countdown, a Battery BITE Status ON indication can most likely be attributed to a weak or failed battery cell, not a discharged battery. To completely recharge a fully discharged battery requires 48 hours of continuous GPC power. The

REDLINE DERIVATION: (Continued)

minimum redline limit of OFF ensures that both cell stacks in the BFS GPC's BBU have attained a level of charge required to exceed 3.1 VDC at the output of the cell stack.

Each of the two battery cell stacks has an associated charger circuit that will supply the stack with a charge current whenever the GPC is powered on. A GPC charger BITE status indicator set to ON indicates that at least one of the two charger circuits is unable to supply a charge current to its associated battery cell stack, either due to a charger circuit failure or an OPEN circuit in the cell stack. A failed charger would not be a constraint to flight. However, an OPEN circuit in a battery cell stack would prevent that stack from maintaining memory in the event of a power interruption to the GPC. The GPC BBU charger BITE indication does not provide insight into which of the two failures has occurred.

There is no maximum redline limit.

Loss of the BBU by itself is not a threat to the proper operation of the BFS. A loss of GPC power must also be encountered for BFS integrity to be compromised.

If a power transient were to occur that affected both PASS and BFS, such as a thunderstorm discharge (e.g., lightning strike, sprite, jet), or an anomaly affecting all three main busses, PASS would go to software halt, requiring an engage of the BFS to maintain vehicle control. An inability of the BFS BBU to retain memory would render BFS unusable, resulting in loss of crew and vehicle.

Short of encountering this single event, a combination of failures (i.e. a generic PASS software error, break-up of the PASS redundant set or any reason to engage BFS coupled with a power transient on GPC 5) would have to be encountered in order for the BBU to be required to maintain GPC memory and allow BFS to properly recover from a power transient during flight. The likelihood of encountering these factors must be considered in evaluating the risk of flight with an existing BBU BITE failure on the BFS GPC.

d. Time Period - Insight into the GPC charger and battery BITE status discrete is possible whenever the BFS GPC is active (i.e. in STBY or RUN modes). The ending effectivity of T-9 minutes was chosen due to the low likelihood that the GPC 5 BBU will be required during flight to maintain BFS viability.

e. Requirements - N/A

f. Preplanned Contingency Procedure - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Inability of the BFS to recover from a power transient affecting GPC 5. This would result in a loss of vehicle control if the power transient also affected PASS (i.e., lightning strike or other anomaly affecting all main busses), or if a separate PASS problem requires engaging of the BFS.

CAUSES OF EXCEEDING REDLINE:

(6) BBU battery cell discharged or failed.
(7) BBU charger circuit anomaly.
(8) BBU battery or charger BITE circuit anomaly.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: BFS

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SECTION 36

REDUNDANT SET LAUNCH SEQUENCER

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SECTION 36: REDUNDANT SET LAUNCH SEQUENCER

SSID No.	Description/Violation Call	Page
RSLS-01	RSLS Hold/Abort	36-01.1

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LCC VIOLATION CALL: RSLS Hold/Abort | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V95X1217X	ME-1 Pad Data Path Fail	(3)	OFF	NA	Event	
V95X1218X	ME-2 Pad Data Path Fail	(3)	OFF	NA	Event	
V95X1219X	ME-3 Pad Data Path Fail	(3)	OFF	NA	Event	
V95X1194X	ME-1 Electronic Lockup Mode Flag	(4)	OFF	NA	Event	
V95X1195X	ME-2 Electronic Lockup Mode Flag	(4)	OFF	NA	Event	
V95X1196X	ME-3 Electronic Lockup Mode Flag	(4)	OFF	NA	Event	
V95X1198X	ME-1 Hydraulic Lockup Mode	(5)	OFF	NA	Event	
V95X1199X	ME-2 Hydraulic Lockup Mode	(5)	OFF	NA	Event	
V95X1200X	ME-3 Hydraulic Lockup Mode	(5)	OFF	NA	Event	
V95X1230X	ME-1 Major Component Fail	(6)	OFF	NA	Event	
V95X1231X	ME-2 Major Component Fail	(6)	OFF	NA	Event	
V95X1232X	ME-3 Major Component Fail	(6)	OFF	NA	Event	
V95X1236X	ME-1 Channel Fail	(7)	OFF	NA	Event	
V95X1237X	ME-2 Channel Fail	(7)	OFF	NA	Event	
V95X1238X	ME-3 Channel Fail	(7)	OFF	NA	Event	
V95X1190X	ME-1 Engine Limit Exceeded	(6)	OFF	NA	Event	
V95X1191X	ME-2 Engine Limit Exceeded	(6)	OFF	NA	Event	
V95X1192X	ME-3 Engine Limit Exceeded	(6)	OFF	NA	Event	
B55V1603C	L-h Voltage Ign. PIC Cap A	(8)	438	NA	Cts	
B55V1604C	L-h Voltage Ign. PIC Cap B	(8)	438	NA	Cts	
B55V2603C	R-h Voltage Ign. PIC Cap A	(8)	438	NA	Cts	
B55V2604C	R-h Voltage Ign. PIC Cap B	(8)	438	NA	Cts	
V99X8829X	LPS Countdown Hold Flag	(9)	OFF	NA	Event	
V91X2845X	FA1 Input PROM Seq. 3,10 Status (HFE)	(10) (21)	OFF	NA	Event	
V91X2846X	FA2 Input PROM Seq. 3,10 Status (HFE)	(10) (21)	OFF	NA	Event	
V91X2847X	FA3 Input PROM Seq. 3,10 Status (HFE)	(10) (21)	OFF	NA	Event	
V91X2848X	FA4 Input PROM Seq. 3,10 Status (HFE)	(10) (21)	OFF	NA	Event	
V91X2904X	FF1 MDM Return Word Bypass (HFE)	(11)	OFF	NA	Event	
V91X2905X	FF2 MDM Return Word Bypass (HFE)	(11)	OFF	NA	Event	
V91X2906X	FF3 MDM Return Word Bypass (HFE)	(11)	OFF	NA	Event	
V91X2907X	FF4 MDM Return Word Bypass (HFE)	(11)	OFF	NA	Event	
V91X2920X	FA1 MDM Return Word Bypass (HFE)	(11)	OFF	NA	Event	
V91X2921X	FA2 MDM Return Word Bypass (HFE)	(11)	OFF	NA	Event	
V91X2922X	FA3 MDM Return Word Bypass (HFE)	(11)	OFF	NA	Event	
V91X2923X	FA4 MDM Return Word Bypass (HFE)	(11)	OFF	NA	Event	
V99X8803C	LPS "Go For Auto Sequence Start"	(12)	ON	NA	Event	
V41X1811X	MPS LO2 Accum. Recirc Vlv 1 OPEN	(13)	ON	NA	Event	
V41X1821X	MPS LO2 Accum. Recirc Vlv 2 OPEN	(13)	ON	NA	Event	
V95X1182X	MPS E-1 Engine Ready Ind	(14)	ON	NA	Event	
V95X1183X	MPS E-2 Engine Ready Ind	(14)	ON	NA	Event	
V95X1184X	MPS E-3 Engine Ready Ind	(14)	ON	NA	Event	
V41X1104X	MPS E-1 LH2 Prevalve Open A	(15)	ON	NA	Event	
V41X1106X	MPS E-1 LH2 Prevalve Open B	(15)	ON	NA	Event	
V41X1204X	MPS E-2 LH2 Prevalve Open A	(15)	ON	NA	Event	

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	(continued)					
V41X1206X	MPS E-2 LH2 Prevalve Open B	(15)	ON	NA	Event	
V41X1304X	MPS E-3 LH2 Prevalve Open A	(15)	ON	NA	Event	
V41X1306X	MPS E-3 LH2 Prevalve Open B	(15)	ON	NA	Event	
V90J8201C	Orbiter Vent Door Status Word	(16)	OFF	NA	Event	
V99X8804X	LPS "Go For Engine Start"	(17)	ON	NA	Event	
V95X1155X	MPS ME-1 Shutdown Phase	(18)	OFF	NA	Event	
V95X1156X	MPS ME-2 Shutdown Phase	(18)	OFF	NA	Event	
V95X1157X	MPS ME-3 Shutdown Phase	(18)	OFF	NA	Event	
V95X1160X	MPS E-1 Post-Shutdown Phase	(18)	OFF	NA	Event	
V95X1161X	MPS E-2 Post-Shutdown Phase	(18)	OFF	NA	Event	
V95X1162X	MPS E-3 Post-Shutdown Phase	(18)	OFF	NA	Event	
V95U1186X	MPS Engine 1 Percent Ch Press	(19)	90	NA	Pct	
V95U1187X	MPS Engine 2 Percent Ch Press	(19)	90	NA	Pct	
V95U1188X	MPS Engine 3 Percent Ch Press	(19)	90	NA	Pct	
V79X1170X	MPS Engine 1 P Actr A Fail	(20)	OFF	NA	Event	
V79X1171X	MPS Engine 1 Y Actr A Fail	(20)	OFF	NA	Event	
V79X1173X	MPS Engine 1 P Actr B Fail	(20)	OFF	NA	Event	
V79X1174X	MPS Engine 1 Y Actr B Fail	(20)	OFF	NA	Event	
V79X1176X	MPS Engine 1 P Actr C Fail	(20)	OFF	NA	Event	
V79X1177X	MPS Engine 1 Y Actr C Fail	(20)	OFF	NA	Event	
V79X1178X	MPS Engine 1 P Actr D Fail	(20)	OFF	NA	Event	
V79X1179X	MPS Engine 1 Y Actr D Fail	(20)	OFF	NA	Event	
V79X1270X	MPS Engine 2 P Actr A Fail	(20)	OFF	NA	Event	
V79X1271X	MPS Engine 2 Y Actr A Fail	(20)	OFF	NA	Event	
V79X1273X	MPS Engine 2 P Actr B Fail	(20)	OFF	NA	Event	
V79X1274X	MPS Engine 2 Y Actr B Fail	(20)	OFF	NA	Event	
V79X1276X	MPS Engine 2 P Actr C Fail	(20)	OFF	NA	Event	
V79X1277X	MPS Engine 2 Y Actr C Fail	(20)	OFF	NA	Event	
V79X1278X	MPS Engine 2 P Actr D Fail	(20)	OFF	NA	Event	
V79X1279X	MPS Engine 2 Y Actr D Fail	(20)	OFF	NA	Event	
V79X1370X	MPS Engine 3 P Actr A Fail	(20)	OFF	NA	Event	
V79X1371X	MPS Engine 3 Y Actr A Fail	(20)	OFF	NA	Event	
V79X1373X	MPS Engine 3 P Actr B Fail	(20)	OFF	NA	Event	
V79X1374X	MPS Engine 3 Y Actr B Fail	(20)	OFF	NA	Event	
V79X1376X	MPS Engine 3 P Actr C Fail	(20)	OFF	NA	Event	
V79X1377X	MPS Engine 3 Y Actr C Fail	(20)	OFF	NA	Event	
V79X1378X	MPS Engine 3 P Actr D Fail	(20)	OFF	NA	Event	
V79X1379X	MPS Engine 3 Y Actr D Fail	(20)	OFF	NA	Event	
V41X1580X	MPS LO2 Ovbd B/V (PV19) CL Ind A	(22)	ON	NA	Event	
V41X1581X	MPS LO2 Ovbd B/V (PV19) CL Ind B	(22)	ON	NA	Event	

TIME PERIOD:

(1) From Ops 1 Transition to SRB Ignition

REQUIREMENTS: FIGURES/TABLES:

(2) These items are automatic Redundant Set Launch Countdown redlines.

REQUIREMENTS: (Continued)

(3) Verifies that the two data paths from the ME Controller have not been lost. Also verifies that all GPCs are functional. Source of measurement is SSME SOP. Class 3 alarm (SM alert) CRT message and amber ME status light initiated. Monitoring starts at T-19 minutes.
(4) Verifies no engine in electronic hold (i.e., propellant valve actuators electronically maintained in positions existing at time of second Pc or fuel flow-rate sensor failure). Monitoring starts at T-19 minutes.
(5) Verifies no engine in hydraulic lockup mode. Monitoring starts at T-19 minutes.
(6) Monitoring starts at T-19 minutes.
(7) Verifies that all three EIU to ME command channels are functional. Monitoring starts at T-19 minutes.
(8) Ref SRB LCC. Monitoring starts at T-15 seconds. 438 cts converts to 35.7 Vdc.
(9) Verifies that no LPS countdown hold flag set. Monitoring starts at T-19 minutes.
(10) Various FA1-4 PROM SEQ 3,10 commfault checks are performed between T-15 seconds and T-0 seconds.
(11) Verifies that all flight critical MDMs are functional (Ref. DPS LCC). Monitoring starts at T-15 seconds.
(12) Ground command initiating RSLS start (onboard GPC software initiates its countdown sequencing operations in parallel with the GLS). Monitoring starts at T-28 seconds.
(13) Verifies valves indicate Open or the LPS Bypass is set. One time check at T-9.5 seconds. Fault indication for two cycles results in a RSLS Hold.
(14) Verifies "Engine Ready" (see SSME LCC for "Engine-Ready" parameters monitored by SSMEC for issuance of Engine Ready). One time check at T-9.5 seconds; continuous monitoring from T-7 seconds until engine start.
(15) 1 of 2 open indicators required ON per LH2 prevalve and not commfaulted by GPC to verify LH2 prevalve is in OPEN position. Monitoring starts at T-7 seconds and ends at engine start.
(16) Verifies 1 of 2 vent door position indicators by checking vent door status word to verify LPS override commands not been set. Monitoring starts at T-7 seconds, and ends at engine start.
(17) Verifies no LPS hold in effect. Monitoring starts at T-7 seconds.
(18) Senses whether engine is in shutdown or post-shutdown phase. Monitoring begins at engine start.
(19) Confirms that all engines have achieved 90% thrust level within 4.6 seconds after ME-3 ignition. Violation on any engine will result in an abort (Ref. V97U9714C for engine percent chamber pressure for GO). Monitored between ME-3 ignition and ME-3 ignition plus 4.6 seconds.
(20) Confirms that no failures in ATVC 1, 2, 3, or 4 for engine 1, 2, 3 have occurred. Monitoring starts at all engine thrust = 90%.
(21) Fault indication for two consecutive cycles of the RSLS required for holding the count; the exception is between T-7 seconds and engine start where RSLS will hold count for single commfault during prevalve checks.
(22) 1 of 2 measurements required ON and not commfaulted by GPC (Ref. V91X2846X and V91X2847X) from T-7 seconds to SSME start to verify proper valve position. Two consecutive cycles of both position indicators OFF or commfaulted will initiate a RSLS countdown hold.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

REDLINE DERIVATION: CRITICALITY: 1R

(23) Exceedance of the specified redline values results in the issuance of a Redundant Set Countdown Hold/Abort flag (in OPS 101). Issuance of Countdown Hold/Abort flag will result in a LPS Hold/Recycle of the RSLS and a GLS Hold/Breakout Safing.

CONSEQUENCES OF EXCEEDING REDLINE:

(24) Termination of launch countdown or recycle to GLS Start.

CAUSES OF EXCEEDING REDLINE:

(25) Hardware/software anomalies/failures.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SSV SUBSYSTEM: RSLS

SECTION 37

PAYLOADS

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SECTION 37: PAYLOADS

SSID No.	Description/Violation Call	Page
PAY-01	Payload Latch Anomaly	37a-01.1
PAY-02	Payload Auxiliary RPC Anomaly (REQUIREMENT DELETED)	37a-02.1
PAY-03	Payload Aft Main B/C Critical Power Anomaly (REQUIREMENT DELETED)	37a-03.1
ROEU-01	ROEU ODA Latch Anomaly	37b-01.1
ROEU-02	ROEU Relax Anomaly	37b-02.1
ROEU-03	ROEU Stow Anomaly	37b-03.1
SH-01	Spacehab ARS(Cabin) Fan Anomaly	37c-01.1
SH-02	Spacehab Emergency Bus Voltage Anomaly	37c-02.1
SH-03	Spacehab Smoke/Fire Anomaly	37c-03.1
SH-04	Spacehab DMU Interface/Power Failure	37c-04.1
SH-05	Spacehab FSS (FSCU) Arm Indication (REQUIREMENT DELETED)	37c-05.1
SH-06	Spacehab Main Power Anomaly	37c-06.1
SH-07	Spacehab Individual Halon Bottle Discharge Indication	37c-07.1
SH-08	Spacehab Cabin (ARS) HX Flow Rate (low) Anomaly	37c-08.1
SH-09	Spacehab Water Pump Accumulator Quantity (high/low) Anomaly	37c-09.1
SH-10	Spacehab Water Pump Inlet Pressure (high/low) Anomaly	37c-10.1
SH-11	Spacehab Water Pump Outlet Pressure (high/low) Anomaly	37c-11.1
SH-12	Payload Aft Main B Power Anomaly	37c-12.1

SECTION 37: PAYLOADS (CONTINUED)

SSID No.	Description/Violation Call	Page
SH-FG05	Figure 37-05 PDU Relay Payload Commanding Requirements (REQUIREMENT DELETED)	37c-FG05.1

LCC VIOLATION CALL: Payload Latch Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V54X8113E	PLD Sel 1 Latch 1A Latched Ind	(2)	ON	NA	Event	CI
V54X8114E	PLD Sel 1 Latch 1B Latched Ind	(2)	ON	NA	Event	CI
V54X8111E	PLD Sel 1 Latch 1A Released Ind	(3)	OFF	NA	Event	CI
V54X8112E	PLD Sel 1 Latch 1B Released Ind	(3)	OFF	NA	Event	CI
V54X8123E	PLD Sel 1 Latch 2A Latched Ind	(2)	ON	NA	Event	CI
V54X8124E	PLD Sel 1 Latch 2B Latched Ind	(2)	ON	NA	Event	CI
V54X8121E	PLD Sel 1 Latch 2A Released Ind	(3)	OFF	NA	Event	CI
V54X8122E	PLD Sel 1 Latch 2B Released Ind	(3)	OFF	NA	Event	CI
V54X8133E	PLD Sel 1 Latch 3A Latched Ind	(2)	ON	NA	Event	CI
V54X8134E	PLD Sel 1 Latch 3B Latched Ind	(2)	ON	NA	Event	CI
V54X8131E	PLD Sel 1 Latch 3A Released Ind	(3)	OFF	NA	Event	CI
V54X8132E	PLD Sel 1 Latch 3B Released Ind	(3)	OFF	NA	Event	CI
V54X8143E	PLD Sel 1 Latch 4A Latched Ind	(2)	ON	NA	Event	CI
V54X8144E	PLD Sel 1 Latch 4B Latched Ind	(2)	ON	NA	Event	CI
V54X8141E	PLD Sel 1 Latch 4A Released Ind	(3)	OFF	NA	Event	CI
V54X8142E	PLD Sel 1 Latch 4B Released Ind	(3)	OFF	NA	Event	CI
V54X8153E	PLD Sel 1 Latch 5A Latched Ind	(2)	ON	NA	Event	CI
V54X8154E	PLD Sel 1 Latch 5B Latched Ind	(2)	ON	NA	Event	CI
V54X8151E	PLD Sel 1 Latch 5A Released Ind	(3)	OFF	NA	Event	CI
V54X8152E	PLD Sel 1 Latch 5B Released Ind	(3)	OFF	NA	Event	CI
V54X8213E	PLD Sel 2 Latch 1A Latched Ind	(2)	ON	NA	Event	CI
V54X8214E	PLD Sel 2 Latch 1B Latched Ind	(2)	ON	NA	Event	CI
V54X8211E	PLD Sel 2 Latch 1A Released Ind	(3,4)	OFF	NA	Event	CI
V54X8212E	PLD Sel 2 Latch 1B Released Ind	(3,4)	OFF	NA	Event	CI
V54X8223E	PLD Sel 2 Latch 2A Latched Ind	(2,4)	ON	NA	Event	CI
V54X8224E	PLD Sel 2 Latch 2B Latched Ind	(2,4)	ON	NA	Event	CI
V54X8221E	PLD Sel 2 Latch 2A Released Ind	(3,4)	OFF	NA	Event	CI
V54X8222E	PLD Sel 2 Latch 2B Released Ind	(3,4)	OFF	NA	Event	CI
V54X8233E	PLD Sel 2 Latch 3A Latched Ind	(2,4)	ON	NA	Event	CI
V54X8234E	PLD Sel 2 Latch 3B Latched Ind	(2,4)	ON	NA	Event	CI
V54X8231E	PLD Sel 2 Latch 3A Released Ind	(3,4)	OFF	NA	Event	CI
V54X8232E	PLD Sel 2 Latch 3B Released Ind	(3,4)	OFF	NA	Event	CI

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V54X8243E	PLD Sel 2 Latch 4A Latched Ind	(2)	ON	NA	Event	CI
V54X8244E	PLD Sel 2 Latch 4B Latched Ind	(2)	ON	NA	Event	CI
V54X8241E	PLD Sel 2 Latch 4A Released Ind	(3)	OFF	NA	Event	CI
V54X8242E	PLD Sel 2 Latch 4B Released Ind	(3)	OFF	NA	Event	CI
V54X8253E	PLD Sel 2 Latch 5A Latched Ind	(2)	ON	NA	Event	CI
V54X8254E	PLD Sel 2 Latch 5B Latched Ind	(2)	ON	NA	Event	CI
V54X8251E	PLD Sel 2 Latch 5A Released Ind	(3)	OFF	NA	Event	CI
V54X8252E	PLD Sel 2 Latch 5B Released Ind	(3)	OFF	NA	Event	CI
V54X8313E	PLD Sel 3 Latch 1A Latched Ind	(2)	ON	NA	Event	CI
V54X8314E	PLD Sel 3 Latch 1B Latched Ind	(2)	ON	NA	Event	CI
V54X8311E	PLD Sel 3 Latch 1A Released Ind	(3)	OFF	NA	Event	CI
V54X8312E	PLD Sel 3 Latch 1B Released Ind	(3)	OFF	NA	Event	CI
V54X8323E	PLD Sel 3 Latch 2A Latched Ind	(2)	ON	NA	Event	CI
V54X8324E	PLD Sel 3 Latch 2B Latched Ind	(2)	ON	NA	Event	CI
V54X8321E	PLD Sel 3 Latch 2A Released Ind	(3)	OFF	NA	Event	CI
V54X8322E	PLD Sel 3 Latch 2B Released Ind	(3)	OFF	NA	Event	CI
V54X8333E	PLD Sel 3 Latch 3A Latched Ind	(2)	ON	NA	Event	CI
V54X8334E	PLD Sel 3 Latch 3B Latched Ind	(2)	ON	NA	Event	CI
V54X8331E	PLD Sel 3 Latch 3A Released Ind	(3)	OFF	NA	Event	CI
V54X8332E	PLD Sel 3 Latch 3B Released Ind	(3)	OFF	NA	Event	CI
V54X8343E	PLD Sel 3 Latch 4A Latched Ind	(2)	ON	NA	Event	CI
V54X8344E	PLD Sel 3 Latch 4B Latched Ind	(2)	ON	NA	Event	CI
V54X8341E	PLD Sel 3 Latch 4A Released Ind	(3)	OFF	NA	Event	CI
V54X8342E	PLD Sel 3 Latch 4B Released Ind	(3)	OFF	NA	Event	CI
V54X8353E	PLD Sel 3 Latch 5A Latched Ind	(2)	ON	NA	Event	CI
V54X8354E	PLD Sel 3 Latch 5B Latched Ind	(2)	ON	NA	Event	CI
V54X8351E	PLD Sel 3 Latch 5A Released Ind	(3)	OFF	NA	Event	CI
V54X8352E	PLD Sel 3 Latch 5B Released Ind	(3)	OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for GLS Start (T-9 minutes). If Payload Retention Latch Assembly (PRLA)/Active Keel Actuator (AKA) Flight Rules preclude monitoring a latch(s) until T-9 minutes, the time period will end with the Pre-Ingress Switch List (T-3 hours) for the affected MSIDS.

REQUIREMENTS: FIGURES/TABLES:

(2) One of two Latched measurements per latch is acceptable for confirmed instrumentation failure. (6)
(3) One of two Released measurements per latch is acceptable for confirmed instrumentation failure. (7)
(4) Mission dependent: These MSIDs are dedicated to the Remotely Operated Electrical Umbilical (ROEU) when installed. Reference SSIDs ROEU-01, -02 and -03 for specific requirements.
(5) Mission dependent: This SSID is effective on missions with Orbiter PRLA/AKA Latch(s) installed, with required mission use and flown in the "Latched" configuration. For retrieval missions where AKA latch(s) are flown in the "Released" configuration, the associated MSID's minimum state shall be: Latched indication = OFF and Released indication = ON. Reference OMRSD File II VOL. IV and Flight Rule 10-137. (8)(9)

PREPLANNED CONTINGENCY PROCEDURE:

(6) Failure Type: Latched Indication OFF/should be ON, latch in "Latched" position.

A. If the loss of the latched indication can be attributed to a Multiplexer/Demultiplexer (MDM) failure then instrumentation failure is confirmed. LCC violation cleared, continue countdown.
B. If the loss of the latched indication can not be attributed to a MDM failure and access to aft flight deck panels available then perform the following.
   1. Verify
      - Payload (PLD) Bay Mech Power OFF
      - PLD Select switch in proper position
      - Motor Control Assembly (MCA) and PLD Retention Logic Power ON
   2. Issue Latch command with PLD Retention Latch switch (Power Drive Unit (PDU) is isolated from AC power with the PLD Bay Mechanical Power switches and PLD Bay mechanical Mid Motor Control Assembly Bus Enable Relays in the OFF position) and Monitor MCA operational status.
      a. If the MCA operational status does not invert the relay is being inhibited by a latched indication in the MCA. Connector integrity is good, dual motor function maintained and latch position verified by the other limit switch. Instrumentation failure is confirmed, LCC violation cleared, continue countdown.
      b. If the MCA operational status does invert then perform the following while monitoring AC current loads.
         - Close MCA Power Circuit Breakers (CB)
         - Verify PLD Select switch in proper position
         - Turn PLD Bay Mech Power ON
         - Issue LATCH command with PLD Retention Latch switch
         1. If the limit switch is activated, LCC violation cleared, continue countdown.
         2. If the limit switch is not activated but AC current increases on all 3 phases, connector integrity is good, dual motor function is maintained and latch position is verified by the other limit switch. Instrumentation failure is confirmed, LCC violation cleared, continue countdown.
         3. If AC current does not increase then connector integrity is

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

suspect and dual motor function is lost. LCC violation confirmed, No Go for launch.

C. If loss of the latched indication can not be attributed to a MDM failure and if access to aft flight deck panels is not available then check the corresponding Ready for Latch (R-F-L) indication.
- If R-F-L indication has remained ON, then connector integrity is confirmed and dual motor function is maintained and latch position is verified by the other limit switch. LCC violation cleared, continue countdown.

(7) Failure type: Released Indication ON/should be OFF, latch in "Latched" position.

A. If transition of released indication can be attributed to a MDM failure then instrumentation failure is confirmed. LCC violation cleared, continue countdown.

B. If transition of released indication can not be attributed to a MDM failure and access to aft flight deck panels is available then perform the following.
1. Verify
- PLD Bay Mech Power OFF
- PLD Select switch in proper position
- MCA and PLD Retention Logic Power ON
2. Issue RELEASE command with PLD Retention Latch switch (PDU is isolated from AC power by Payload Bay (PLB) Mechanical Power Switches and Payload Bay Mechanical Mid-Motor Control Assembly Bus Enable relays in the OFF position) and monitor MCA operational status.
a. If the MCA operational status inverts, the relay has activated (MCA does not see the indication on) which confirms instrumentation failure. Motor function is not lost (still have dual motor release capability), LCC violation cleared, continue countdown.
b. If the MCA operational status does not invert, the relay is being inhibited by the release indication in the MCA and dual motor release capability is lost, LCC violation confirmed, No Go for launch.

(8) Failure Type: Released Indication OFF/should be ON, latch in "Released" position.

A. If the loss of the release indication can be attributed to a MDM failure then instrumentation failure is confirmed. LCC violation cleared, continue countdown.

B. If the loss of the release indication can not be attributed to a MDM failure and access to aft flight deck panels is available then perform the following.
1. Verify
- PLD Bay Mech Power OFF
- PLD Select switch in proper position
- MCA and PLD Retention Logic Power ON
2. Issue RELEASE command with PLD Retention Latch switch (PDU is isolated from AC power by Payload Bay (PLB) Mechanical Power Switches and Payload Bay Mechanical Mid-Motor Control Assembly Bus Enable relays) and monitor MCA operational status.
a. If the MCA operational status does not invert, the relay is being

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

inhibited by a released indication in the MCA, which confirms instrumentation failure. Connector integrity is good, dual motor function maintained and latch position is verified by the other limit switch, LCC violation cleared, continue countdown.

b. If the MCA operational status does invert, then perform the following while monitoring AC current loads.
- Close MCA Power CBs
- Verify PLD Select switch in proper position
- Turn PLD Bay Mech Power ON
- Issue RELEASE command with PLD Retention Latch switch

1. If the limit switch is picked up, LCC violation cleared, continue countdown.
2. If the limit switch is not picked up but AC current increases on all 3 phases, connector integrity is good, dual motor function is maintained and latch position is verified by the other limit switch. Instrumentation failure is confirmed, LCC violation cleared, continue countdown.
3. If AC current does not increase, then connector integrity is suspect and dual motor function is lost. LCC violation confirmed, No Go for launch.

(9) Failure Type: Latched Indication ON/should be OFF, latch in "Released" position.

A. If transition of latched indication can be attributed to a MDM failure then instrumentation failure is confirmed. LCC violation cleared, continue countdown.

B. If transition of latched indication can not be attributed to a MDM failure and access to aft flight deck panels is available then perform the following.

1. Verify
- PLD Bay Mech Power OFF
- PLD Select switch in proper position
- MCA and PLD Retention Logic Power ON

2. Issue LATCH command with PLD Retention Latch switch (PDU is isolated from AC power by Payload Bay (PLB) Mechanical Power Switches and Payload Bay Mechanical Mid-Motor Control Assembly Bus Enable relays) and monitor MCA operational status.

a. If the MCA operational status inverts, the relay has activated (MCA does not see the indication on) which confirms instrumentation failure. Motor function is not lost (still have dual motor latch capability), LCC violation cleared, continue countdown.

b. If the MCA operational status does not invert, the relay is being inhibited by the latch indication and dual motor latch capability is lost, LCC violation confirmed, No Go for launch.

NOTES:

(10) PRLA System A status may be verified via talkbacks on Panel A6U. To receive the talkbacks, the Payload Select switch must be in the position assigned for the latch(es) being statused. PRLA System A is powered by Payload Mechanical power system one driving Payload retention latch(es) motor one.

NOTES: (Continued)

(11) The measurements monitored by this SSID utilize Operational Instrumentation (OI) MDMs only.
(12) Payload provided hardware/mechanisms utilizing Orbiter PRLA/AKA MSIDs, are addressed in mission specific LCC requirements when required.

REDLINE DERIVATION: CRITICALITY: 1R

(13) a. SSID Intent Summary - The intent of this LCC is to ensure that the Payload is properly restrained for launch and that the Payload Latches will adequately support the mission. This includes dual motor capability for the latch positioning.

b. Voting Logic - N/A.

c. Minimum and Maximum Redline Development - Each position indicator is either ON or OFF depending on the last commanded position. Once electrically driven to that position the expected state should remain to ensure the payload retention/configuration.

d. Time Effectivity - The Payload Latches are configured prior to launch countdown and are committed for launch prior to Go For GLS Start. The position of the Payload Select switch (panel A6U) is mission unique, determined by the "PRLA/AKA" Flight Rules and reflected in the Ascent Switch List. In the "Monitor" position, all PRLA indications are visible on console. If the Payload Select switch is taken to a select position 1,2 or 3, then only the PRLA indications configured to that select position are visible for LCC monitoring. This limitation is due to the indicator power internal wiring of panel A6U and is not software related.

e. Requirements - For each Payload Latch there are two Latched indicators and two Released indicators. One of two Latched indicators and one of two Released indicators are acceptable for confirmed instrumentation failure. Dual motor function must be confirmed unless instrumentation failure can be attributed to a MDM failure or in the case of the latched indication, the corresponding R-F-L indication is verified to ensure connector integrity.

f. Preplanned Contingency Procedures -

Failure type: Latch "Latched" Indication OFF/should be ON. Ensures that the payload retention latches are properly latched for launch and ascent. Ensures connector integrity, and therefore, dual motor capability.

Failure type: Latch "Released" Indication ON/should be OFF. Ensures that the payload retention latches are properly latched for launch and ascent. Ensures dual motor operational capability for latch releasing.

Failure type: Latch "Released" Indication OFF/should be ON. Ensures that the payload retention latches are properly released for launch and

REDLINE DERIVATION: (Continued)

ascent. Ensures connector integrity and therefore, dual motor capability.

Failure type: Latch "Latched" Indication ON/should be OFF. Ensures that the payload retention latches are properly configured for launch and ascent. Ensures dual motor operational capability for latch latching.

CONSEQUENCES OF EXCEEDING REDLINE:

(14) Failure type: Latch "Latched" Indication OFF/should be ON. Payload retention latches not properly configured for launch and during ascent could incur structural damage. A faulty indication has the potential for a demated connector at the PDU resulting in loss of motor function.
(15) Failure type: Latch "Released" Indication ON/should be OFF. Presence of a faulty release indication results in loss of dual motor capability for releasing the payload retention latch. Failure of both release indications for the same latch results in loss of release capability.
(16) Failure type: Latch "Released" Indication OFF/should be ON. May indicate that the latch is out of configuration for launch and ascent. A latch that is partially latched may inhibit trunnion from entering latch envelope and result in loss of capability to retrieve payload. A faulty indication has the potential for a demated connector at the PDU resulting in loss of motor function.
(17) Failure type: Latch "Latched" Indication ON/should be OFF. Presence of a faulty latch indication results in loss of dual motor capability for latching the latch. Failure of both latch indications results in loss of latch capability.

CAUSES OF EXCEEDING REDLINE:

(18) Failure type: Latch "Latched" Indication OFF/should be ON. Instrumentation failure or open circuit or improperly positioned latch.
(19) Failure type: Latch "Released" Indication ON/should be OFF. Instrumentation failure or short circuit.
(20) Failure type: Latch "Released" Indication OFF/should be ON. Instrumentation failure or improperly positioned latch or open circuit.
(21) Failure type: Latch "Latched" Indication ON/should be OFF. Instrumentation failure or short circuit.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 14.3 SHEET 1 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-540209 SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: MECHANISMS

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Payload Auxiliary RPC Anomaly

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Payload Aft Main B/C Critical Power Anomaly

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LCC VIOLATION CALL: ROEU ODA Latch Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	ROEU in deployed position					
V54X8231E	Pld Sel 2 Latch 3A Released Ind	1 of	OFF	NA	Event	CI
V54X8232E	Pld Sel 2 Latch 3B Released Ind	2	OFF	NA	Event	CI
V54X8233E	Pld Sel 2 Latch 3A Latched Ind	1 of	ON	NA	Event	CI
V54X8234E	Pld Sel 2 Latch 3B Latched Ind	2	ON	NA	Event	CI
	ROEU in stowed position					
V54X8231E	Pld Sel 2 Latch 3A Released Ind	1 of	ON	NA	Event	CI
V54X8232E	Pld Sel 2 Latch 3B Released Ind	2	ON	NA	Event	CI
V54X8233E	Pld Sel 2 Latch 3A Latched Ind	1 of	OFF	NA	Event	CI
V54X8234E	Pld Sel 2 Latch 3B Latched Ind	2	OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) This LCC applicable for missions with the Remotely Operated Electrical Umbilical (ROEU) installed.

PREPLANNED CONTINGENCY PROCEDURE:

(3) For indication, ON should be OFF, monitor Motor Control Assembly (MCA) Op status. When latch is commanded in direction of failed ON indication with AC power OFF, if an Op status inverts, instrumentation failure is indicated, LCC violation cleared, continue countdown. Reference S0007, Vol. 5.

(4) For indication, OFF should be ON, Monitor MCA Op status. When latch is commanded in direction of failed OFF indication with AC power OFF, if an Op status does not invert, instrumentation failure is indicated, LCC violation cleared, continue countdown. With AC power ON, when latch is commanded in direction of failed OFF indication, if latch motor current is seen to increase and the associated limit switch is picked up, single motor function is verified, LCC violation cleared, continue countdown. Reference S0007, Vol. 5.

NOTES:

(5) Talkback DS9 indicates system A status only.

(6) Panels A6U and R13L are only accessible prior to crew ingress.

(7) Measurements available in OI.

(8) Measurements V54X8233E and V54X8234E indicate latches (hooks) are latched. Measurements V54X8231E and V54X8232E indicate latches (hooks) are unlatched.

REDLINE DERIVATION: CRITICALITY:

(9) ROEU deployed at launch.
Release indication OFF ensures single motor release capability.
Latched indication ON ensures hooks are in the latched position.
(10) ROEU in stowed position.
Release indication ON ensures hooks are in the released position.
Latch indication OFF ensures single motor latch capability.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) ROEU deployed at launch.
Release indication ON, should be OFF:
Presence of a release indication inhibits MCA release logic resulting in loss of motor function. Failure of both indications would result in loss of release capability.
Latch indication OFF, should be ON:
Loss of both latch indications indicates the Orbiter Disconnect Assembly/Payload Disconnect Assembly (ODA/PDA) is not latched for launch and ascent. The ROEU could become separated from the payload and damage could occur.
(12) ROEU in stowed position at launch.
Release indication OFF, should be ON:
Loss of both release indications indicate latches are not in the release position. A latch that is partially latched may result in the loss of deploy capability.
Latch indication ON, should be OFF:
Presence of a latched indication inhibits the MCA latch logic resulting in loss of motor function. Failure of both indications would result in loss of latch capability.

CAUSES OF EXCEEDING REDLINE:

(13) Instrumentation Failure.

		MDM	Card	Ch	St Bit
V54X8231E	Pld Sel 2 Latch 3A Released Ind	OF4	12	02	06
V54X8232E	Pld Sel 2 Latch 3B Released Ind	OF1	12	01	03
V54X8233E	Pld Sel 2 Latch 3A Latched Ind	OF4	13	02	06
V54X8234E	Pld Sel 2 Latch 3B Latched Ind	OF1	14	00	06

(14) Failure type: Indication OFF, should be ON.
Instrumentation failure, open circuit or improperly positioned hooks.
(15) Failure type: Indication ON, should be OFF.
Instrumentation failure, short circuit, or improperly positioned hooks.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 14.12 SHEET 1-3 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-540xxx SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: Payload

LCC VIOLATION CALL: ROEU Relax Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V54X8211E	Pld Sel 2 Latch 1A Released Ind	1 of	ON	NA	Event	CI
V54X8212E	Pld Sel 2 Latch 1B Released Ind	2	ON	NA	Event	CI
V54X8223E	Pld Sel 2 Latch 2A Latched Ind	1 of	OFF	NA	Event	CI
V54X8224E	Pld Sel 2 Latch 2B Latched Ind	2	OFF	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) This LCC applicable for missions with the Remotely Operated Electrical Umbilical (ROEU) installed.

PREPLANNED CONTINGENCY PROCEDURE:

(3) For indication, ON should be OFF, monitor Motor Control Assembly (MCA) Op status. When commanded in direction of failed ON indication with AC power OFF, if an Op status inverts, instrumentation failure is indicated, LCC violation cleared, continue countdown. Reference S0007, Vol. 5.

(4) For indication, OFF should be ON, Monitor MCA Op status. When commanded in direction of failed OFF indication with AC power OFF, if an Op status does not invert, instrumentation failure is indicated, LCC violation cleared, continue countdown. With AC power ON, when commanded in direction of failed OFF indication, if motor current is seen to increase and the associated limit switch is picked up, single motor function is verified, LCC violation cleared, continue countdown. Reference S0007, Vol. 5.

NOTES:

(5) Talkbacks DS1 and DS8 indicate system A status only.
(6) Panels A6U and R13L are only accessible prior to crew ingress.
(7) Measurements available in OI.
(8) Measurements V54X8223E and V54X8224E indicate ROEU is in deployed position. Measurements V54X8211E and V54X8212E indicate ROEU is in relax position.

REDLINE DERIVATION: CRITICALITY:

(9) ROEU in deployed position at launch:
Ensures ROEU relax condition, no preload on Orbiter Disconnect Assembly/Payload Disconnect Assembly (ODA/PDA) interface.

(10) ROEU in stowed position at launch:
Ensures relax capability (after deploy).

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Failure type: Indication OFF, should be ON.
A) ROEU deployed:
ROEU may be under tension and damage to ODA/PDA may be incurred during launch/ascent.
B) ROEU stowed:
Loss of release (relax) indication will result in loss of motor shut off capability when driven (on orbit) to the relax position after deploy.

(12) Failure type: Indication ON, should be OFF.
Presence of a latch (deployed) indication inhibits MCA logic. Failure of both indications would result in loss of deploy capability.

CAUSES OF EXCEEDING REDLINE:

(13) Instrumentation Failure.

		MDM	Card	Ch	St Bit
V54X8211E	Pld Sel 2 Latch 1A Released Ind	OF3	12	01	11
V54X8212E	Pld Sel 2 Latch 1B Released Ind	OF2	14	02	10
V54X8223E	Pld Sel 2 Latch 2A Latched Ind	OF4	07	02	05
V54X8224E	Pld Sel 2 Latch 2B Latched Ind	OF1	04	01	04

(14) Failure type: Indication ON, should be OFF.
Instrumentation failure, short circuit or improperly positioned ROEU.

(15) Failure type: Indication OFF, should be ON.
Instrumentation failure, open circuit or improperly positioned ROEU.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 14.12 SHEET 1-3 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-540xxx SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: Payload

LCC VIOLATION CALL: ROEU Stow Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	ROEU in deployed position					
V54X8221E	Pld Sel 2 Latch 2A Released Ind	1 of	OFF	NA	Event	CI
V54X8222E	Pld Sel 2 Latch 2B Released Ind	2	OFF	NA	Event	CI
	ROEU in stowed position					
V54X8221E	Pld Sel 2 Latch 2A Released Ind	1 of	ON	NA	Event	CI
V54X8222E	Pld Sel 2 Latch 2B Released Ind	2	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) This LCC applicable for missions with the Remotely Operated Electrical Umbilical (ROEU) installed.

PREPLANNED CONTINGENCY PROCEDURE:

(3) For indication, ON should be OFF, monitor Motor Control Assembly (MCA) Op status. When commanded in direction of failed ON indication with AC power OFF, if an Op status inverts, instrumentation failure is indicated, LCC violation cleared, continue countdown. Reference S0007, Vol. 5.
(4) For indication, OFF should be ON, Monitor MCA Op status. When commanded in direction of failed OFF indication with AC power OFF, if an Op status does not invert, instrumentation failure is indicated, LCC violation cleared, continue countdown. With AC power ON, when commanded in direction of failed OFF indication, if motor current is seen to increase and the associated limit switch is picked up, single motor function is verified, LCC violation cleared, continue countdown. Reference S0007, Vol. 5.

NOTES:

(5) Talkback DS8 indicates system A status only.
(6) Panels A6U and R13L are only accessible prior to crew ingress.
(7) Measurements available in OI.
(8) Measurements V54X8221E and V54X8222E indicate ROEU is in stowed position.

REDLINE DERIVATION: CRITICALITY:

(9) Indication ON; ensures ROEU configured for launch.
(10) Indication OFF; ensures single motor stow capability.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Failure type: Indication ON, should be OFF.
Presence of a released (stowed) indication inhibits MCA release logic resulting in loss of motor function. Failure of both indications would result in loss of retract/stow capability.

(12) Failure type: Indication OFF, should be ON.
The ROEU may not be properly configured for launch/ascent and damage may be incurred.

CAUSES OF EXCEEDING REDLINE:

		MDM	Card	Ch	St Bit
(13)	Instrumentation Failure.				
V54X8221E	Pld Sel 2 Latch 2A Released Ind	OF4	05	02	08
V54X8222E	Pld Sel 2 Latch 2B Released Ind	OF1	14	00	04

(14) Failure type: Indication ON, should be OFF.
Instrumentation failure, short circuit or improperly positioned ROEU.

(15) Failure type: Indication OFF, should be ON.
Instrumentation failure, open circuit or improperly positioned ROEU.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO 14.12 SHEET 1-3 ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO VS70-540xxx SHEET ZONE

ELEMENT: Orbiter SUBSYSTEM: Payload

LCC VIOLATION CALL: Spacehab ARS(Cabin) Fan Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
P47P2001A	ARS Fan Delta Pressure 1	1 of	1.3	5.2	inH2O	CI
P47P2002A	ARS Fan Delta Pressure 2	2 (4)	1.3	5.2	inH2O	CI
	OR					
P47P2006A	Cabin Fan Delta Pressure 1	1 of	0.5	5.2	inH2O	CI
P47P2007A	Cabin Fan Delta Pressure 2	2 (4)	0.5	5.2	inH2O	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES: Figure 37-02

(2) This LCC is effective only for Spacehab (SH) (except RDM) flights in which the module subsystems are powered during the LCC time period.
(3) 1 of 2 functional fans required for launch. (4)

PREPLANNED CONTINGENCY PROCEDURE:

(4) Perform SH Atmospheric Revitalization System (ARS) (Cabin) Fan Anomaly Contingency Procedure per Figure 37-02, Go/No Go conclusions are provided in the flowchart.

NOTES:

(5) Only 1 fan (ARS fan or Cabin fan) active during LCC timeframe. Either fan may be used. Standard configuration is ARS fan active.
(6) Payload Safety LCC.
(7) Commanding of fans via Launch Processing System (LPS) not available after T-20 minutes and counting.
(8) If required, Mission Control Center (MCC) can uplink fan commands after T-18 minutes (BFS to RUN).
(9) This LCC will be monitored by NASA/KSC.
(10) Configuration 1 is defined as a SH single module with Tunnel Adapter and Transition Section. Configuration 2 is defined as a SH single module with Orbiter Docking System (ODS) and long tunnel. Configuration 3 is defined as a SH double module with ODS and long tunnel. Configuration 4 is defined as a SH single module with International Space Station Assembly (ISSA) tunnel adapter, external airlock, and long tunnel excluding the SH Transfer Tunnel (STT) extension. Configuration 5 is the same as Configuration 4 except with SH double module. Configuration 6 is defined as a SH single module with ISSA tunnel adapter external airlock and short SH tunnel.

REDLINE DERIVATION: CRITICALITY: 1R

(11) a. SSID Intent Summary - This instrumentation is used to verify the health of the fan providing air circulation within the SH Module for smoke

REDLINE DERIVATION: (Continued)

detection and cooling. Smoke detection is considered a safety critical function. Redundant instrumentation is provided to monitor the fan performance.

b. Voting Logic - A single measurement out of limit for the operational fan is considered instrumentation failure. Both measurements out of limit is required for action to be taken.

c. Minimum and Maximum Redline Development - Nominal flowrate during prelaunch/ascent configuration is 260-280 SCFM. ARS fan nominally powered during prelaunch/ascent.

- Minimum of 1.3 in. H2O for ARS fan delta pressure (0.5 for Cabin fan) corresponds to approximately 210-230 SCFM airflow with ARS (Cabin) fan filter partially clogged.

- Maximum of 5.2 in. H2O for ARS (Cabin) fan delta pressure corresponds to approximately 160 SCFM airflow with blockage in air loop. This value represents the fan instability point as taken from fan qualification test data.

d. Time Period - Ending time effectivity of T-31 seconds was chosen based on the fact that smoke detection is considered safety critical.

e. Requirements - Either the ARS or the Cabin Fan is required to provide airflow for smoke detection and cooling whenever the SH Module is powered. ARS is the nominal fan for airflow during the pre-launch timeframe but in case of ARS fan failure the Cabin Fan provides equivalent airflow for smoke detection and cooling.

f. Preplanned Contingency Procedures - These procedures determine if out of limit fan delta pressure readings are the result of power source problem or main power kill. If not, then switch to the alternate fan is performed. If performance of alternate fan is within limits then launch countdown can continue. For fan power source problem then SH is No Go for Launch since both fans use the same power source. For a main power kill, recovery is attempted using SH-06 preplanned procedures.

CONSEQUENCES OF EXCEEDING REDLINE:

(12) ARS (Cabin) Fan Delta Pressure - Minimum or Maximum: Reduced fire/smoke detection in SH.
(13) Reduced heat rejection for experiments and subsystems in SH.

CAUSES OF EXCEEDING REDLINE:

(14) Low Delta P:
- Power Distribution Unit (PDU) relay failure (open).
- PDU fuse failure.
- Fan internal problem.
- Fan filter blockage.
- SH inverter failure.
- Loss of SH Main Power.

CAUSES OF EXCEEDING REDLINE: (Continued)

(15) High Delta P: - Inlet air muffler blockage.
- Ascent/Descent inlet stub screen blockage (Config. 1).
- Ventbox Air Inlet Fitting screen blockage (Config. 2 & 3).
- ARS duct inlet screen blockage (Config. 4, 5, & 6).
- Floor debris screen blockage.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	in.H2O								
P47P2001A	0.028	0.0	7.14			0.2	5.5		
P47P2002A	0.028	0.0	7.14			0.2	5.5		
P47P2006A	0.028	0.0	7.14						
P47P2007A	0.028	0.0	7.14						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Spacehab SUBSYSTEM: ECS

SUPPORTING DATA:

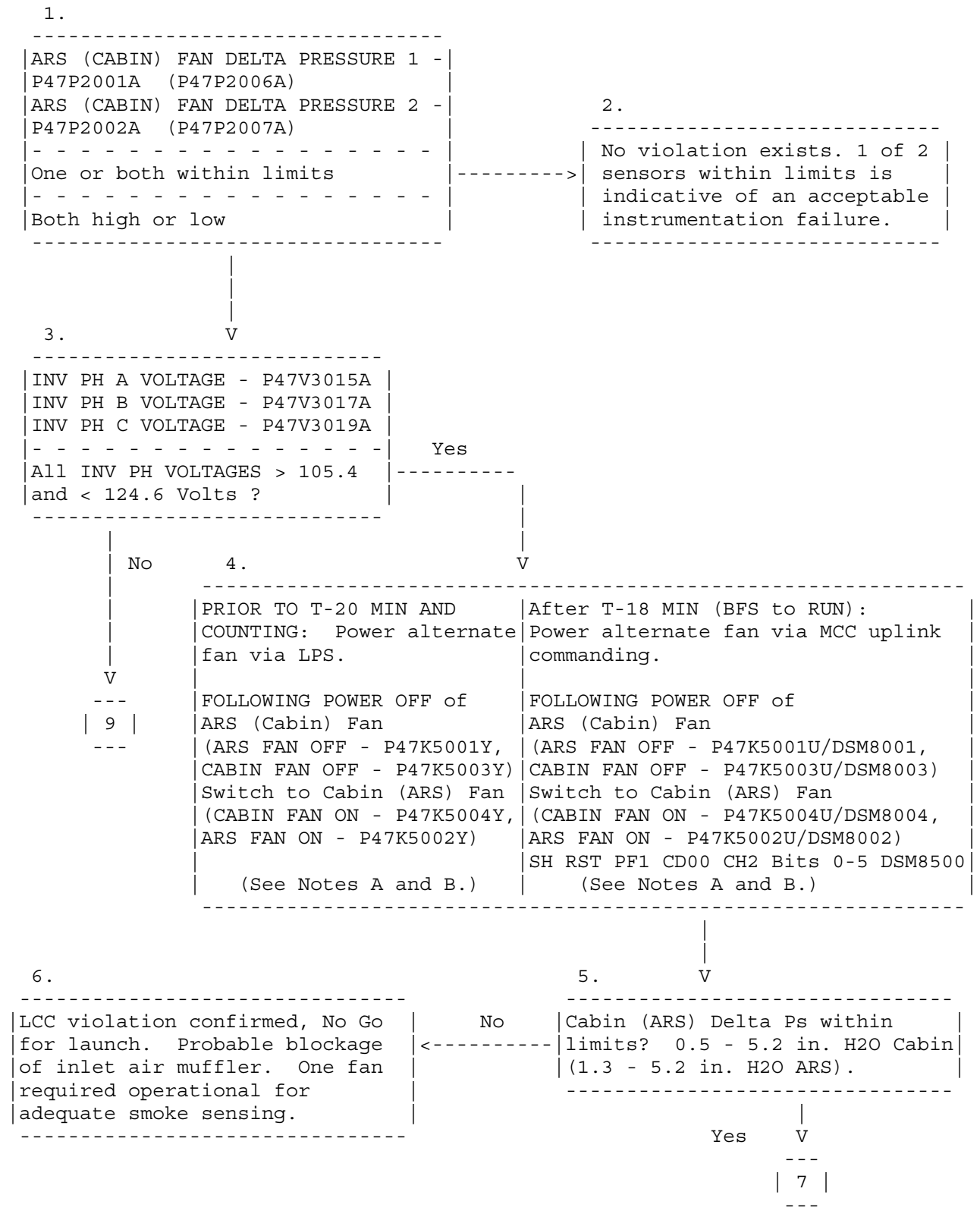


Figure 37-02, SH ARS (Cabin) Fan Anomaly Contingency Procedure

SUPPORTING DATA: (Continued)

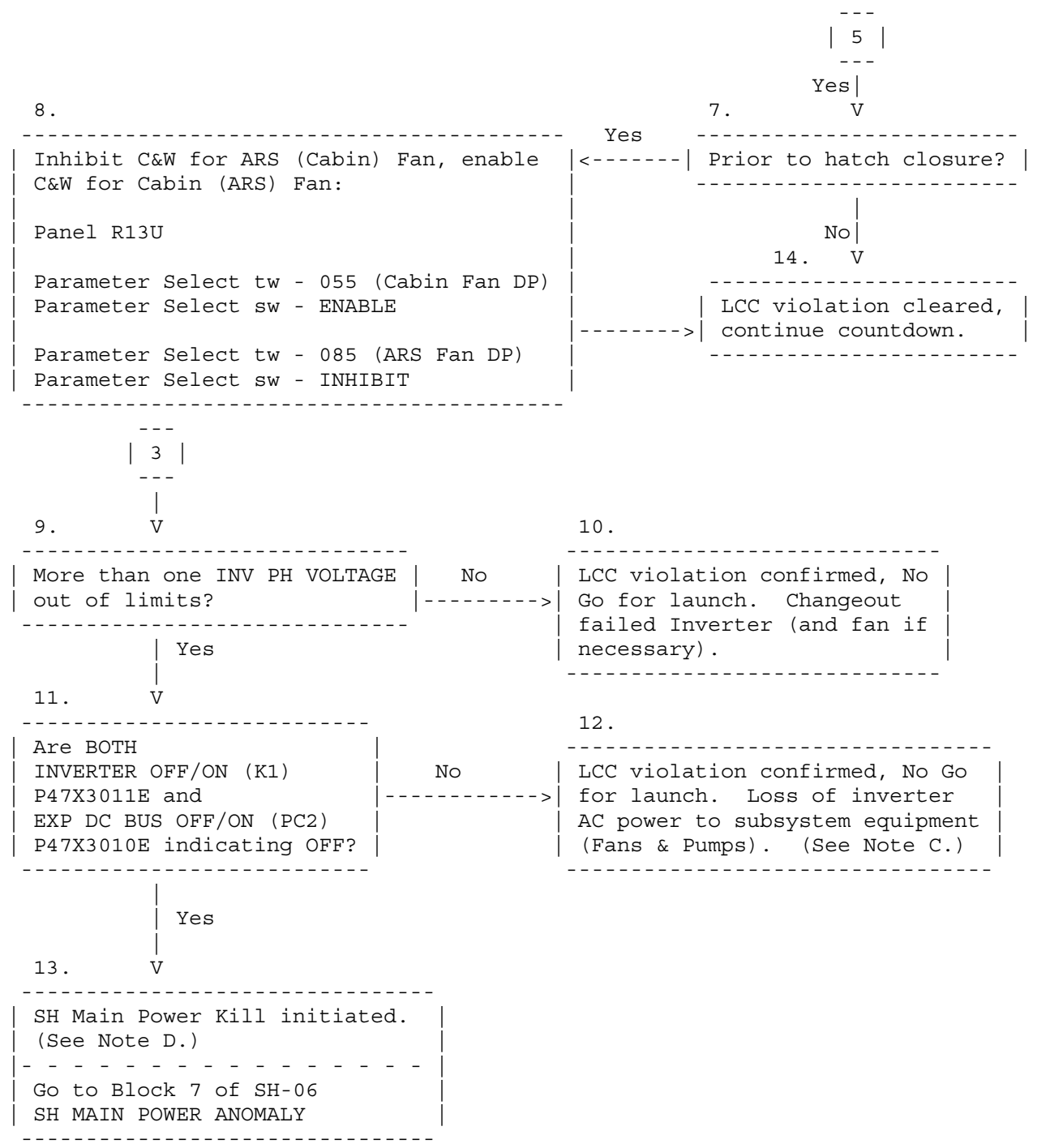


Figure 37-02, SH ARS (Cabin) Fan Anomaly Contingency Procedure (Continued)

SUPPORTING DATA: (Concluded)

NOTES:

A. Commanding of fans via LPS is not available after T-20 min. and counting. No commanding is available between T-20 and T-18 min. (OPS 101 Transition). Commanding after T-18 min. available via MCC uplink commands.

B. Possible failure of following: ARS(Cabin)

LOW Delta P
- PDU relays K22(K23) and/or K30(K31) - (open).
- PDU fuses F4(F7), F5(F8), or F6(F9).
- ARS(Cabin) fan internal problem.
- Fan filter blockage.

HIGH Delta P
- Inlet air muffler blockage.
- Ascent/Descent inlet stub screen blockage (Config. 1).
- Ventbox air inlet fitting screen blockage (Config. 2 and 3).
- ARS duct inlet screen blockage (Config. 4, 5, & 6).
- Floor debris screen blockage.

C. Possible loss of Inverter Master Sync, Phase A Inverter Overvoltage shutdown, PDU K1 relay failure, or PDU F94 fuse failure (feeds Inverter Phase A). K1 relay failure can be determined by checking INV DC BUS CURRENT (P47C3012A) and INV DC BUS VOLTAGE (P47V3013A) measurements. 0 volt condition for Inv Bus Voltage is 18 V, while 0 current condition for Inv Bus Current is 0 amps. F94 fuse failure, Inverter overvoltage shutdown, and Inverter Master Sync failures all give same failure signature: All inverter phase voltages out of limits (Phase A controls sync for other two inverter phases).

D. ARS Fan Delta Pressure Low Anomaly caused by SH Main power kill. SH module remains in a safe configuration following a main power kill. Smoke detection is slowed due to lack of fan air circulation.

Figure 37-02, SH ARS (Cabin) Fan Anomaly Contingency Procedure (Concluded)

LCC VIOLATION CALL: Spacehab Emergency Bus Voltage Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
P47V3001A	Emergency Bus Voltage		24.0	NA	Volts	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES: Figure 37-03

(2) This LCC is effective only for Spacehab (except RDM) flights in which the module subsystems are powered during the LCC time period.

PREPLANNED CONTINGENCY PROCEDURE:

(3) See Figure 37-03, SH Emergency Bus Voltage Anomaly Contingency Procedure.

NOTES:

(4) Spacehab Emergency Bus maximum limit (32.0 V) is protected by Orbiter LCC (SSID: EPDC-01).
(5) Payload Safety LCC.
(6) This LCC will be monitored by NASA/KSC.

REDLINE DERIVATION: CRITICALITY:

(7) Limit represents minimum design operating voltage for equipment powered by the emergency bus.
Minimum redline: 24.0 = 24.0 + 0 + 0.
Redline = minimum design operating voltage for equipment powered by bus + negligible IR drop + negligible instrumentation error.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Possible loss of Spacehab safety critical sensors due to insufficient operating voltage.

The following safety critical hardware is powered via the Emergency Bus:

- Fire Suppression System Firing Circuits (FSCU).
- Signal Conditioning for safety critical circuits.
- Smoke Sensor A.
- ARS Fan Delta Pressure #1.
- PPCO2 #1.
- Forward Sensor Panel.
  - PPO2 #1.

CAUSES OF EXCEEDING REDLINE:

(9) Sensor failure.
FSCU Internal Bus failure.
FSCU fuse failure.

MEASUREMENT INFORMATION TABLE:

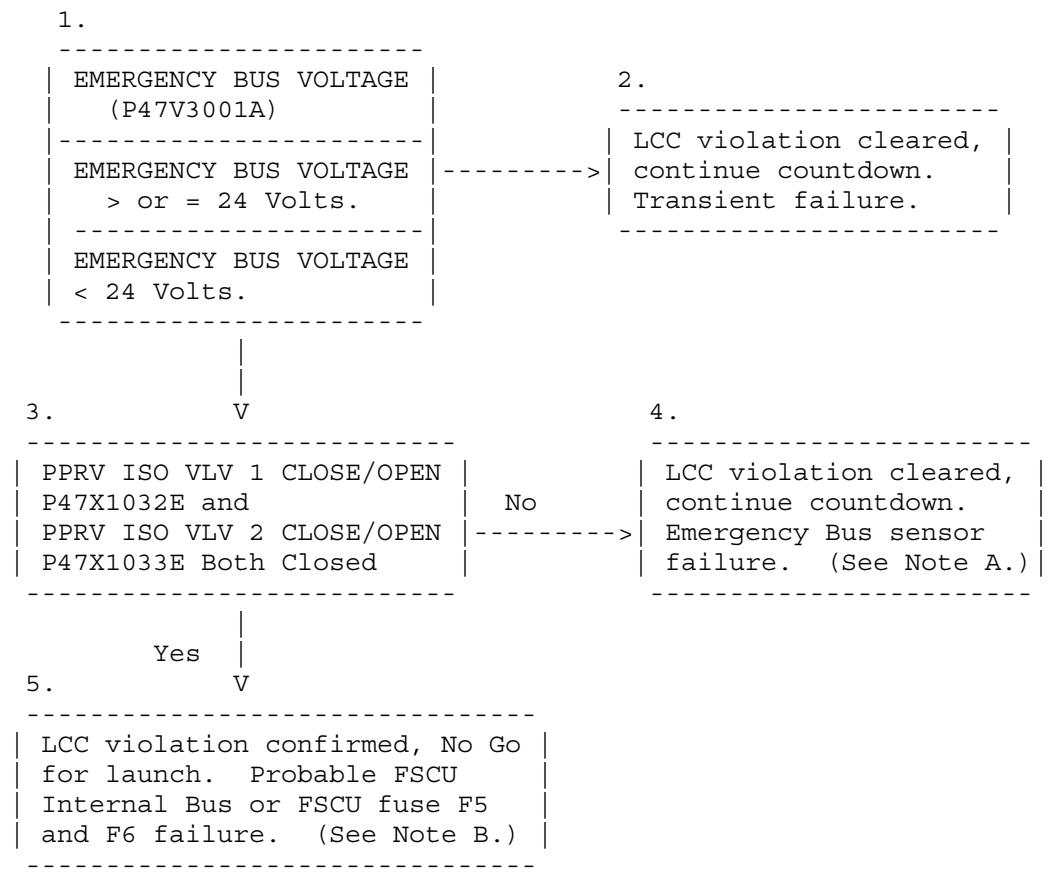
MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	Vdc								
P47V3001A	0.056	18.0	32.28					24	32

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Spacehab SUBSYSTEM: EPS

SUPPORTING DATA:



NOTES:

A. Inhibit sensor on-orbit.

B. Troubleshooting of FSCU required to determine possible failure. FSCU changeout possible within 96 hours.

Figure 37-03, SH Emergency Bus Voltage Anomaly Contingency Procedure

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LCC VIOLATION CALL: Spacehab Smoke/Fire Anomaly | EMERG COND: Yellow (10)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
P47X2017Y	Smoke Sen A Alarm	(1)	OFF	N/A	Event	CI
P47X2019Y	Smoke Sen B Alarm	(1)	OFF	N/A	Event	CI
P47X2017YV	Smoke Sen A Alarm BFS	(2)	OFF	N/A	Event	CI
P47X2019YV	Smoke Sen B Alarm BFS	(2)	OFF	N/A	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to PASS to Ops 101 (T-20 minutes)
(2) From BFS GPC to Run (approximately T-18 minutes) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES: Figure 37-04

(3) 1 of 2 sensors acceptable for confirmed instrumentation failure. (5)
(4) This LCC is effective only for Spacehab (except RDM) flights in which the module subsystems are powered during the LCC time period.

PREPLANNED CONTINGENCY PROCEDURE:

(5) See Figure 37-04, SH Smoke/Fire Anomaly Contingency Procedure.

NOTES:

(6) Payload Safety LCC.
(7) Parameters P47X2017Y and P47X2019Y are available only in format 60.
(8) This LCC will be monitored by NASA/KSC.

REDLINE DERIVATION: CRITICALITY:

(9) The "ON" event (and the C&W alarm) occurs if the rate of increase of the smoke concentration equals or exceeds 22 micrograms per cubic meter-second for 20 seconds or if the total concentration equals or exceeds 2000 micrograms per cubic meter. The redline is established to notify the crew and ground personnel of fire or smoke in the Spacehab.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Emergency condition is yellow because fire/smoke in Spacehab is a potential hazard to crew and/or pad personnel.

CAUSES OF EXCEEDING REDLINE:

(11) Failed sensor alarm.
Transient failure.
Failed smoke sensor.
Fire/smoke.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	Event								
P47X2017Y				OFF					
P47X2019Y				OFF					
P47X2017YV				OFF		OFF			
P47X2019YV				OFF		OFF			

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Spacehab SUBSYSTEM: ECS

SUPPORTING DATA:

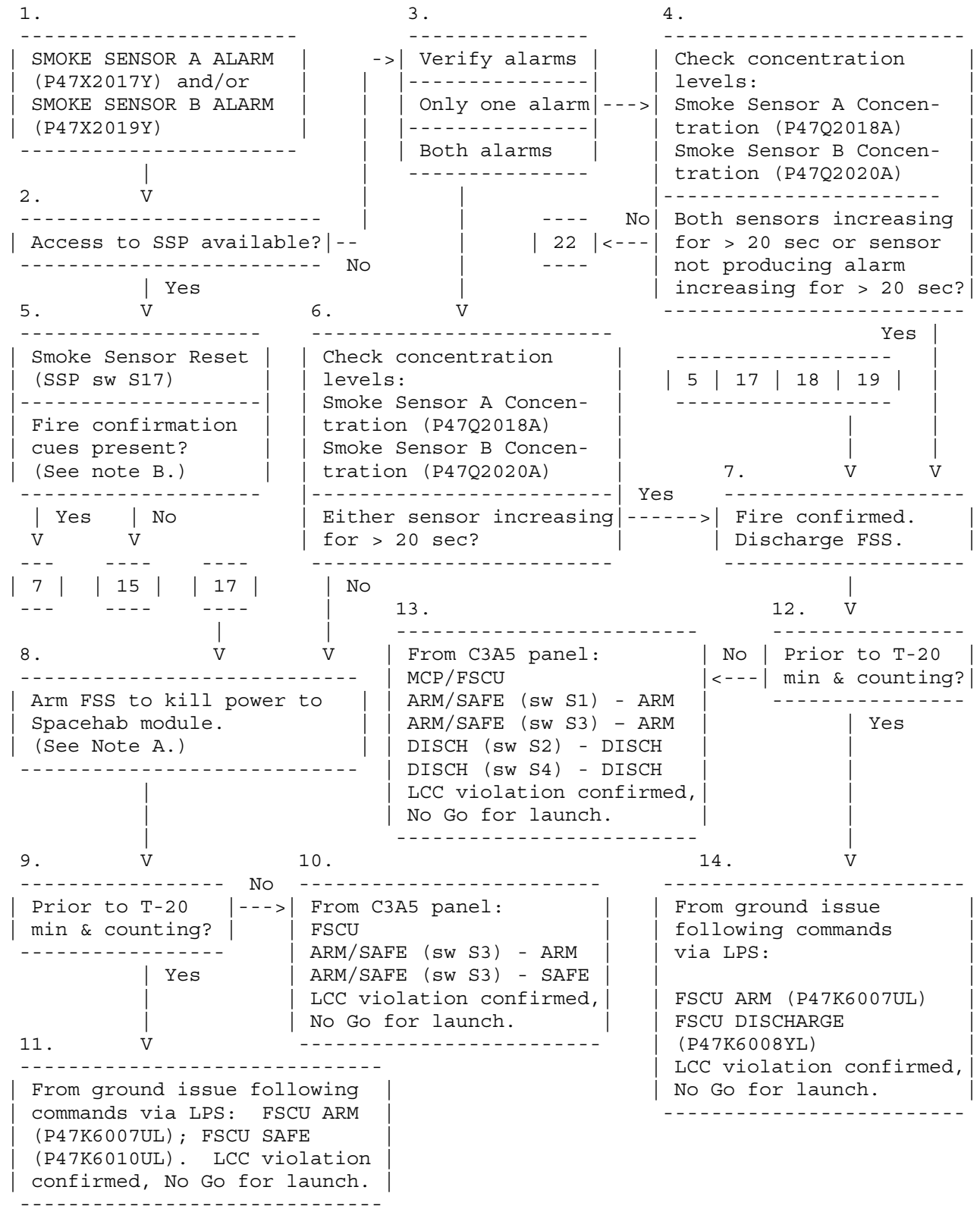

Figure 37-04, SH Smoke/Fire Anomaly Contingency Procedure

SUPPORTING DATA: (Continued)

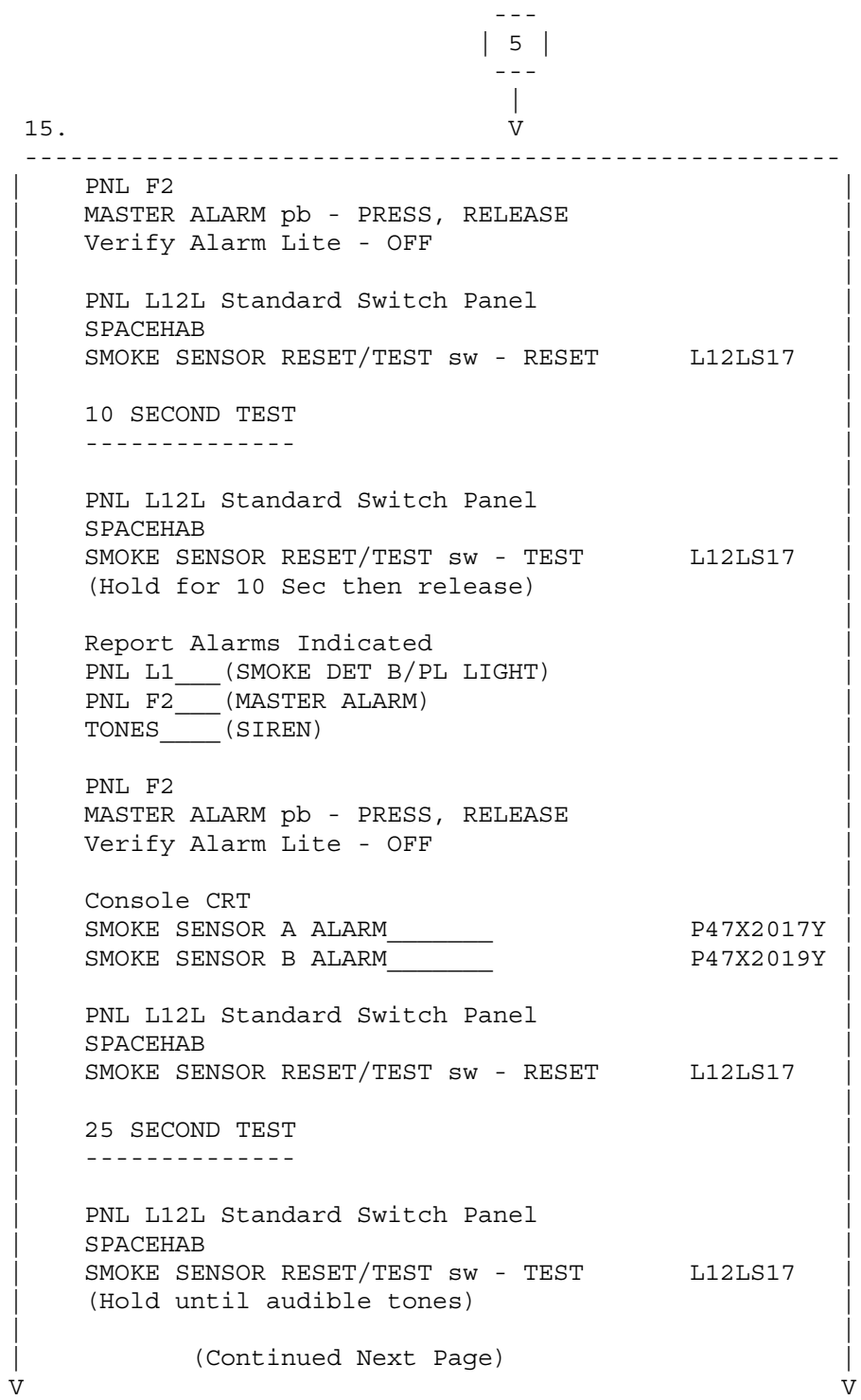

Figure 37-04, SH Smoke/Fire Anomaly Contingency Procedure (Continued)

SUPPORTING DATA: (Continued)

Figure 37-04, SH Smoke/Fire Anomaly Contingency Procedure (Continued)

SUPPORTING DATA: (Continued)

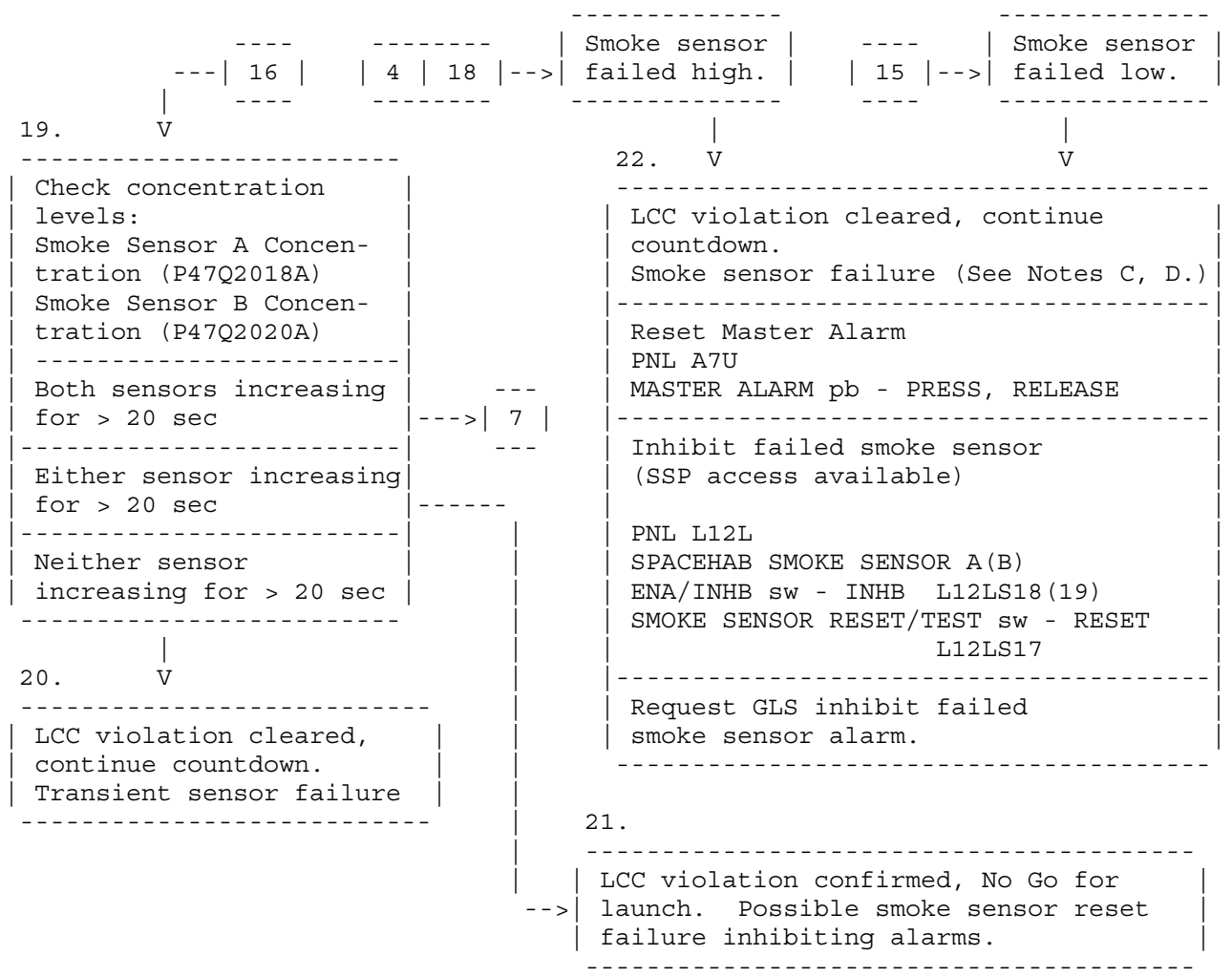

Figure 37-04, SH Smoke/Fire Anomaly Contingency Procedure (Continued)

SUPPORTING DATA: (Concluded)

NOTES:

A. FSS Discharge will only occur upon Firing Room confirmation of increasing smoke sensor concentrations (increase for > or = 20 sec). Since no increase in either smoke sensor concentration measurement was identified, main power to the module is removed (via FSS Arming), but the FSS is NOT discharged. Smoke sensors and DMU powered by Emergency Bus. Smoke sensor concentration data is provided by DMU. SH module remains in a safe configuration following Main Power Kill caused by FSS Arming. Smoke detection is slowed due to lack of fan air circulation.

B. The following are fire confirmation cues:
- Both smoke sensor alarms with increasing concentration(s) for > 20 sec.
- One sensor alarm and the other smoke sensor concentration increasing for > 20 sec.
- Both concentrations increasing for > 20 sec.

C. Inhibit failed sensor alarm if possible via SSP. Concentration data for sensor may still be valid. Any subsequent alarms should be treated as if both alarms enunciated.

D. PNL L1 SMOKE DET B/PL LIGHT will remain lit during ascent if failed smoke sensor alarm cannot be inhibited from the SSP prior to launch.

Figure 37-04, SH Smoke/Fire Anomaly Contingency Procedure (Concluded)

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LCC VIOLATION CALL: Spacehab DMU Interface/Power Failure | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V75X6409D	Master Frame Lock 3 WD1B09	1 of 2	ON	N/A	Event	CI
V75X6401D	Master Frame Lock 1 WD1B01	2	ON	N/A	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) This LCC is effective only for Spacehab (except RDM) flights in which the module subsystems are powered during the LCC time period.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) If PDI BITE word 2 (V75M6420P) = FFFF with both active Master Frame Locks = OFF(NO), probable DMU failure. If PDI BITE word 2 is other than FFFF with both Master Frame Locks = OFF(NO), probable PDI Failure (PDI required per MEL-13).
(4) During period following Ops 101 transition, ARS Fan Delta Pressure 1 (P47P2001A) is available via BFS Variable Parameter Downlist. Partial Pressure O2 2 (P47P2113VV) is available via BFS Downlist.
(5) Master Frame Lock 1 and 3 are processed simultaneously in the same TFL.
(6) Payload Mission Success LCC.
(7) This LCC will be monitored by the customer from a NASA/KSC console.

REDLINE DERIVATION: CRITICALITY:

(8) Status of both DECOM locked provides functional verification of Spacehab DMU and Orbiter PDI.
(9) DMU command capability required to nominally configure PDU relays for power to experiment and subsystem equipment not powered during the LCC timeframe. Additionally, nominal subsystem configuration cannot be achieved.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Loss of PDI/DMU Interface results in loss of subsystem/experiment data.
(11) Loss of DMU power results in inability to command via DMU.

CAUSES OF EXCEEDING REDLINE:

(12) Loss of both DECOM locked status indicates potential problem with the Orbiter PDI/Spacehab DMU interface.
- DMU/PDI failure:
  - DMU voltage converter failure.
  - Loss of power to DMU (possible causes include 3 Amp. fuse failures in FSCU (F3, F4) and DMU power supply failure).
  - DMU to PDI interface failure.
  - Orbiter PDI failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Spacehab SUBSYSTEM: CDS

Spacehab FSS (FSCU) Arm Indication

(THIS REQUIREMENT HAS BEEN DELETED)

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LCC VIOLATION CALL: Spacehab Main Power Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
P47V3013A	INV DC BUS VOLTAGE	1 of 2 (3)	24	NA	Volts	CI
P47V3008A	EXP DC BUS VOLTAGE	1 of 2 (3)	24	NA	Volts	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES: Figure 37-09

(2) This LCC is effective only for Spacehab (SH) (except RDM) flights in which the module subsystems are powered during the LCC time period.

PREPLANNED CONTINGENCY PROCEDURE:

(3) Perform SH Main Power Anomaly Contingency Procedure per Figure 37-09, Go/No Go conclusions are provided in the flowchart.

NOTES:

(4) SH Main Power maximum limit (32.0 V) is protected by Orbiter LCC (SSID: EPDC-01).
(5) Payload Mission Success LCC.
(6) This LCC will be monitored by the customer from a NASA/KSC console.

REDLINE DERIVATION: CRITICALITY: 3

(7) a. SSID Intent Summary - This instrumentation is used to verify the health of the Orbiter power feed within the SH Power Distribution Unit (PDU). Both the INV DC Bus and EXP DC Bus voltage sensors within the PDU receive power from the Orbiter Main DC feed. The SH system is safe without Orbiter Main DC power, however loss of Orbiter power to the SH PDU could result in complete loss of mission objectives.

b. Voting Logic - A single measurement out of limit is considered instrumentation failure. Both measurements out of limit is required for action to be taken.

c. Minimum and Maximum Redline Development - Limits represent minimum design operating voltages for SH equipment powered by the Main dc Bus.

Minimum redline: 24.0 = 24.0 + 0 + 0.
Redline = minimum design operating voltage for equipment powered by bus + negligible IR drop + negligible instrumentation error.

d. Time Period - Ending time effectivity of T-31 seconds was chosen based

REDLINE DERIVATION: (Continued)

on the fact that loss of Orbiter power to the SH PDU could result in complete loss of mission objectives.

e. Requirements - Unrecoverable loss of DC Main power to the PDU will result in complete loss of capability to provide power to experiments within the SH Module and DC power to subsystem equipment. If power can be recovered some loss of science may result but a majority of mission objectives may be accomplished.

f. Preplanned Contingency Procedures - These procedures determine if out of limit voltage readings are the result of Orbiter power source problem, potential SH PDU fuse failure or main power kill. For Orbiter power source problem or PDU fuse failure then SH is No Go for Launch. For a main power kill, recovery is attempted per preplanned procedures.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Possible loss of SH subsystem/experiment equipment due to insufficient operating voltage.

CAUSES OF EXCEEDING REDLINE:

(9)
- Possible Orbiter Main Bus (B or C) failure.
- Transient Failure.
- SH short blowing 150 Amp fuses on dc input to PDU.
- Multiplexer/Demultiplexer (MDM) output failed high causing Fire Suppression System (FSS) arming via Fire Suppression Control Unit(FSCU).
- Hard main power kill caused by failure of main power kill circuitry in FSCU, Monitoring and Control Panel (MCP), Standard Switch Panel (SSP) (switch), or PDU.
- Intermittent failure of main power kill circuitry in FSCU, MCP or PDU.
- Power supply ramping/transient causing main power kill.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
UNITS-->	Vdc								
P47V3013A	0.056	18.0	32.28						
P47V3008A	0.056	18.0	32.28						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Spacehab SUBSYSTEM: EPS

SUPPORTING DATA:

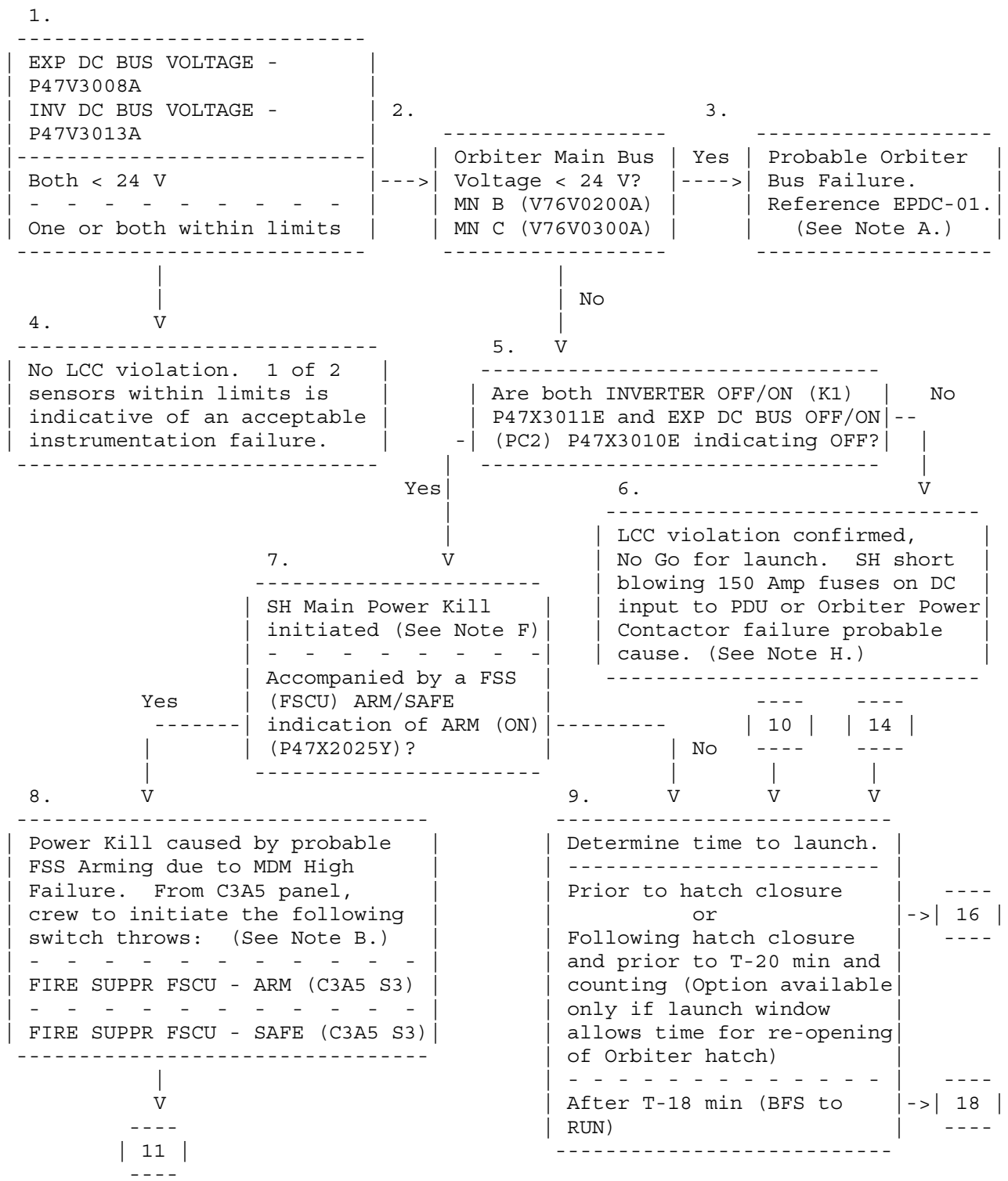


Figure 37-09, SH Main Power Anomaly Contingency Procedure

SUPPORTING DATA: (Continued)

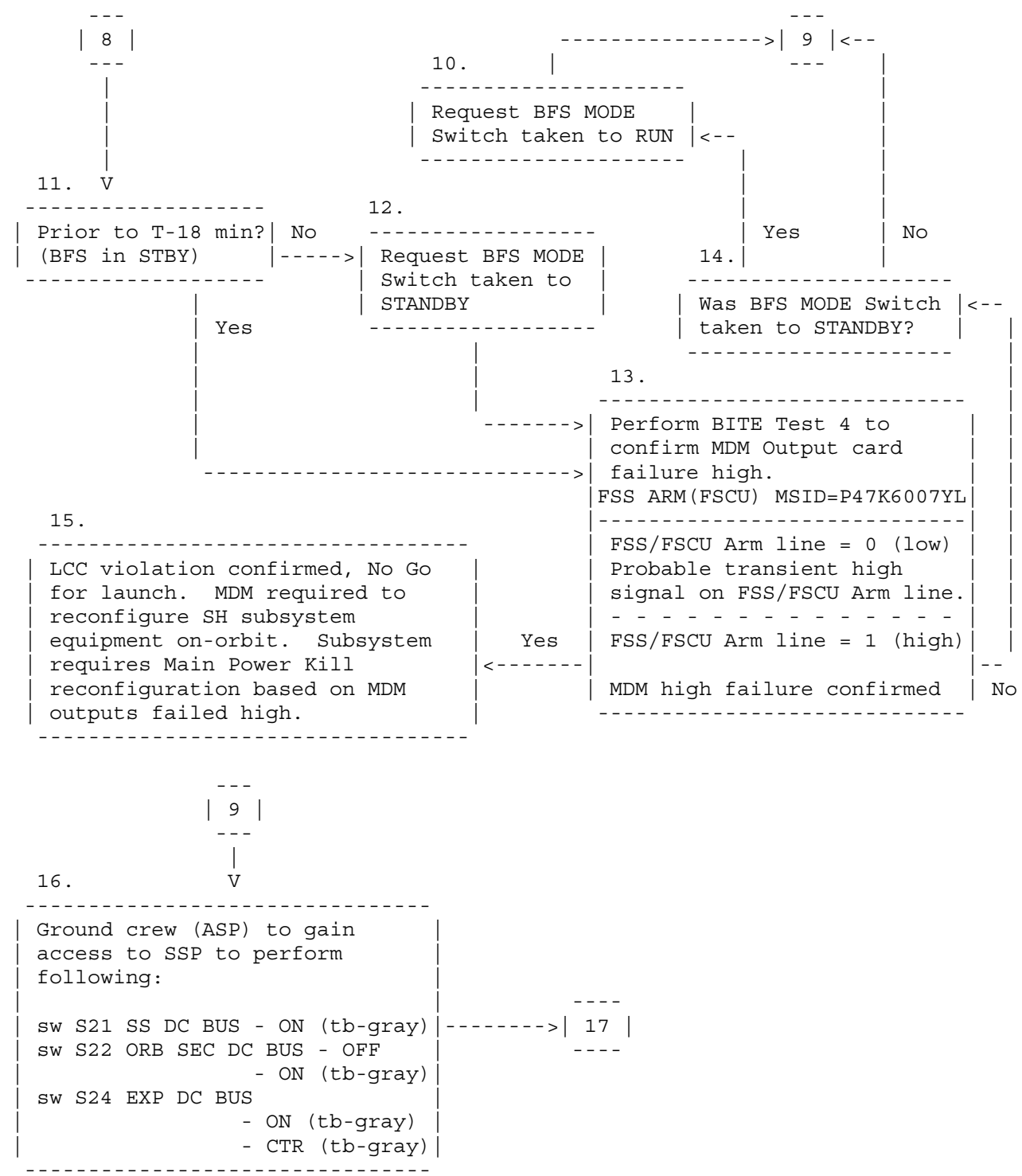


Figure 37-09, SH Main Power Anomaly Contingency Procedure (Continued)

SUPPORTING DATA: (Continued)

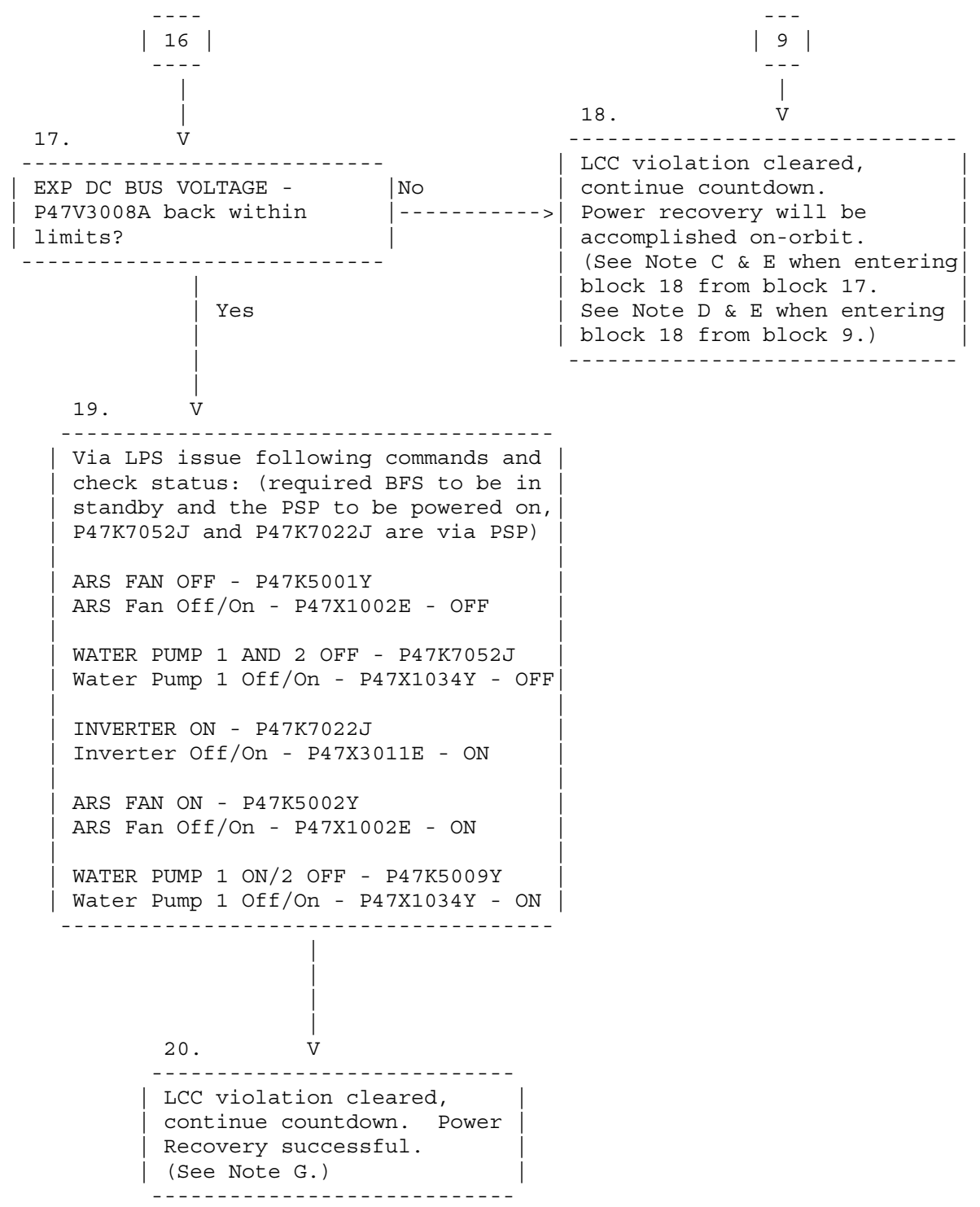


Figure 37-09, SH Main Power Anomaly Contingency Procedure (Continued)

SUPPORTING DATA: (Concluded)

NOTES:

A. Orbiter LCC (EPDC-01) would be invoked if Orbiter Main Bus Voltage is less than 28.3 V.

B. Switch throw will bring system back to safe configuration such that the FSS bottles cannot be discharged via a discharge command (Gate reset to nominal configuration which will require both an arm one-shot command and discharge command prior to halon bottle firing). Prior to recovery of MDM, FSS Arm capability via MDM commanding is lost. Arming of FSS prior to MDM recovery requires access to the C3A5 panel or Standard Switch Panel (SSP).

C. This note is applicable to non FSS-arming via MDM cases only. Hard failure of Main Power Kill Circuitry in FSCU, MCP, SSP, or PDU causing a Main Power Kill. All hard Main Power Kill cases can be recovered by performing an In Flight Maintenance (IFM) procedure to disconnect the Jiffy Junctions at the Power Distribution Unit (PDU) interface in the SH subfloor on-orbit.

D. Since Launch Processing System (LPS) commanding is unavailable, and crew access to SSP commanding is not easily accomplished, power recovery will be accomplished on-orbit. In case of inadvertent (FSS Arm via MDM high), intermittent (power kill circuitry in MCP, FSCU, or PDU), or power supply ramping/transient power kill, basic commanding will recover power. For a hard power kill, an IFM to disconnect Jiffy Junctions at the SH Power Distribution Unit will be performed to allow recovery of system power.

E. Prior to Flow Proportioning Valve repositioning on-orbit, the SH power should be recovered to the WFCEU for control of the Water Flow Control Valve Motors. Recovery of the Water Flow Control Electronics Unit (WFCEU) is required to prevent possible transients in SH water loop. Power to the Water Flow Control Valve motors allows the SH water loop to correct for a situation where a large slug of cold water is released from the Payload Heat Exchanger.

F. The SH Module remains in a safe configuration following a Main Power Kill. Smoke detection is slowed due to lack of fan air circulation.

G. This note is applicable to non FSS-arming via MDM cases only. Ability to recover from Main Power Kill indicates one of the following conditions occurred:

- Intermittent failure of Main Power Kill circuitry in MCP, FSCU, or PDU
- Power Supply ramping/transient causing Main Power Kill.

H. Verify PL PRI MN C V76X2838E (PL PRI MN B V76X2833E)- ON. If OFF PL PRI power contactor failure. If ON probable SH short blowing 150 A fuses on DC input to PDU probable problem.

Figure 37-09, SH Main Power Anomaly Contingency Procedure (Concluded)

LCC VIOLATION CALL: Spacehab Individual Halon Bottle Discharge Indication | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
P47X1020E	Halon Bottle 1 Discharge		ON	N/A	EVENT	CI
P47X1021E	Halon Bottle 2 Discharge		ON	N/A	EVENT	CI
P47X1022E	Halon Bottle 3 Discharge		ON	N/A	EVENT	CI
P47X1023E	Halon Bottle 4 Discharge		ON	N/A	EVENT	CI
P47X1024E	Halon Bottle 5 Discharge		ON	N/A	EVENT	CI
P47X1025E	Halon Bottle 6 Discharge		ON	N/A	EVENT	CI
P47X1026E	Halon Bottle 7 Discharge		ON	N/A	EVENT	CI
P47X1027E	Halon Bottle 8 Discharge		ON	N/A	EVENT	CI
P47X1028E	Halon Bottle 9 Discharge		ON	N/A	EVENT	CI
P47X1029E	Halon Bottle 10 Discharge		ON	N/A	EVENT	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) This LCC is effective only for Spacehab (except RDM) flights in which the module subsystems are powered during the LCC time period.
(3) Number of Halon bottles flown is mission dependent depending on SH mission configuration. Requirement applies only to bottles installed for flight.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) Payload Mission Success LCC. SH Fire Suppression system is still capable of providing sufficient Halon Concentration to suppress a fire with one failed Halon bottle.
(5) Halon bottles 1 through 10 discharge statuses are nominally ON (NO).
(6) The mission specific number of Halon bottles installed for launch will be documented in the Boeing mission specific Launch Commit Criteria console support document.
(7) This LCC will be monitored by the customer from a NASA/KSC console.

REDLINE DERIVATION: CRITICALITY:

(8) Individual Halon Bottle Discharge Statuses: OFF (YES) status event triggered when contacts 1 & 3 on Halon bottle discharge switch closes at 60 +/- 10 psig on decreasing bottle pressure.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Halon leaking or discharged from bottles creating toxic Spacehab module unsuitable for crew habitability.

CAUSES OF EXCEEDING REDLINE:

(10) - Halon Bottle discharge/leakage.
- Halon Bottle pressure switch failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Spacehab SUBSYSTEM: FSS

LCC VIOLATION CALL: Spacehab Cabin (ARS) HX Flow Rate (low) Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
P47R1005A	ARS HX H2O Flowrate		250	N/A	lbm/hr	CI
P47R1012A	Cabin HX H2O Flowrate		250	N/A	lbm/hr	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for APU Start (T-5 minutes)

REQUIREMENTS: FIGURES/TABLES: Figure 37-11

(2) 1 of 2 measurements acceptable for confirmed instrumentation failure. (4)
(3) This LCC is effective only for Spacehab (SH) (except RDM) flights in which the module subsystems are powered during the LCC time period.

PREPLANNED CONTINGENCY PROCEDURE:

(4) Perform SH Cabin Air Revitalization System (ARS) HX Flowrate (low) Contingency Procedure per Figure 37-11, Go/No Go conclusions are provided in the flowchart.

NOTES:

(5) Backup monitoring of LCC is available at Mission Control Center (MCC) if data is lost at KSC.
(6) This LCC will be monitored by the customer from a NASA/KSC console.
(7) Payload Mission Success LCC.

REDLINE DERIVATION: CRITICALITY: 1R

(8) a. SSID Intent Summary - This instrumentation is used to verify the health of the Water Pump providing water circulation between the SH Module and the Orbiter Cooling loop. Two separate water flowmeters located in parallel portions of the SH water loop provide the two measurements used to monitor the Water pump performance.

b. Voting Logic - A single measurement out of limit is required for action to be taken. Additional measurements will be assessed during the preplanned procedures to determine if single sensor out of limits is instrumentation failure.

c. Minimum and Maximum Redline Development - Minimum values of 250 lbm/hr for each Heat Exchanger allows for 500 lbm/hr total flowrate minimum. 500 lbm/hr flowrate allows for approximately a 30% reduction from design total flowrate of 720 lbm/hr, but still provides for 6.5 kW heat rejection capability with 45 deg F temperature rise.

REDLINE DERIVATION: (Continued)

d. Time Period - Ending time effectivity of T-5 minutes was chosen based on the fact that loss of the SH Water Loop could result in complete loss of mission objectives. Power source for the water pump during prelaunch time frame is same as the ARS fan therefore pump power source failure is protected by SH-01.

e. Requirements - The SH Water Pump package contains two redundant water pumps. A single operational pump is required to provide water circulation for cooling whenever the SH Module is powered. Pump 1 is nominally operational during the pre-launch timeframe but in case of pump 1 failure, pump 2 provides equivalent performance for cooling. Pump 1 and pump 2 receive power from a common power source during the prelaunch timeframe.

f. Preplanned Contingency Procedures - These procedures determine if out of limit flowmeter readings are the result of water loop obstruction, instrumentation failure, power source problem or main power kill. If not then switch to the alternate pump is performed. If performance of alternate pump is within limits then launch countdown can continue. For pump power source problem or water loop obstruction SH is No Go for Launch. For a main power kill, recovery is attempted using SH-06 preplanned procedures. The countdown is continued for confirmed instrumentation failure.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Reduced or no water cooling for module temperature control.

CAUSES OF EXCEEDING REDLINE:

(10) -Flowrate sensor failure.
-Pump failure.
-Clogged pump filter.
-Obstruction in water loop.
-Transient condition.
-Loss of SH Main Power.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	lbm/hr								
P47R1005A	NL	50.43	607.0						
P47R1012A	NL	50.43	607.0						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Spacehab SUBSYSTEM: ECS

SUPPORTING DATA:

Figure 37-11, SH Cabin (ARS) HX Flowrate (low) Contingency Procedure

SUPPORTING DATA: (Continued)

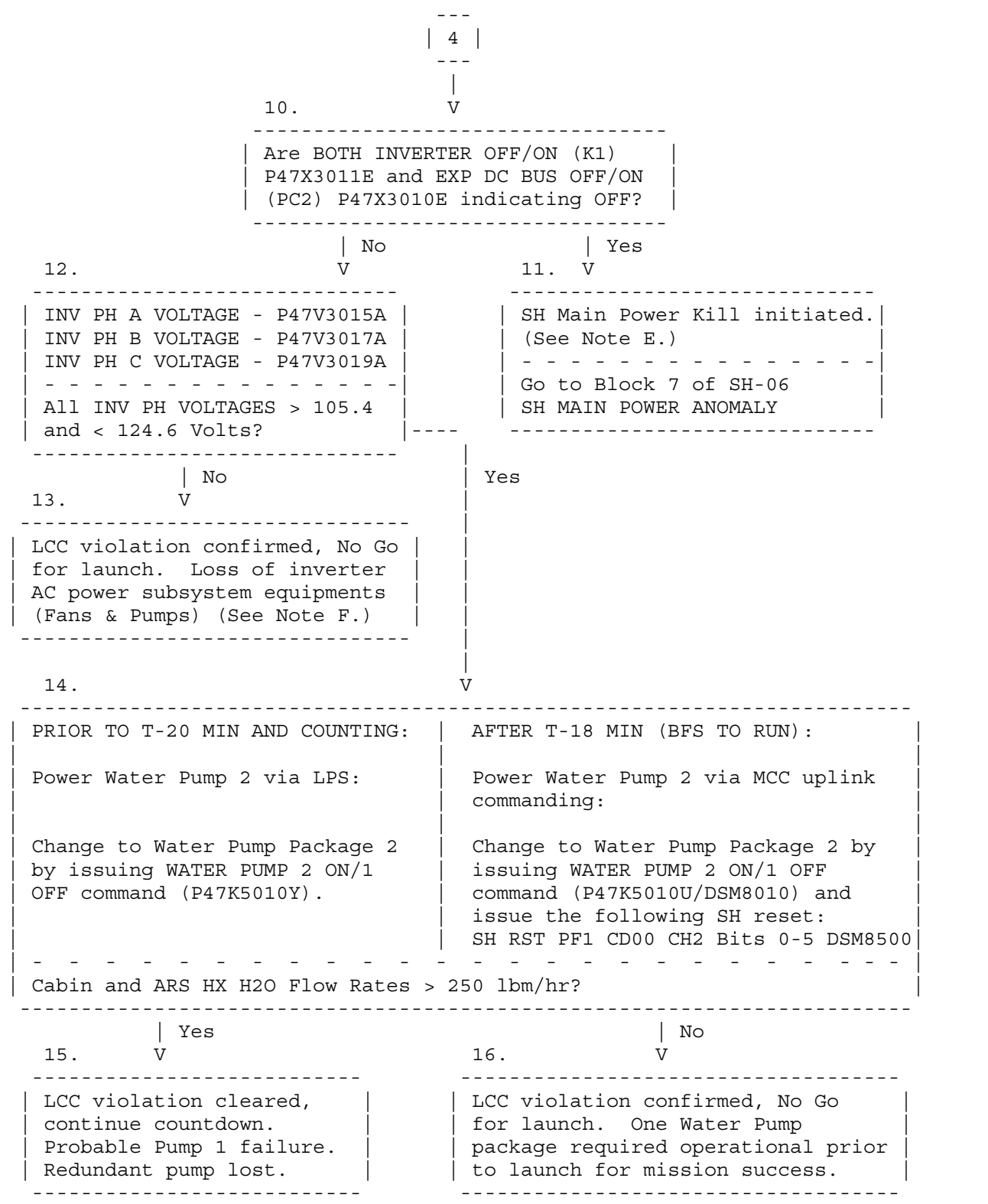


Figure 37-11, SH Cabin (ARS) HX Flowrate (low) Contingency Procedure (Continued)

SUPPORTING DATA: (Continued)

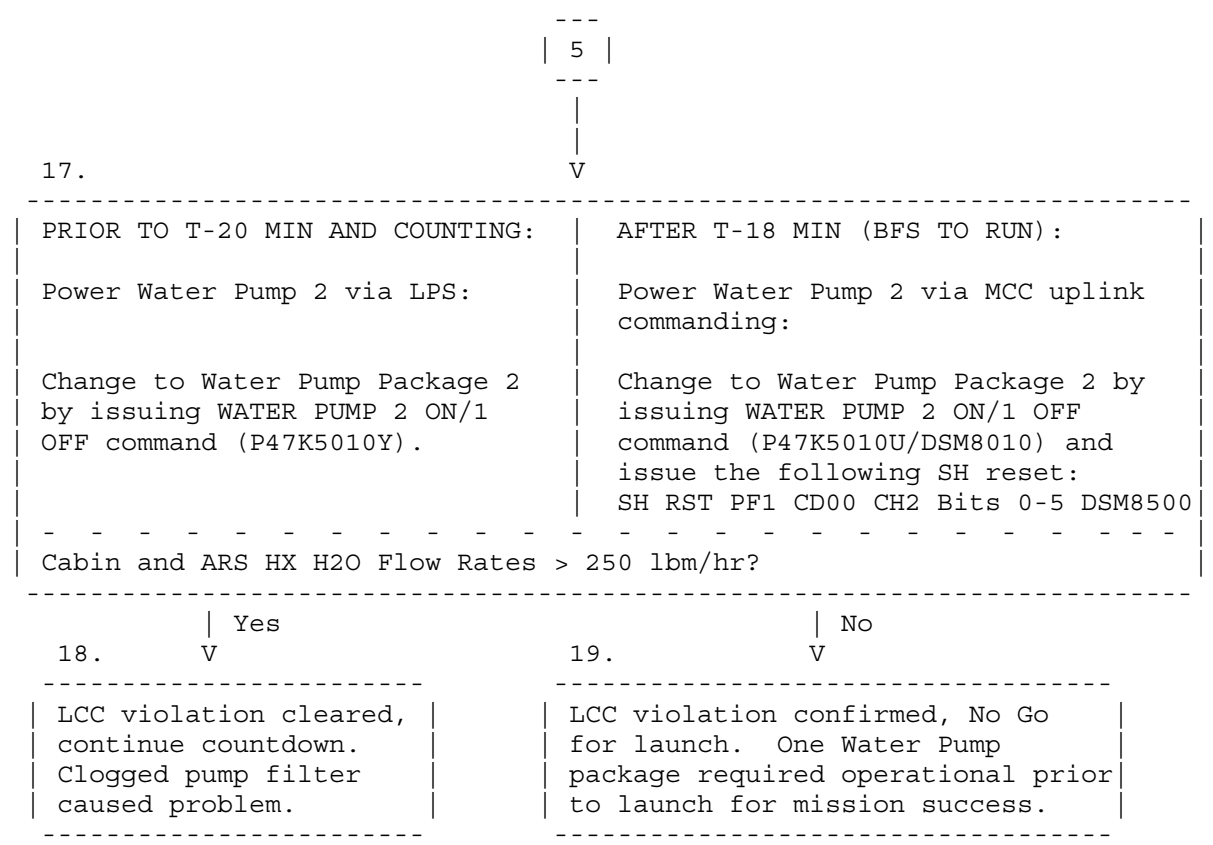


Figure 37-11, SH Cabin (ARS) HX Flowrate (low) Contingency Procedure (Continued)

SUPPORTING DATA: (Continued)

NOTES:

A. Measurement which was originally out of limits (Cabin (ARS) HX H2O Flow Rate) determines which side of loop (Cabin or ARS) has failure.

B. Obstruction in either ARS or Cabin loop will decrease system heat rejection capability, however margins are adequate for Spacehab-4 to continue with single heat exchanger operations.

C. If Cabin side of loop fails and Cabin fan is powered during prelaunch:
Turn Cabin Fan OFF, ARS Fan ON.
If ARS side of loop fails and ARS fan is powered during prelaunch:
Turn ARS fan OFF, Cabin fan ON.

Power according to the following:

PRIOR TO T-20 MIN AND COUNTING:	AFTER T-18 MIN (BFS to RUN):
Power alternate fan via LPS: Power off ARS (Cabin) Fan (ARS FAN OFF P47K5001Y) (CABIN FAN OFF P47K5003Y) Switch to Cabin (ARS) Fan (CABIN FAN ON P47K5004Y) (ARS FAN ON P47K5002Y)	Power alternate fan via MCC uplink commanding: Power off ARS (Cabin) Fan (ARS FAN OFF P47K5001U/DSM8001) (CABIN FAN OFF P47K5003U/DSM8003) Switch to Cabin (ARS) Fan (CABIN FAN ON P47K5004U/DSM8004) (ARS FAN ON P47K5002U/DSM8002) Issue the following SH reset: SH RST PF1 CD00 CH2 Bits 0-5 DSM8500

D. Commanding of Fans via Launch Processing System (LPS) is not available after T-20 minutes and counting. No commanding is available between T-20 minutes and T-18 minutes (OPS 101 transition). Commanding after T-18 minutes available via Mission Control Center (MCC) uplink commands.

E. SH Cabin (ARS) HX Flow Rate (low) Anomaly caused by SH Main Power Kill. Power loss to the Water Pump Package results from a Main Power Kill.

F. Possible loss of inverter Master Sync, Phase A Inverter overvoltage shutdown, PDU K1 relay failure or PDU F94 fuse failure (feeds Inverter Phase A). K1 relay failure can be determined by checking INV DC BUS CURRENT (P47C3012A) and INV DC BUS VOLTAGE (P47V3013A) measurements. 0 volt condition for INV DC BUS VOLTAGE is 18 V, while 0 current condition for INV DC BUS CURRENT is 0 amps. F94 fuse failure, inverter overvoltage shutdown and inverter master sync failures all give same failure signature: all inverter phase voltages out of limits (Phase A controls sync for other two inverter phases).

Figure 37-11, SH Cabin (ARS) HX Flowrate (low) Contingency Procedure (Continued)

SUPPORTING DATA: (Concluded)

GENERAL NOTES

G. Accumulator Quantity, Water Pump Inlet Pressure, and Water Pump Outlet Pressure values may change after Flow Proportioning Valve repositioning at approximately L-6 hrs.

H. Any changes in Water Pump package sensors (Accumulator Quantity, Water Pump Inlet Pressure, Water Pump Outlet Pressure) or ARS or Cabin HX H2O Flow rates should be investigated for possible anomalies after allowing for temperature change effects.

Figure 37-11, SH Cabin (ARS) HX Flowrate (low) Contingency Procedure (Concluded)

LCC VIOLATION CALL: Spacehab Water Pump Accumulator Quantity (high/low) Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
P47Q1037A	Water Pump Accumulator Quan		60	90	pct	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for APU Start (T-5 minutes)

REQUIREMENTS: FIGURES/TABLES: Figure 37-12

(2) This LCC is effective only for Spacehab (except RDM) flights in which the module subsystems are powered during the LCC time period.

PREPLANNED CONTINGENCY PROCEDURE:

(3) See Figure 37-12, SH Water Pump Accumulator Quantity (high/low) Anomaly Contingency Procedure.

NOTES:

(4) This LCC will be monitored by the customer from a NASA/KSC console.
(5) Backup monitoring of LCC is available at MCCH if data is lost at KSC.
(6) Payload Mission Success LCC.

REDLINE DERIVATION: CRITICALITY:

(7) Minimum value of 60% allows for 15% decrease in nominal accumulator charge due to leakage, thermal contraction of water in loop and accumulator charge inaccuracies.

Maximum value of 90% allows for 15% increase in nominal accumulator charge due to thermal expansion of water in loop and accumulator charge inaccuracies.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) MIN or MAX: Reduced or no water cooling for module temperature control.

CAUSES OF EXCEEDING REDLINE:

(9) Minimum value:
- Accumulator sensor failure.
- Spacehab water loop leak.
- Transient condition.

Maximum value:
- Accumulator sensor failure.
- Orbiter freon loop to Spacehab water loop leak.
- Transient condition.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	pcnt								
P47Q1037A	0.4	-2.0	100.0						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Spacehab SUBSYSTEM: ECS

SUPPORTING DATA:

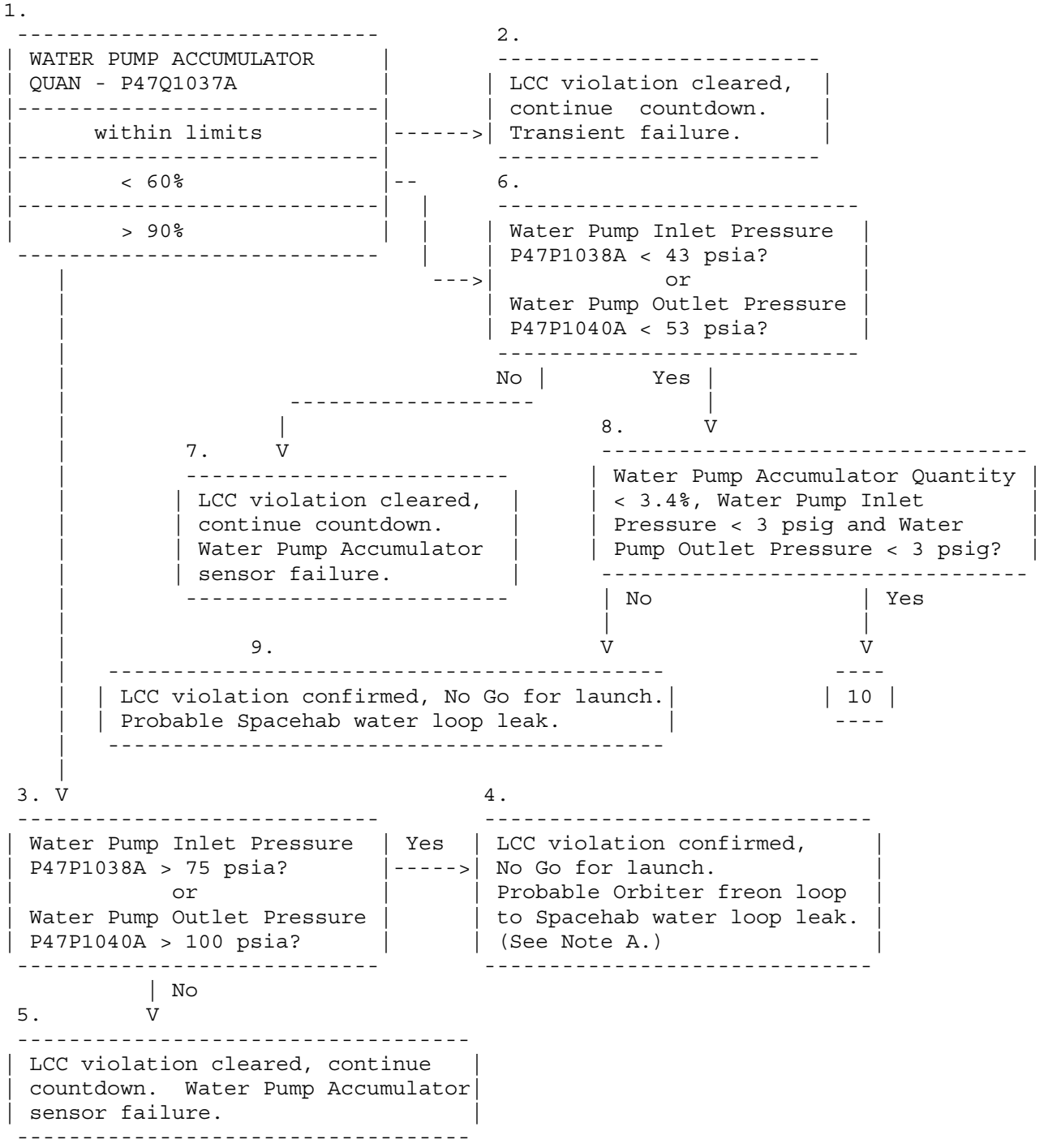
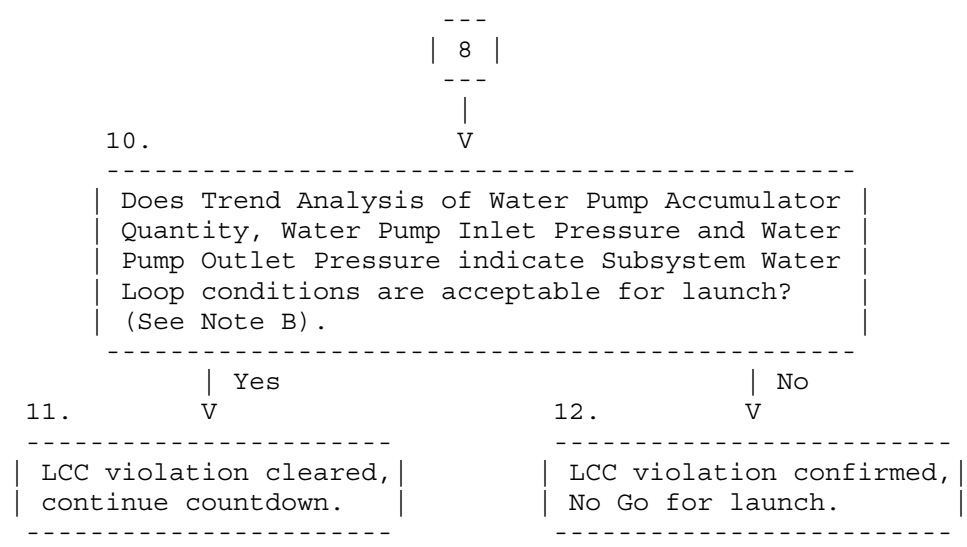


Figure 37-12, SH Water Pump Accumulator Quantity (high/low) Anomaly Contingency Procedure

SUPPORTING DATA: (Concluded)



NOTES:

A. Orbiter freon loop operates at higher pressure than SH Water loop. A leak in Orbiter heat exchanger would cause the mass in the SH water loop to increase. Orbiter freon loop leak would be confirmed with Orbiter LCC SSID: ECL-41.

B. A common DC/DC converter powers the Water Pump Accumulator Quantity, Water Pump Inlet Pressure, and Water Pump Outlet Pressure sensors. Failure of this converter will cause the three sensor outputs to go to their 0 Volt (low) value. The mission specific data and criteria used to determine acceptable Subsystem Water Loop status for launch after loss of Water Pump Accumulator Quantity, Water Pump Inlet Pressure, and Water Pump Outlet Pressure sensor readings will be documented in the Boeing mission specific Launch Commit Criteria console support document.

GENERAL NOTES:

C. Accumulator Quantity, Water Pump Inlet Pressure, and Water Pump Outlet Pressure values may change after Flow Proportioning Valve repositioning at approximately L-6 hrs.

D. Any changes in Water Pump package sensors (Accumulator Quantity, Water Pump Inlet Pressure, Water Pump Outlet Pressure) or ARS or Cabin HX H2O Flow rates should be investigated for possible anomalies after allowing for temperature change effects.

Figure 37-12, SH Water Pump Accumulator Quantity (high/low) Anomaly Contingency Procedure (Concluded)

LCC VIOLATION CALL: Spacehab Water Pump Inlet Pressure (high/low) Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
P47P1038A	Water Pump Inlet Pressure		43	75	psia	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for APU Start (T-5 minutes)

REQUIREMENTS: FIGURES/TABLES: Figure 37-13

(2) This LCC is effective only for Spacehab (except RDM) flights in which the module subsystems are powered during the LCC time period.

PREPLANNED CONTINGENCY PROCEDURE:

(3) See Figure 37-13, SH Water Pump Inlet Pressure (high/low) Anomaly Contingency Procedure.

NOTES:

(4) This LCC will be monitored by the customer from a NASA/KSC console.
(5) Backup monitoring of LCC is available at MCCH if data is lost at KSC.
(6) Payload Mission Success LCC.

REDLINE DERIVATION: CRITICALITY:

(7) Minimum value of 43 psia corresponds to a nominal accumulator charge that has decreased to 60% with an accumulator gas side temperature of 60 deg F.

Maximum value of 75 psia corresponds to a nominal accumulator charge that has increased to 90% with an accumulator gas side temperature of 87 deg F.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) MIN or MAX: Reduced or no water cooling for module temperature control.

CAUSES OF EXCEEDING REDLINE:

(9) Minimum value:
- Water pump inlet pressure sensor failure.
- Spacehab H2O loop leak or external GN2 leak from accumulator housing.
- Transient condition.

Maximum value:
- Water pump inlet pressure sensor failure.
- Orbiter freon loop to Spacehab water loop leak.
- Transient condition.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	psia								
P47P1038A	0.851	-2.32	214.7						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Spacehab SUBSYSTEM: ECS

SUPPORTING DATA:

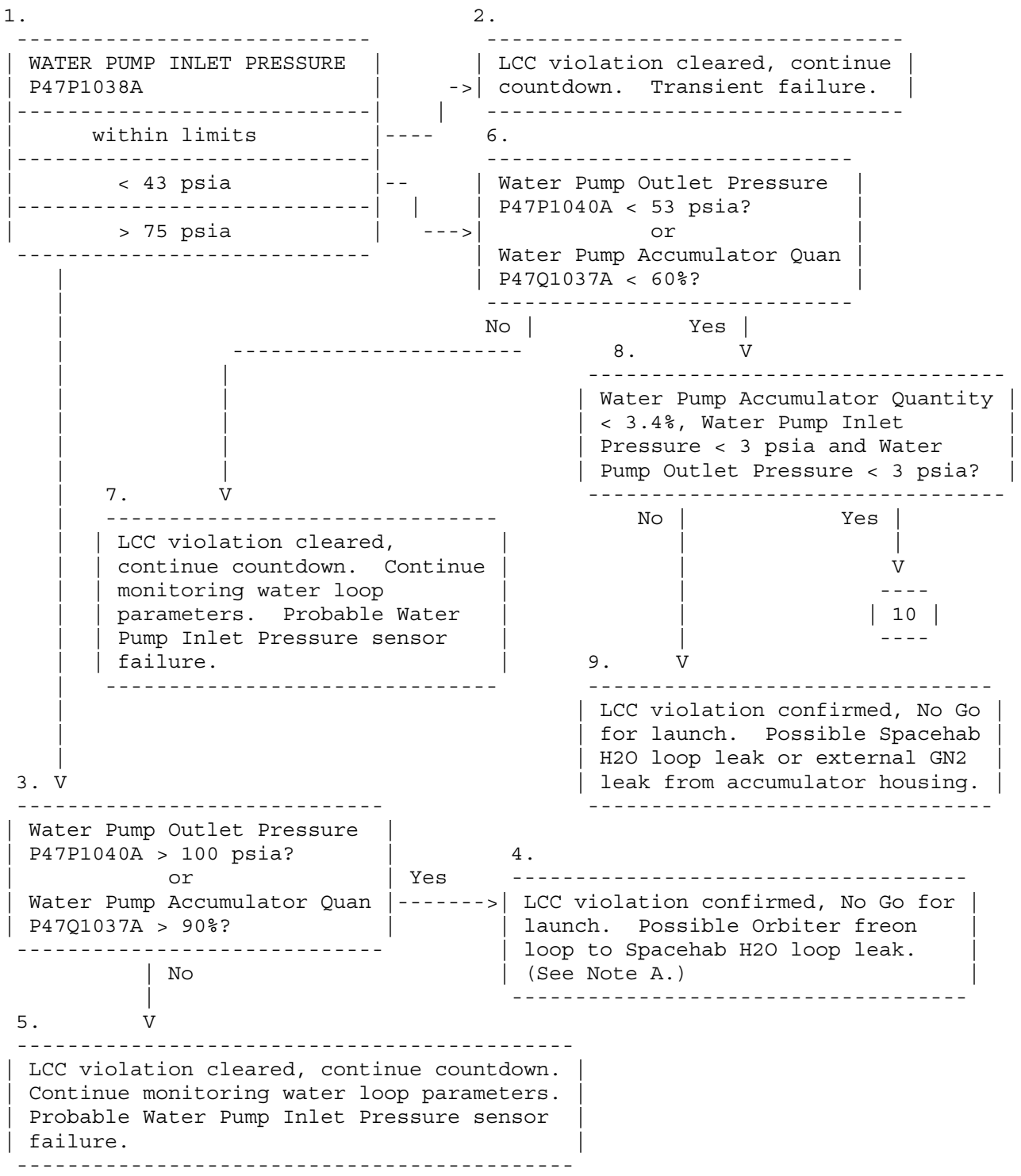
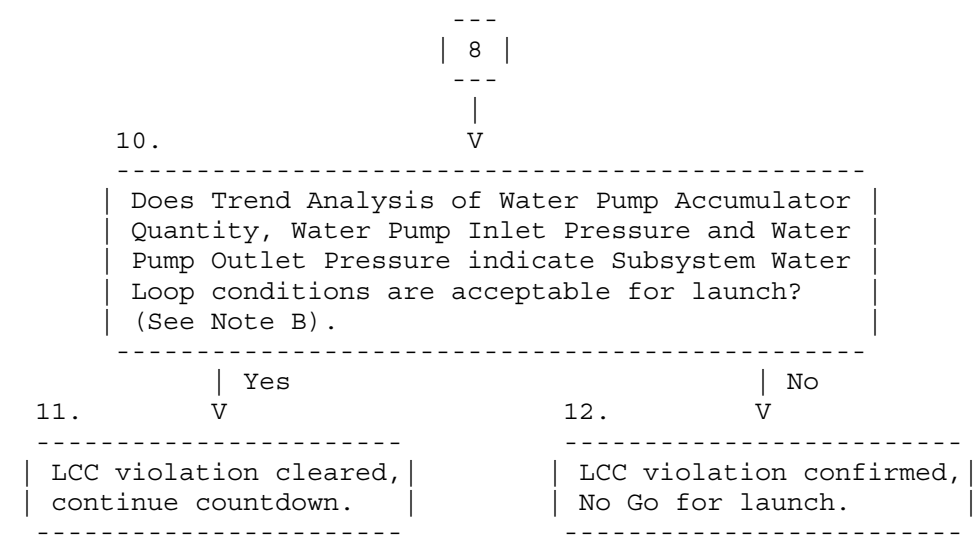


Figure 37-13, SH Water Pump Inlet Pressure (high/low) Anomaly Contingency Procedure

SUPPORTING DATA: (Concluded)



NOTES:

A. Orbiter freon loop operates at higher pressure than SH Water loop. A leak in Orbiter heat exchanger would cause the mass in the SH water loop to increase. Orbiter freon loop leak would be confirmed with Orbiter LCC SSID: ECL-41.

B. A common DC/DC converter powers the Water Pump Accumulator Quantity, Water Pump Inlet Pressure, and Water Pump Outlet Pressure sensors. Failure of this converter will cause the three sensor outputs to go to their 0 Volt (low) value. The mission specific data and criteria used to determine acceptable Subsystem Water Loop status for launch after loss of Water Pump Accumulator Quantity, Water Pump Inlet Pressure, and Water Pump Outlet Pressure sensor readings will be documented in the Boeing mission specific Launch Commit Criteria console support document.

GENERAL NOTES:

C. Accumulator Quantity, Water Pump Inlet Pressure, and Water Pump Outlet Pressure values may change after Flow Proportioning Valve repositioning at approximately L-6 hrs.

D. Any changes in Water Pump package sensors (Accumulator Quantity, Water Pump Inlet Pressure, Water Pump Outlet Pressure) or ARS or Cabin HX H2O Flow rates should be investigated for possible anomalies after allowing for temperature change effects.

Figure 37-13, SH Water Pump Inlet Pressure (high/low) Anomaly Contingency Procedure (Concluded)

LCC VIOLATION CALL: Spacehab Water Pump Outlet Pressure (high/low) Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
P47P1040A	Water Pump Outlet Pressure	(3)	53	100	psia	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for APU Start (T-5 minutes)

REQUIREMENTS: FIGURES/TABLES: Figure 37-14

(2) This LCC is effective only for Spacehab (SH) (except RDM) flights in which the module subsystems are powered during the LCC time period.

PREPLANNED CONTINGENCY PROCEDURE:

(3) Perform SH Water Pump Outlet Pressure (high/low) Anomaly Contingency Procedure per Figure 37-14, Go/No Go conclusions are provided in the flow chart.

NOTES:

(4) This LCC will be monitored by the customer from a NASA/KSC console.
(5) Backup monitoring of LCC is available at Mission Control Center (MCC) if data is lost at KSC.
(6) Payload Mission Success LCC.

REDLINE DERIVATION: CRITICALITY: 1R

(7) a. SSID Intent Summary - This instrumentation is used to verify the health of the Water loop providing water circulation between the SH Module and the Orbiter Cooling loop.

b. Voting Logic - Additional measurements will be assessed during the preplanned procedures to determine if out of limits condition is caused by instrumentation failure.

c. Minimum and Maximum Redline Development - Minimum value of 53 psia corresponds to a pump inlet pressure of 43 psia with a pump rise of 10 psia. Inlet pressure value of 43 psia corresponds to a 15% decrease in nominal accumulator charge with a gas side temperature of 60 deg F. Maximum value of 100 psia corresponds to a pump inlet pressure of 75 psia with a pump rise of 25 psia. Inlet pressure value of 75 psia corresponds to a 15% increase in nominal accumulator charge with a gas side temperature of 87 deg F.

d. Time Period - Ending time effectivity of T-5 minutes was chosen based on the fact that loss of the SH Water Loop could result in complete loss of mission objectives.

REDLINE DERIVATION: (Continued)

e. Requirements - An operational water loop is required to provide water circulation for cooling whenever the SH Module is powered.

f. Preplanned Contingency Procedures - These procedures determine if out of limit pressure reading is the result of water loop leak, instrumentation failure or pump problem. If pump problem then switch to the alternate pump is performed. If performance of alternate pump is within limits then launch countdown can continue. For water loop leak SH is No Go for Launch. The countdown is continued for confirmed instrumentation failure.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) MIN or MAX: Reduced or no water cooling for module temperature control.

CAUSES OF EXCEEDING REDLINE:

(9) Minimum value:
- SH water loop leak.
- Obstruction in water pump filter.
- Transient condition.

Maximum value:
- Orbiter freon loop to SH water loop leak.
- Obstruction in water line.
- Transient condition.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	psia								
P47P1040A	.851	-2.32	214.7						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Spacehab SUBSYSTEM: ECS

SUPPORTING DATA:

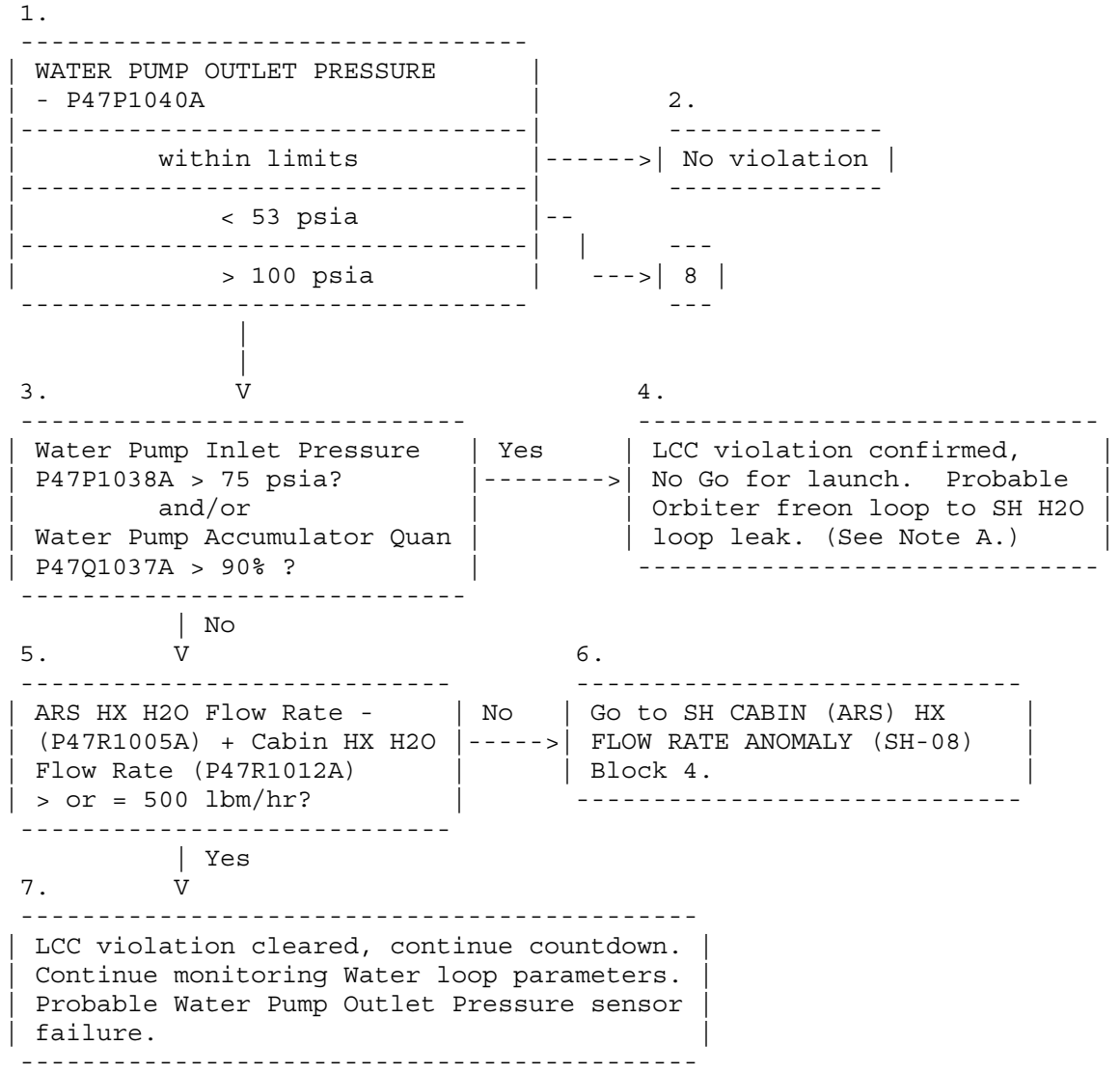


Figure 37-14, SH Water Pump Outlet Pressure (high/low) Anomaly Contingency Procedure

SUPPORTING DATA: (Continued)

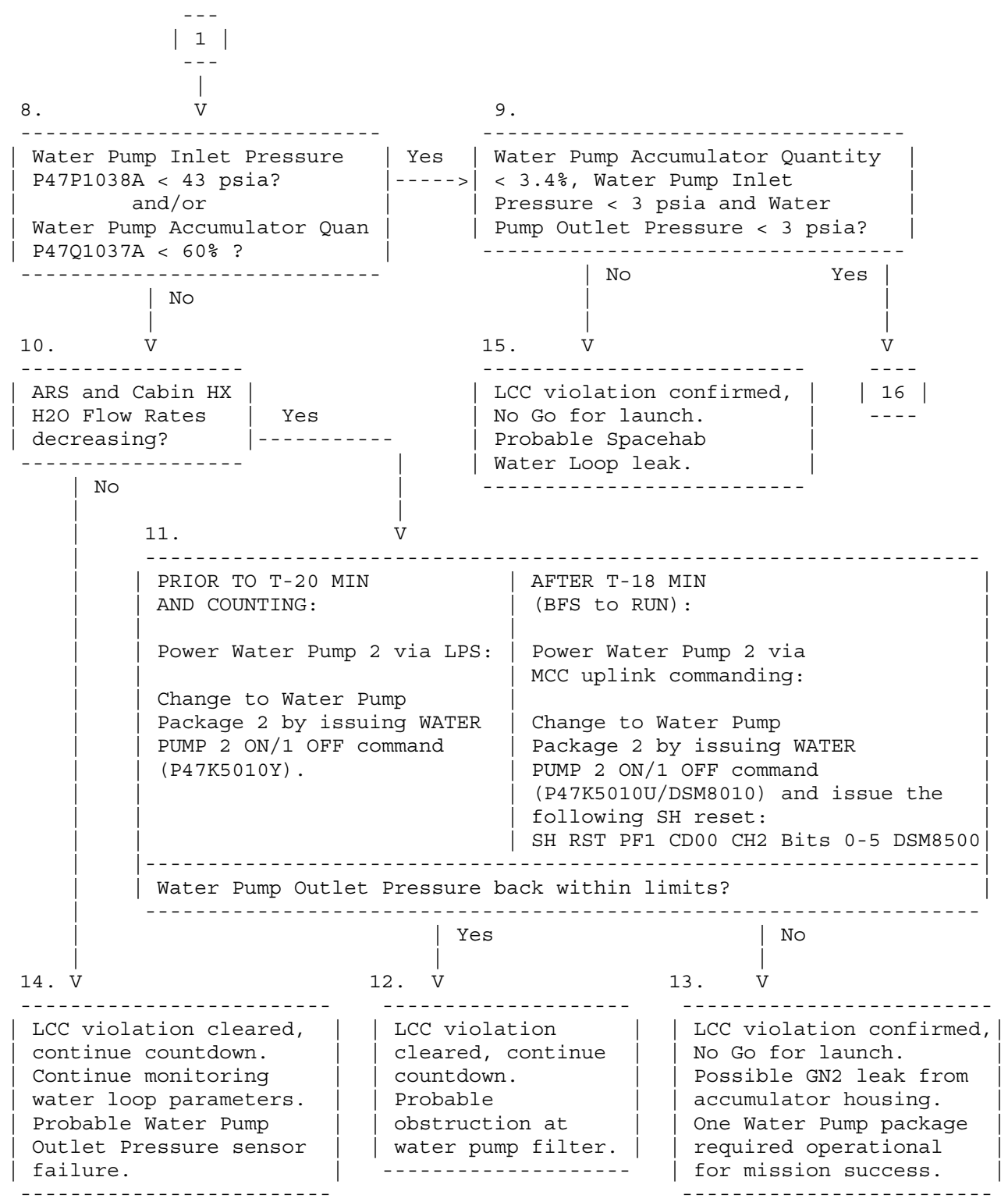
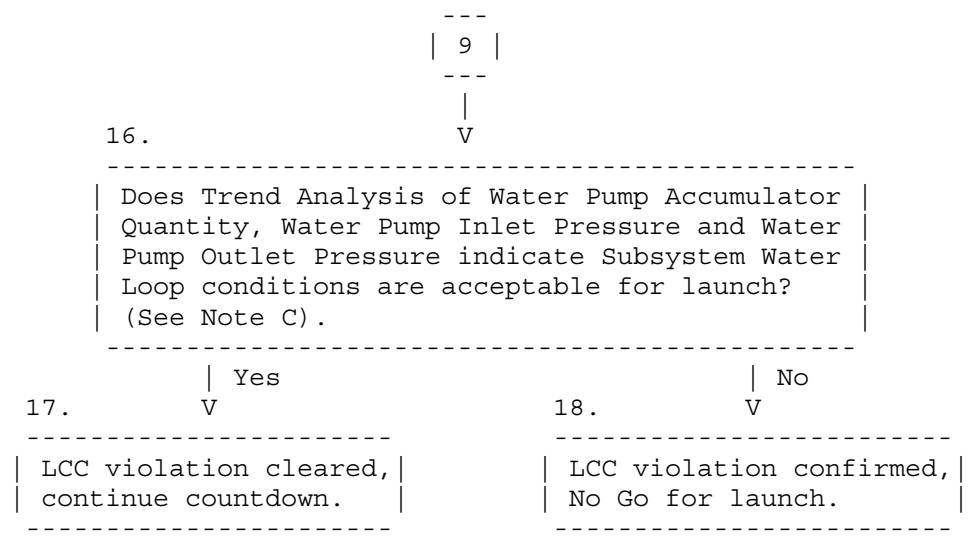


Figure 37-14, SH Water Pump Outlet Pressure (high/low) Anomaly Contingency Procedure (Continued)

SUPPORTING DATA: (Concluded)



NOTES:

A. Orbiter freon loop operates at higher pressure than SH Water loop. A leak in Orbiter heat exchanger would cause the mass in the SH water loop to increase. Orbiter freon loop leak would be confirmed with Orbiter LCC SSID: ECL-41.

B. Commanding of Pumps via Launch Processing System (LPS) is not available after T-20 min. and counting. No commanding is available between T-20 min. and T-18 min. (OPS 101 transition). Commanding after T-18 min. available via Mission Control Center (MCC) uplink commands.

C. A common DC/DC converter powers the Water Pump Accumulator Quantity, Water Pump Inlet Pressure, and Water Pump Outlet Pressure sensors. Failure of this converter will cause the three sensor outputs to go to their 0 volt (low) value. The mission specific data and criteria used to determine acceptable Subsystem Water Loop status for launch after loss of Water Pump Accumulator Quantity, Water Pump Inlet Pressure, and Water Pump Outlet Pressure sensor readings will be documented in the Boeing mission specific Launch Commit Criteria console support document.

GENERAL NOTES:

D. Accumulator Quantity, Water Pump Inlet Pressure, and Water Pump Outlet Pressure values may change after Flow Proportioning Valve repositioning at approximately L-6 hrs.

E. Any changes in Water Pump package sensors (Accumulator Quantity, Water Pump Inlet Pressure, Water Pump Outlet Pressure) or Air Revitalization System (ARS) or Cabin HX H2O Flow rates should be investigated for possible anomalies after allowing for temperature change effects.

Figure 37-14, SH Water Pump Outlet Pressure (high/low) Anomaly Contingency Procedure (Concluded)

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LCC VIOLATION CALL: Payload Aft Main B Power Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
V76X2810E	Payload Aft Main B Pwr - ON	(3)	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES: 37-15

(2) This LCC is effective only for Spacehab (SH) (except RDM) flights in which the module subsystems are powered during the LCC time period.
(3) For confirmed instrumentation failure, LCC violation cleared, continue countdown. (4)

PREPLANNED CONTINGENCY PROCEDURE:

(4) Confirm Instrumentation Failure by performing Payload Aft Main B Power Anomaly Contingency Procedure per Figure 37-15, Go/No Go conclusions are provided in the flow chart.

NOTES:

(5) Mission Success LCC.
(6) This LCC will be monitored by the customer from a NASA/KSC console.

REDLINE DERIVATION: CRITICALITY: 1R

(7) a. SSID Intent Summary - This instrumentation is used to verify the health of the power contactor providing Payload Aft Main B power to SH.

b. Voting Logic - Additional measurements will be assessed during the preplanned procedures to determine if out of limits condition is caused by instrumentation failure.

c. Minimum and Maximum Redline Development - Payload Aft Main B Pwr - OFF indicates potential loss of Aft Main B power to SH. PL Aft Main B and PL AUX A are combined to form the SH Emergency Bus.

d. Time Period - Ending time effectivity of T-9 minutes was chosen based on the fact that loss of Payload Aft Main B Pwr to SH would result in loss of redundant power to Safety critical functions and complete loss of power to the SH Water Line heaters.

e. Requirements - An operational SH Emergency Bus is required to provide power to SH safety critical functions. The SH Water Line heaters are used to protect the Orbiter Payload Heat Exchanger (PHX) in case of failure of the SH Water Loop or loss of monitoring capability.

REDLINE DERIVATION: (Continued)

f. Preplanned Contingency Procedures - These procedures determine if out of limit pressure reading is the result of instrumentation failure or power contactor problem. For power contactor failure SH is No Go for Launch. The countdown is continued for confirmed instrumentation failure.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Possible loss of redundant power to SH safety critical hardware and possible loss of power to SH Water Line Heaters.

The following safety critical hardware is powered via the Emergency Bus:

- Fire Suppression System Firing Circuits (FSCU)
- Signal Conditioning for safety critical circuits
- Smoke Sensor A
- ARS Fan Delta Pressure #1
- Partial Pressure Carbon Dioxide (PPCO2) #1
- Forward Sensor Panel
  - Partial Pressure Oxygen (PPO2) #1

PL Aft Main B is the sole source of power to the SH Water Line Heaters.

CAUSES OF EXCEEDING REDLINE:

(9) - Open or failed Power Contactor (K1 APC2)
- Loss of Discrete measurement power (ESS2CA AP&LC2)
  - Open Fuse (10 APC5)
  - Open limiting resistor (A2R6 APC2)
- Instrumentation failure: MDM/Card/Channel/SB OA2/Cd 05/Ch 00/Bit 11
- Loss of Orbiter Main B busses: Main B DA2, APC5, APC2
- Open Payload Aft Main B fuse APC2

==========

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: SPACEHAB SUBSYSTEM: EPS

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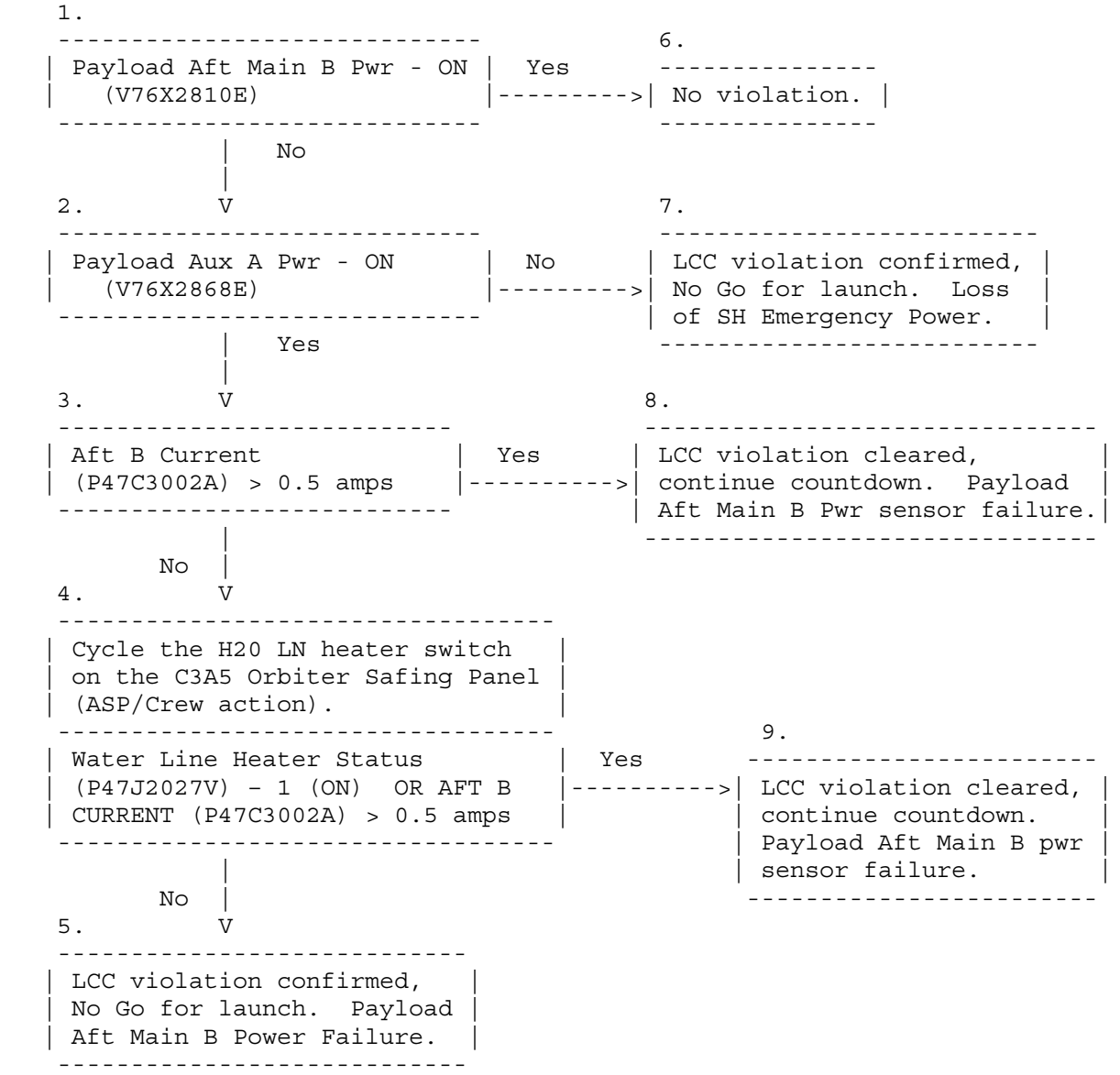
SUPPORTING DATA:



GENERAL NOTES:

A. Troubleshooting to be coordinated with CPLE (Payload Electrical Engineer). Further troubleshooting may be performed by CPLE after SPACEHAB LCC violation has been confirmed.

B. H2O LINE HTR STATUS is not available in Backup Flight Software (BFS) downlist.

Figure 37-15, Payload Aft Main B Power Anomaly Contingency Procedure

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Figure 37-05 PDU Relay Payload Commanding Requirements

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SECTION 38

SPACELAB

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SECTION 38: SPACELAB

SSID No.	Description/Violation Call	Page
SL-01	Spacelab Main Bus Volts Anomaly (REQUIREMENT DELETED)	38-01.1
SL-02	Spacelab Auxiliary Bus A/B Undervoltage Anomaly (REQUIREMENT DELETED)	38-02.1
SL-03	Spacelab Inverter Current In Anomaly (REQUIREMENT DELETED)	38-03.1
SL-04	Spacelab SS AC Bus Voltage Anomaly (REQUIREMENT DELETED)	38-04.1
SL-05	Spacelab SPDB SS AC/DC All On Power Relay Anomaly (REQUIREMENT DELETED)	38-05.1
SL-06	Spacelab RAAB 28-1 or 28-2 Bus Status Anomaly (REQUIREMENT DELETED)	38-06.1
SL-07	RAHF Configuration Anomaly (REQUIREMENT DELETED)	38-07.1
SL-08	EPDB 3 Command Anomaly (REQUIREMENT DELETED)	38-08.1
SL-09	SSID SL-09 Reserved (REQUIREMENT DELETED)	38-09.1
SL-10	Spacelab Avionics Fan Anomaly (REQUIREMENT DELETED)	38-10.1
SL-11	Spacelab Water Cooling Loop Anomaly (REQUIREMENT DELETED)	38-11.1
SL-12	Spacelab Water Cooling Loop Leak Anomaly (REQUIREMENT DELETED)	38-12.1
SL-13	Spacelab Nitrogen Supply System Anomaly (REQUIREMENT DELETED)	38-13.1
SL-14	Spacelab Depress Valve Anomaly (REQUIREMENT DELETED)	38-14.1
SL-15	Spacelab Smoke Detector/Fire Anomaly (REQUIREMENT DELETED)	38-15.1

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SECTION 39

GROUND SUPPORT EQUIPMENT

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SECTION 39: GROUND SUPPORT EQUIPMENT

SSID No.	Description/Violation Call	Page
GSE-01	Orbiter Aft Compartment Purge Pressure Anomaly	39-01.1
GSE-02	Orbiter Purge Circuit #1 Pressure Anomaly	39-02.1
GSE-03	Orbiter Payload Bay Purge Pressure Anomaly	39-03.1
GSE-04	GSE PIC Rack Voltage Anomaly	39-04.1
GSE-05	TSM PIC Cap Voltage Anomaly	39-05.1
GSE-06	ET Vent Arm PIC Cap Voltage Anomaly	39-06.1
GSE-07	SRB Hold Down Post PIC Cap Voltage Anomaly	39-07.1
GSE-08	H2 Burn System PIC Rack Voltage Anomaly	39-08.1
GSE-09	Hydrogen Burn System PIC Cap Voltage Anomaly	39-09.1
GSE-10	Orbiter Access Arm Accumulator GN2 Pressure Anomaly	39-10.1
GSE-11	OAA Hydraulic Accumulator Level Anomaly	39-11.1
GSE-12	OAA Retract Indication Anomaly	39-12.1
GSE-13	GOX Vent Arm Retract Anomaly	39-13.1
GSE-14	Sound Suppression Water Valve Actuation Pressure Anomaly	39-14.1
GSE-15	Sound Suppression Water Tank Level Anomaly	39-15.1
GSE-16	Firing Room/Launch Processing System Command Bus Control Anomaly	39-16.1
GSE-17	Sound Suppression Solenoid Power Bus Indication Anomaly	39-17.1
GSE-18	Sound Suppression Postlift-off Vent Valve Open Indication Anomaly	39-18.1
GSE-19	Sound Suppression Prelift-off Valves Open Indication Anomaly	39-19.1
GSE-20	ETVAS Lanyard PIC Voltage Anomaly	39-20.1

SECTION 39: GROUND SUPPORT EQUIPMENT (CONTINUED)

SSID No.	Description/Violation Call	Page
GSE-21	Orbiter/ET LH2 Disconnect Purge (REQUIREMENT DELETED)	39-21.1
GSE-22	SRB Aft Skirt GN2 Purge Anomaly	39-22.1
GSE-23	SRB Ignition Overpressure Water Bag Anomaly	39-23.1
GSE-24	Surface Wind Limits	39-24.1
GSE-25	Launch Release PIC Fire 1 Anomaly	39-25.1
GSE-26	Photo Optical Control System Anomaly	39-26.1
GSE-27	GOX Vent Hood Purge Termination Anomaly	39-27.1
GSE-FG01	Figure 39-01 SRB Ignition Overpressure Water Bag System	39-FG01.1
GSE-FG02	Figure 39-02 LH2 Orbiter/ET Disconnect Cavity Purge Pressure	39-FG02.1
GSE-FG03	Maximum Allowable Surface Wind Vectors (REQUIREMENT DELETED)	39-FG03.1

LCC VIOLATION CALL: Orbiter Aft Compartment Purge Pressure Anomaly | EMERG COND: Yellow (8)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GECP5A07A	Orb Aft I/F Press Ind	1 of	43	86	InH2O	CI
GECP8A03A	Orb Aft Duct Press Ind	2	50	98	InH2O	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) -CAUTION-
Reestablish inert environment and thermal conditioning by performing GN2 flowrate adjustments (ref. V1122.004 and V1122.203).

NOTES:

(3) Loss of purge will adversely affect (aft) hazardous gas detection system (hydrogen/oxygen) readings.
(4) Orb compartments/components purged by aft circuit #3. (Purge consists of gaseous nitrogen (GN2) for inerting and thermal conditioning.)
A. Aft compartment.
B. SSME controllers.
C. SSME Chamber Coolant Valve Actuator.
(5) Nominally, GECP5A07A is approximately 69 inch H2O at 110 lbs/min flowrate.
(6) Nominally, GECP8A03A is approximately 88 inch H2O at 110 lbs/min flowrate.

REDLINE DERIVATION: CRITICALITY: 1S

(7) (a) SSID Intent Summary - The intent of this SSID is to ensure Orbiter AFT compartment has an established GN2 inert atmosphere during cyrogenic loading. Depleted inert environment could result in potential accumulation of hazardous gases and loss of thermal conditioning. The system is single fault tolerant.

(b) Voting Logic - Purge pressure output is monitored by two independent pressure transducers (I/F and Duct) downstream of the purge flow control valves. If one transducer fails the remaining transducer will still provide adequate purge monitoring capability. Failure of both transducers, with one outside of expected range and LCC limits and one indicating within nominal pressure range and LCC limits, is not considered credible.

(c) Minimum and Maximum Redline Derivation - A minimum flow rate of approximately 75 lbs/min ensures that the Aft compartment environment

REDLINE DERIVATION: (Continued)

is inert. The minimum redlines are based on test data at the minimum required flow rate of approximately 75 lbs/min, plus accountability for instrumentation error.

The maximum Orb Aft I/F Press Ind value reflects PVD purge duct design certification levels of 79 inch H2O (2.85 psig) plus line loss between a pressure transducer and the flight purge quick disconnect. Line loss is approximately 8 inch H2O. The maximum Orb Aft Duct Press Ind value indicates the point at which a blockage or obstruction could prevent minimum inerting of the affected compartments.

(d) Time Effectivity - GN2 purge initiation begins at least at the start of cryo tanking (T-6 hrs). The LCC ends at T-31 seconds; at that time the vent doors are switched to open position, system stability can be verified, and the ground system is committed to launch.

(e) Requirements - The AFT compartment must be inerted with GN2 from ET cryo tanking through T-31 seconds. Minimum pressure ensures that the Aft compartments are inerted adequately as well as thermally conditioned.

(f) Preplanned Contingency Procedures - If a violation occurs an inert environment needs to be reestablished as soon as possible to prevent the possibility of the accumulation of hazardous gases and to prevent environmental contamination of the payload and orbiter compartments.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Possible loss of the inert environment which could result in potential accumulation of hazardous gases, loss of meaningful prelaunch hazardous gas data, and loss of thermal conditioning.
(9) Reference Integrated Hazard Reports IMEO-01, IMPS-03, IMPS-04 and ISPR-03.

CAUSES OF EXCEEDING REDLINE:

(10) Duct and Interface Low:
- A. Loss of ECS flow control (fail close).
- B. Duct failure/Leakage.
  1. Connect point separation.
  2. Fracture of Orbiter/GSE purge duct components.

(11) Duct and Interface High:
- A. Impediment of flow in GSE Ducting, at Orbiter interface or internal Orbiter purge duct system.
- B. ECS GN2 system fail high.

(12) Duct High and Interface Low:
- A. Blockage between Duct and I/F Pressure Measurements.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	in.H2O								
GECP5A07A	0.552	0	138						
GECP8A03A	0.552	0	138						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: GSE SUBSYSTEM: PVD

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LCC VIOLATION CALL: Orbiter Purge Circuit #1 Pressure Anomaly | EMERG COND: Yellow (8)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GECP5F07A	Orb Fwd I/F Press Ind	1 of 2	33	86	InH2O	CI
GECP8F03A	Orb Fwd Duct Press Ind	2	35	90	InH2O	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) -CAUTION-
Reestablish inert environment and thermal conditioning by performing GN2 flowrate adjustments (ref. V1122.004 and V1122.203).

NOTES:

(3) Loss of purge will adversely affect hazardous gas detection system (hydrogen/oxygen) readings.
(4) Orbiter compartments purged by the forward purge circuit #1. (Purge consists of gaseous nitrogen (GN2) for inerting and thermal conditioning.)
A. RCS cavity.
B. Fwd fuselage annulus.
C. Drag chute compartment.
D. R/H & L/H OMS pods.
E. Vertical stabilizer.
(5) Nominally, GECP5F07A is approximately 63 inch H2O at 85 lbs/min flowrate.
(6) Nominally, GECP8F03A is approximately 67 inch H2O at 85 lbs/min flowrate.

REDLINE DERIVATION: CRITICALITY: 1S

(7) (a) SSID Intent Summary - The intent of this SSID is to ensure Orbiter FWD Fuselage Annulus, Drag Chute, RCS, OMS pods and vertical stab have an established GN2 inert atmosphere during cyrogenic loading. Depleted inert environment could result in potential accumulation of hazardous gases and loss of thermal conditioning. The system is single fault tolerant.

(b) Voting Logic - Purge pressure output is monitored by two independent pressure transducers (I/F and Duct) downstream of the purge flow control valves. If one transducer fails the remaining transducer will still provide adequate purge monitoring capability. Failure of both transducers, with one outside of expected range and LCC limits and one indicating within nominal pressure range and LCC limits, is not considered credible.

REDLINE DERIVATION: (Continued)

(c) Minimum and Maximum Redline Derivation - A minimum flow rate of approximately 55 lbs/min ensures that the compartment environments purged by the FWD circuit are inert. The minimum redlines are based on test data at the minimum required flow rate of approximately 55 lbs/min, plus accountability for instrumentation error.

The maximum Orb FWD I/F Press Ind value reflects PVD purge duct design certification levels of 79 inch H2O (2.85 psig) plus line loss between a pressure transducer and the flight purge quick disconnect. Line loss is approximately 8 inch H2O. The maximum Orb Fwd Duct Press Ind value indicates the point at which a blockage or obstruction could prevent minimum inerting of the affected compartments.

(d) Time Effectivity - GN2 purge initiation begins at least at the start of cryo tanking (T-6 hrs). The LCC ends at T-31 seconds; at that time the vent doors are switched to open position, systems stability can be verified, and the ground system is committed to launch.

(e) Requirements - The FWD fuselage annulus, RCS, OMS pods, drag chute, and Vertical Stab must be inerted with GN2 from ET cryo tanking through T-31 seconds. Minimum pressure ensures that the listed compartments are inerted adequately as well as thermally conditioned.

(f) Preplanned Contingency Procedures - If a violation occurs an inert environment needs to be reestablished as soon as possible to prevent the possibility of the accumulation of hazardous gases and to prevent environmental contamination of the payload and orbiter compartments.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Possible loss of the inert environment which could result in potential accumulation of hazardous gases and loss of thermal conditioning.
(9) Reference Integrated Hazard Report ISPR-03.

CAUSES OF EXCEEDING REDLINE:

(10) Duct and Interface Low:
- A. Loss of ECS flow control (fail close).
- B. Duct failure/Leakage.
  1. Connect point separation.
  2. Fracture of Orbiter/GSE purge duct components.

(11) Duct and Interface High:
- A. Impediment of flow in GSE Ducting, at Orbiter interface or internal Orbiter purge duct system.
- B. ECS GN2 system fail high.

(12) Duct High and Interface Low:
- A. Blockage between Duct and I/F Pressure Measurements.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	in.H2O								
GECP5F07A	0.552	0	138						
GECP8F03A	0.552	0	138						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: GSE SUBSYSTEM: PVD

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LCC VIOLATION CALL: Orbiter Payload Bay Purge Pressure Anomaly | EMERG COND: Yellow (11)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GECP5P07A	Orb PLB I/F Press Ind	1	30(2)	86(2)	InH2O	CI
		of	25(3)	86(3)	InH2O	CI
GECP8P03A	Orb PLB Duct Press Ind	2	31(2)	90(2)	InH2O	CI
			26(3)	90(3)	InH2O	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Minimum and maximum redlines for missions with all spigots closed.
(3) Minimum and maximum redlines for missions with the spigot #3 in open configuration in support of HST-SM4.

PREPLANNED CONTINGENCY PROCEDURE:

(4) -CAUTION-
Reestablish inert environment and thermal conditioning by performing GN2 flowrate adjustments (ref. V1122.004 and V1122.203).

NOTES:

(5) Loss of purge will adversely affect hazardous gas detection system (hydrogen/oxygen) readings.
(6) Orbiter compartments purged by PLB purge circuit #2. (Purge consists of gaseous nitrogen (GN2) for inerting and thermal conditioning.)
A. PLB compartment.
B. Lower mid fuselage.
C. R/H & L/H wing glove compartment(s).
D. (If configured) Cargo components.
E. Aft compartment (through 1307 bulkhead).
F. R/H & L/H wings (through Xo940 wing vent).
(7) Nominally, GECP5P07A is approximately 40 inch H2O at 170 lbs/min flowrate with spigots closed.
(8) Nominally, GECP8P03A is approximately 42 inch H2O at 170 lbs/min nominal with spigots closed.
(9) LCC for other open-spigot configurations will be evaluated on a mission specific basis as the configurations are identified.

REDLINE DERIVATION: CRITICALITY: 1S

(10) (a) SSID Intent Summary - The intent of this SSID is to ensure Orbiter PLB, Wing, and Aft compartments have an established GN2 inert atmosphere during cyrogenic loading. Depleted inert environment could result in potential accumulation of hazardous gases and loss of thermal

REDLINE DERIVATION: (Continued)

conditioning. The system is single fault tolerant.

(b) Voting Logic - Purge pressure output is monitored by two independent pressure transducers (I/F and Duct) downstream of the purge flow control valves. If one transducer fails the remaining transducer will still provide adequate purge monitoring capability. Failure of both transducers, with one outside of expected range and LCC limits and one indicating within nominal pressure range and LCC limits, is not considered credible.

(c) Minimum and Maximum Redline Derivation - A minimum flow rate of approximately 115 lbs/min ensures that the PLB/Midbody environment is inert. The minimum values are based on test data at a minimum required flow rate of approximately 115 lbs/min, plus accountability for instrumentation error.

The maximum Orb PLB I/F Press Ind value corresponds to the highest value obtainable without a flow distribution problem (i.e., impeded branch lines) or flow rate in excess of 240 lbs/min with spigots closed. These values are based on test data. The maximum Orb PLB Duct Press Ind value indicates the point at which a blockage or obstruction could prevent minimum inerting of the affected compartments.

(d) Time Effectivity - GN2 purge initiation begins at least at the start of cryo tanking (T-6 hrs). The LCC ends at T-31 seconds; at that time the vent doors are switched to open position, system stability can be verified, and the ground system is committed to launch.

(e) Requirements - The PLB compartment, lower mid fuselage, wing gloves, wings, and aft compartments must be inerted with GN2 from ET cryo tanking through T-31 seconds. Minimum pressure ensures that the listed compartments are inerted adequately as well as thermally conditioned.

(f) Preplanned Contingency Procedures - If a violation occurs an inert environment needs to be reestablished as soon as possible to prevent the possibility of the accumulation of hazardous gases and to prevent environmental contamination of the payload and orbiter compartments.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Possible loss of the inert environment which could result in potential accumulation of hazardous gases, loss of meaningful prelaunch hazardous gas data, and loss of thermal conditioning.
(12) Reference Integrated Hazard Report ISPR-03.

CAUSES OF EXCEEDING REDLINE:

(13) Duct and Interface Low:
A. Loss of ECS flow control (fail close).
B. Duct failure/Leakage.

CAUSES OF EXCEEDING REDLINE: (Continued)

1. Connect point separation.
2. Fracture of Orbiter/GSE purge duct components.

(14) Duct and Interface High:
A. Impediment of flow in GSE Ducting, at Orbiter interface or internal Orbiter purge duct system.
B. ECS GN2 system fail high.

(15) Duct High and Interface Low:
A. Blockage between Duct and I/F Pressure Measurements.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	in.H2O								
GECP5P07A	1.107	0	276.7						
GECP8P03A	1.108	0	277						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: GSE SUBSYSTEM: PVD

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LCC VIOLATION CALL: GSE PIC Rack Voltage Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GMSV1313A	Sys A CPA DC Volts	1 of	26	NA	Volts	CI
GMSV3313A	Sys A CPA DC Red Volts	2	26	NA	Volts	CI
GMSV2313A	Sys B CPA DC Volts	1 of	26	NA	Volts	CI
GMSV4313A	Sys B CPA DC Red Volts	2	26	NA	Volts	CI

TIME PERIOD:

(1) From System Activation (T-4 hours) to Go for APU Start (T-5 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) The PIC system must be up for launch with total functional redundancy. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) A failure prior to APU start will result in a Hold in order to perform a PIC resistance test to determine System status. Both system A and B must be verified operational prior to resumption of the countdown.

NOTES:

(4) Visibility of System performance is monitored by PIC voltages (SSIDs GSE-05, -06, -07) after the Launch Release system is armed at T-18 seconds.

REDLINE DERIVATION: CRITICALITY:

(5) 1978 LETF testing results indicated 26 volts minimum is necessary to yield 100% detonation. The nominal value is approximately 28 volts. Instrumentation error is accounted for in the test setup.
(6) CPA (Control Panel Assembly) logic power is required to charge and fire the PICs.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Redline violation indicates PIC system will not provide redundancy for HDP (Hold-Down Post), TSM (Tail-Service Mast) and ETVAS (ET Vent Arm System) pyrotechnic release.

CAUSES OF EXCEEDING REDLINE:

(8) A dc power supply malfunction.
(9) Although measurements are redundant, the electrical path from PIC rack to patch rack is a single point failure. Loss of PIC rack 6743 would result in loss of primary system A and redundant system B.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	Vdc								
GMSV1313A	.1176	0	29.4						
GMSV3313A	.1176	0	29.4						
GMSV2313A	.1176	0	29.4						
GMSV4313A	.1176	0	29.4						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: GSE SUBSYSTEM: EPD

LCC VIOLATION CALL: TSM PIC Cap Voltage Anomaly | EMERG COND: Yellow

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GMSV1309A	Sys A LH2 TSM PIC Cap Volts	1 of	35.7	NA	Volts	CI
GMSV3309A	Sys A LH2 TSM PIC Cap Red Volts	2	35.7	NA	Volts	CI
GMSV1310A	Sys A LO2 TSM PIC Cap Volts	1 of	35.7	NA	Volts	CI
GMSV3310A	Sys A LO2 TSM PIC Cap Red Volts	2	35.7	NA	Volts	CI
GMSV2309A	Sys B LH2 TSM PIC Cap Volts	1 of	35.7	NA	Volts	CI
GMSV4309A	Sys B LH2 TSM PIC Cap Red Volts	2	35.7	NA	Volts	CI
GMSV2310A	Sys B LO2 TSM PIC Cap Volts	1 of	35.7	NA	Volts	CI
GMSV4310A	Sys B LO2 TSM PIC Cap Red Volts	2	35.7	NA	Volts	CI

TIME PERIOD:

(1) From T-16 seconds to SRB Ignition (T-0)

REQUIREMENTS: FIGURES/TABLES:

(2) The PIC system must be up for launch with total functional redundancy mandatory.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) PIC arm performed by RSLS (T-18 sec) - LPS monitoring begins 2 sec after PIC arming to allow PICs to charge and to allow for instrumentation delays.

REDLINE DERIVATION: CRITICALITY:

(4) The Avionics Integration Panel has determined this minimum value to be all time all fire minimum voltage.
(5) The nominal value is approximately 38.3 volts.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Violation of redline indicates a PIC System failure which eliminates redundancy for pyro release of LH2/LO2 TSM umbilical.

CAUSES OF EXCEEDING REDLINE:

(7) PIC card failure.
(8) Single point failure - although measurements are redundant, path from PIC rack to patch rack is a single point failure. Loss of PIC rack 6743 would result in loss of primary system A and redundant system B.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	Vdc								
GMSV1309A	0.163	0	40.75						
GMSV3309A	0.163	0	40.75						
GMSV1310A	0.163	0	40.75						
GMSV3310A	0.163	0	40.75						
GMSV2309A	0.163	0	40.75						
GMSV4309A	0.163	0	40.75						
GMSV2310A	0.163	0	40.75						
GMSV4310A	0.163	0	40.75						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: GSE SUBSYSTEM: EPD

LCC VIOLATION CALL: ET Vent Arm PIC Cap Voltage Anomaly | EMERG COND: Yellow

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GMSV1311A	Sys A ETVAS PIC Cap Volts	1 of	35.7	NA	Volts	CI
GMSV3311A	Sys A ETVAS PIC Cap Red Volts	2	35.7	NA	Volts	CI
GMSV2311A	Sys B ETVAS PIC Cap Volts	1 of	35.7	NA	Volts	CI
GMSV4311A	Sys B ETVAS PIC Cap Red Volts	2	35.7	NA	Volts	CI

TIME PERIOD:

(1) From T-16 seconds to SRB ignition (T-0)

REQUIREMENTS: FIGURES/TABLES:

(2) The PIC System must be up for launch with total functional redundancy mandatory.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) PIC arm performed by RSLS (T-18 sec) - LPS monitoring begins 2 sec after PIC arming to allow PICs to charge and to allow for instrumentation delays.

REDLINE DERIVATION: CRITICALITY:

(4) The Avionics Integration Panel has determined this minimum voltage to be all time all fire minimum voltage.
(5) The nominal value is approximately 38.3 volts.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Violation of redline indicates a PIC System failure which eliminates redundancy for pyro release of ET vent arm.

CAUSES OF EXCEEDING REDLINE:

(7) PIC card failure.
(8) Single Point Failure - although measurements are redundant, path from PIC rack to patch rack is a single point failure. Loss of PIC rack 6743 would result in loss of primary system A and redundant system B.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	Vdc								
GMSV1311A	0.163	0	40.75						
GMSV3311A	0.163	0	40.75						
GMSV2311A	0.163	0	40.75						
GMSV4311A	0.163	0	40.75						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: GSE SUBSYSTEM: EPD

LCC VIOLATION CALL: SRB Hold Down Post PIC Cap Voltage Anomaly | EMERG COND: Yellow

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GMSV1301A	Sys A RH SRB HDP M1 PIC Cap Volts	1 of	35.7	NA	Volts	CI
GMSV3301A	Sys A RH HDP M1 PIC Cap Volts Red	2	35.7	NA	Volts	CI
GMSV1302A	Sys A RH SRB HDP M2 PIC Cap Volts	1 of	35.7	NA	Volts	CI
GMSV3302A	Sys A RH HDP M2 PIC Cap Volts Red	2	35.7	NA	Volts	CI
GMSV1303A	Sys A RH SRB HDP M3 PIC Cap Volts	1 of	35.7	NA	Volts	CI
GMSV3303A	Sys A RH HDP M3 PIC Cap Volts Red	2	35.7	NA	Volts	CI
GMSV1304A	Sys A RH SRB HDP M4 PIC Cap Volts	1 of	35.7	NA	Volts	CI
GMSV3304A	Sys A RH HDP M4 PIC Cap Volts Red	2	35.7	NA	Volts	CI
GMSV1305A	Sys A LH SRB HDP M5 PIC Cap Volts	1 of	35.7	NA	Volts	CI
GMSV3305A	Sys A LH HDP M5 PIC Cap Volts Red	2	35.7	NA	Volts	CI
GMSV1306A	Sys A LH SRB HDP M6 PIC Cap Volts	1 of	35.7	NA	Volts	CI
GMSV3306A	Sys A LH HDP M6 PIC Cap Volts Red	2	35.7	NA	Volts	CI
GMSV1307A	Sys A LH SRB HDP M7 PIC Cap Volts	1 of	35.7	NA	Volts	CI
GMSV3307A	Sys A LH HDP M7 PIC Cap Volts Red	2	35.7	NA	Volts	CI
GMSV1308A	Sys A LH SRB HDP M8 PIC Cap Volts	1 of	35.7	NA	Volts	CI
GMSV3308A	Sys A LH HDP M8 PIC Cap Volts Red	2	35.7	NA	Volts	CI
GMSV2301A	Sys B RH SRB HDP M1 PIC Cap Volts	1 of	35.7	NA	Volts	CI
GMSV4301A	Sys B RH HDP M1 PIC Cap Volts Red	2	35.7	NA	Volts	CI
GMSV2302A	Sys B RH SRB HDP M2 PIC Cap Volts	1 of	35.7	NA	Volts	CI
GMSV4302A	Sys B RH HDP M2 PIC Cap Volts Red	2	35.7	NA	Volts	CI
GMSV2303A	Sys B RH SRB HDP M3 PIC Cap Volts	1 of	35.7	NA	Volts	CI
GMSV4303A	Sys B RH HDP M3 PIC Cap Volts Red	2	35.7	NA	Volts	CI
GMSV2304A	Sys B RH SRB HDP M4 PIC Cap Volts	1 of	35.7	NA	Volts	CI
GMSV4304A	Sys B RH HDP M4 PIC Cap Volts Red	2	35.7	NA	Volts	CI
GMSV2305A	Sys B LH SRB HDP M5 PIC Cap Volts	1 of	35.7	NA	Volts	CI
GMSV4305A	Sys B LH HDP M5 PIC Cap Volts Red	2	35.7	NA	Volts	CI
GMSV2306A	Sys B LH SRB HDP M6 PIC Cap Volts	1 of	35.7	NA	Volts	CI
GMSV4306A	Sys B LH HDP M6 PIC Cap Volts Red	2	35.7	NA	Volts	CI
GMSV2307A	Sys B LH SRB HDP M7 PIC Cap Volts	1 of	35.7	NA	Volts	CI
GMSV4307A	Sys B LH HDP M7 PIC Cap Volts Red	2	35.7	NA	Volts	CI
GMSV2308A	Sys B LH SRB HDP M8 PIC Cap Volts	1 of	35.7	NA	Volts	CI
GMSV4308A	Sys B LH HDP M8 PIC Cap Volts Red	2	35.7	NA	Volts	CI

TIME PERIOD:

(1) From T-16 seconds to SRB Ignition (T-0)

REQUIREMENTS: FIGURES/TABLES:

(2) The PIC System must be up for launch with total functional redundancy mandatory.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) PIC arm performed by RSLS (T-18 sec) - LPS monitoring begins 2 sec after PIC arming to allow PICs to charge and to allow for instrumentation delays.

REDLINE DERIVATION: CRITICALITY:

(4) The Avionics Integration Panel has determined this minimum value to be all time all fire minimum voltage.
(5) The nominal value is approximately 38.3 volts.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Violation of redline indicates a PIC System failure which eliminates redundancy for pyro release of SRB HDP (M1, M2, M3, M4, M5, M6, M7, M8).

CAUSES OF EXCEEDING REDLINE:

(7) PIC card failure.
(8) Single point failure - although measurements are redundant, path from PIC rack to patch rack is a single point failure. Loss of PIC rack 6743 would result in loss of primary system A and redundant system B.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	Vdc								
GMSV1301A	0.163	0	40.75						
GMSV3301A	0.163	0	40.75						
GMSV1302A	0.163	0	40.75						
GMSV3302A	0.163	0	40.75						
GMSV1303A	0.163	0	40.75						
GMSV3303A	0.163	0	40.75						
GMSV1304A	0.163	0	40.75						
GMSV3304A	0.163	0	40.75						
GMSV1305A	0.163	0	40.75						
GMSV3305A	0.163	0	40.75						
GMSV1306A	0.163	0	40.75						
GMSV3306A	0.163	0	40.75						
GMSV1307A	0.163	0	40.75						
GMSV3307A	0.163	0	40.75						
GMSV1308A	0.163	0	40.75						
GMSV3308A	0.163	0	40.75						
GMSV2301A	0.163	0	40.75						
GMSV4301A	0.163	0	40.75						
GMSV2302A	0.163	0	40.75						
GMSV4302A	0.163	0	40.75						
GMSV2303A	0.163	0	40.75						
GMSV4303A	0.163	0	40.75						
GMSV2304A	0.163	0	40.75						
GMSV4304A	0.163	0	40.75						
GMSV2305A	0.163	0	40.75						
GMSV4305A	0.163	0	40.75						
GMSV2306A	0.163	0	40.75						
GMSV4306A	0.163	0	40.75						
GMSV2307A	0.163	0	40.75						
GMSV4307A	0.163	0	40.75						
GMSV2308A	0.163	0	40.75						
GMSV4308A	0.163	0	40.75						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: GSE SUBSYSTEM: EPD

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LCC VIOLATION CALL: H2 Burn System PIC Rack Voltage Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GMSV5313A	H2-Burn Sys A CPA DC Volts	1 of	26	NA	Volts	CI
GMSV7313A	Sys A H2-Burn CPA DC Red Volts	2	26	NA	Volts	CI
GMSV6313A	H2-Burn Sys B CPA DC Volts	1 of	26	NA	Volts	CI
GMSV8313A	Sys B H2-Burn CPA DC Red Volts	2	26	NA	Volts	CI

TIME PERIOD:

(1) From System Activation (T-4 hours) to Go For APU Start (T-5 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) The PIC system must be up for launch with total functional redundancy. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) A failure prior to APU start will result in a Hold in order to perform PIC resistance tests to determine System status. Both system A and B must be verified operational prior to resumption of the countdown.

NOTES:

(4) Visibility of System performance is monitored by PIC voltages (SSIDs GSE-09, -20) after the H2 BURN system is armed at T-55 seconds.

REDLINE DERIVATION: CRITICALITY:

(5) 1978 LETF testing results indicated 26 volts minimum is necessary to yield 100% detonation. The nominal value is approximately 28 volts. Instrumentation error is accounted for in the test setup.
(6) CPA (Control Panel Assembly) logic power is required to charge and fire the PICs.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Violation of redline indicates PIC system will not provide redundancy for free hydrogen burn resulting in Orbiter base heatshield overpressurization at SSME ignition.

CAUSES OF EXCEEDING REDLINE:

(8) A dc power supply malfunction.
(9) Although measurements are redundant, the electrical path from PIC rack to patch rack is a single point failure. Loss of PIC rack 6744 would result in loss of primary system A and redundant system B.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	Vdc								
GMSV5313A	.1176	0	29.4						
GMSV7313A	.1176	0	29.4						
GMSV6313A	.1176	0	29.4						
GMSV8313A	.1176	0	29.4						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: GSE SUBSYSTEM: EPD

LCC VIOLATION CALL: Hydrogen Burn System PIC Cap Voltage Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GMSV5309A	H2-Burn Sys A Eng 2 Cap Volts	1 of	35.7	NA	Volts	CI
GMSV5319A	H2-Burn Sys A Eng 2 Cap Volts Red	2	35.7	NA	Volts	CI
GMSV5310A	H2-Burn Sys A Eng 3 Cap Volts	1 of	35.7	NA	Volts	CI
GMSV5320A	H2-Burn Sys A Eng 3 Cap Volts Red	2	35.7	NA	Volts	CI
GMSV5311A	H2-Burn Sys A Eng 1 Cap Volts	1 of	35.7	NA	Volts	CI
GMSV5321A	H2-Burn Sys A Eng 1 Cap Volts Red	2	35.7	NA	Volts	CI
GMSV6309A	H2-Burn Sys B Eng 2 Cap Volts	1 of	35.7	NA	Volts	CI
GMSV6319A	H2-Burn Sys B Eng 2 Cap Volts Red	2	35.7	NA	Volts	CI
GMSV6310A	H2-Burn Sys B Eng 3 Cap Volts	1 of	35.7	NA	Volts	CI
GMSV6320A	H2-Burn Sys B Eng 3 Cap Volts Red	2	35.7	NA	Volts	CI
GMSV6311A	H2-Burn Sys B Eng 1 Cap Volts	1 of	35.7	NA	Volts	CI
GMSV6321A	H2-Burn Sys B Eng 1 Cap Volts Red	2	35.7	NA	Volts	CI

TIME PERIOD:

(1) After Systems ARM (T-50 seconds) to Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) H2-Burn Pyrotechnic Initiator Controllers (PICs) are armed at T-55 seconds. Launch Processing System (LPS) monitoring starts at T-50 seconds.

REDLINE DERIVATION: CRITICALITY: 1R

(3) a. SSID Intent Summary - The purpose of this redline is to ensure the PICs are properly armed (charged) prior to the ignition of the H2 Burn ordnance. If an H2 Burn igniter does not get properly armed and fired, then expelled/accumulated hydrogen in the area would not be burned off prior to Main Engine Start. There are six H2 Burn igniters, two for each main engine. Each igniter is started by a NASA Standard Initiator (NSI) and a PIC. The PIC capacitor voltage is the only means available to verify that the PIC has been armed.

b. Voting Logic - The 1 of 2 voting logic for H2 Burn capacitor voltages accommodates a single instrumentation failure per PIC while ensuring the visibility required to verify that each PIC remains charged prior to

REDLINE DERIVATION: (Continued)

firing it is maintained.

c. Minimum and Maximum Redline Development - Based upon the PIC specification MC450-0018 and allowing for a +/- 2 count instrumentation error, 35.7 VDC has been determined to be the minimum voltage for a lower limit indication when a PIC has been armed. The Avionics Integration Panel has determined this minimum value to be all time all fire minimum voltage.

d. Time Period - T-50 seconds start time chosen to begin monitoring H2 Burn capacitor volts just after the ARM commands are issued at T-55 seconds (providing a minimum 2 second charge time). T-10 second stop time chosen because the FIRE commands are sent at that time to start the igniters prior to Main Engine Start at T-6.6 seconds.

e. Requirements - Full System A and System B PIC redundancy is required for all engine PICs. One of two measurement verification for each PIC CAP Voltage ensures redundancy is maintained.

f. Preplanned Contingency Procedure - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(4) Possible damage to orbiter heat shield because of overpressure.
(5) Damage to SSME nozzle.

CAUSES OF EXCEEDING REDLINE:

(6) Equipment malfunction (PIC Rack, Control Power Assembly (CPA)).
(7) Instrumentation error.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	Vdc								
GMSV5309A	0.163	0	40.75						
GMSV5319A	0.163	0	40.75						
GMSV5310A	0.163	0	40.75						
GMSV5320A	0.163	0	40.75						
GMSV5311A	0.163	0	40.75						
GMSV5321A	0.163	0	40.75						
GMSV6309A	0.163	0	40.75						
GMSV6319A	0.163	0	40.75						
GMSV6310A	0.163	0	40.75						
GMSV6320A	0.163	0	40.75						
GMSV6311A	0.163	0	40.75						
GMSV6321A	0.163	0	40.75						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: GSE SUBSYSTEM: EPD

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LCC VIOLATION CALL: Orbiter Access Arm Accumulator GN2 Pressure Anomaly | EMERG COND: Yellow (13)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GSAX7731E	OAA 3000 psi GN2 Press Sw-Normal	(1)	ON (3)	NA	Event	CI
		(2)	ON (3)	NA	Event	DI
GSAX7736E	OAA 3000 psi GN2 Press Sw-Normal	(1)	ON (3)	NA	Event	CI
		(2)	ON (3)	NA	Event	DI
GSAP7801A	OAA 2700 psi GN2 Press Transducer	(1)	2000(3)	2800(4)	psi	CI
		(2)	2000(3)	NA	psi	DI
GSAP7806A	OAA 2700 psi GN2 Press Transducer	(1)	2000(3)	2800(4)	psi	CI
		(2)	2000(3)	NA	psi	DI

TIME PERIOD:

(1) From Accumulator Forced Recharge (approximately T-2 hours) to prior to OAA Retract (T-7 minutes, 30 seconds)
(2) Verify after completion of accumulator recharge (approximately T-3 minutes).

REQUIREMENTS: FIGURES/TABLES:

(3) 1 of 4 Measurements required for verification of Minimum Redline. (5,6)
(4) 1 of 2 Measurements required for verification of Maximum Redline. (7)

PREPLANNED CONTINGENCY PROCEDURE:

(5) For indications of low GN2 pressure, check GN2 charging valve:
(GSAX7101E/GSAX7106E OPEN & GSAX7102E/GSAX7107E CLOSED)
- If valve indicates CLOSED, command GN2 charging valve OPEN. If either transducer or pressure switch measurement indicates acceptable GN2 pressure, LCC violation cleared, continue countdown.

(6) For indications of low GN2 pressure prior to Orbiter Access Arm (OAA) retract (after verifying charging valve is OPEN), assemble Red Crew to adjust GN2 regulator to increase pressure. If at least one measurement indicates acceptable GN2 pressure, LCC violation cleared, continue countdown.
(7) For indications of high GN2 pressure prior to OAA retract, assemble Red Crew to vent GN2 pressure from accumulator and, if required, adjust GN2 regulator to decrease pressure. If at least one transducer measurement indicates acceptable GN2 pressure, LCC violation cleared, continue countdown.

NOTES:

(8) Indications of high GN2 pressure after retract/recharge, with no violation of GSE-11, does not constitute an LCC violation.
(9) OAA Accumulator GN2 Pressure is monitored by pressure switch A101442 and pressure transducer A101441. Nominal operating pressure is 2650 psi.

REDLINE DERIVATION: CRITICALITY:

(10) a. SSID Intent Summary - The purpose of this requirement is to ensure OAA Accumulators have the correct GN2 pressure to ensure OAA retraction and emergency extension. OAA Accumulator GN2 pressure is monitored by a pressure switch and a pressure transducer. The output for each device is split into two MSID indications using independent Hardware Interface Modules (HIMs) and Launch Processing System (LPS) paths.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - The minimum redline of 2000 psi for the OAA 2700 psi GN2 Press Transducer(s) ensures there is enough pressure for a 30 second emergency extend of the OAA. The minimum redline of ON for the OAA 2700 psi GN2 Press Switch(s)is another way of verifying that adequate pressure exists for a 30 second emergency extend.

The maximum redline of 2800 psi for the OAA 2700 psi GN2 Press Transducer(s) was chosen because successful hydraulic recharge of accumulators after OAA retract can not be assured above these pressures.

d. Time Period - The OAA accumulator is recharged at T-2 hours and the OAA is retracted at T-7 minutes, 30 seconds. A one time verification at approximately T-3 minutes is sufficient to ensure accumulator recharge for emergency OAA extend.

e. Requirements - Only one measurement is needed to verify adequate pressure for OAA retract or emergency extend. Only one of the OAA 2700 psi GN2 Press Transducer(s) is required to verify the maximum redline requirement.

f. Preplanned Contingency Procedures - The GN2 Charging Valve needs to be open and the GN2 Supply Regulator needs to be properly set to ensure the GN2 accumulator is at the right pressure. The pre-planned procedures return the system to the correct configuration so launch countdown can continue.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Improper pressure indications (before retract) suggest that the hydraulic accumulators are not within normal operating pressure parameters and may not support a normal OAA retraction or extension within the required time frames.
(12) Retract/extend can be accomplished with hydraulic pressure supplied by the Hydraulic Charging Unit (HCU), without any accumulators, provided the hydraulic system does not have a gross external leak. However, extend time may be greater than 30 seconds without stored accumulator pressure (ref OMRS G51FEGPAO.012 for Pad A, or G61FEGPAO.012 for Pad B).
(13) Loss of safe Crew egress route from Orbiter to Fixed Service Structure (FSS) if OAA is not extended and locked.

CAUSES OF EXCEEDING REDLINE:

(14) Fault in the GN2 regulation system.
(15) Significant GN2 leakage.
(16) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	psi								
GSAP7801A	16	0	4000						
GSAP7806A	16	0	4000						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: GSE SUBSYSTEM: ARMS

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LCC VIOLATION CALL: OAA Hydraulic Accumulator Level Anomaly | EMERG COND: Yellow (12)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	PRIMARY MEASUREMENTS:					
GSAX7651E	OAA Accum Level Sw No 1-Normal	(1,2)	ON	NA	Event	CI
GSAX7671E	OAA Accum Level Sw No 2-Normal	(1,2)	ON	NA	Event	CI
GSAX7691E	OAA Accum Level Sw No 3-Normal	(1,2)	ON	NA	Event	CI
GSAX7711E	OAA Accum Level Sw No 4-Normal	(1,2)	ON	NA	Event	CI
	SECONDARY MEASUREMENTS:					
GSAX7656E	OAA Accum Level Sw No 1-Normal	(1,2)	ON	NA	Event	CI
GSAX7676E	OAA Accum Level Sw No 2-Normal	(1,2)	ON	NA	Event	CI
GSAX7696E	OAA Accum Level Sw No 3-Normal	(1,2)	ON	NA	Event	CI
GSAX7716E	OAA Accum Level Sw No 4-Normal	(1,2)	ON	NA	Event	CI

TIME PERIOD:

(1) From Accumulator Forced Recharge (approximately T-2 hours) to prior to OAA retract (T-7 minutes, 30 seconds). (3)
(2) After completion of accumulator recharge (approximately T-3 minutes) to Go for RSLS Start (T-31 seconds). (4)

REQUIREMENTS: FIGURES/TABLES:

(3) 2 of 4 primary measurements or 2 of 4 secondary measurements are required ON. (5)
(4) 1 of 4 primary measurements or 1 of 4 secondary measurements are required ON. (6)

PREPLANNED CONTINGENCY PROCEDURE:

(5) Prior to Orbiter Access Arm (OAA) retract, if the hydraulic accumulator level switch(s) indicates OFF, the console operator may perform a manual recharge (Ref S0007 Volume 5 and V2153). If the hydraulic accumulator level switch(s) indicate ON, then LCC violation cleared, continue countdown.
(6) After OAA retract and accumulator recharge, if the hydraulic accumulator level switch(s) indicates OFF, the console operator may perform a manual recharge. If unable to attain 1 of 4 accumulator level switch ON indications, utilize Pressure vs. Volume chart to verify sufficient fluid volume (10 gallons minimum) remains for OAA re-extend (Ref S0007 Volume 5 and V2153). If either the hydraulic accumulator level switch(s) indicate ON or the Pressure vs. Volume chart indicates sufficient volume for OAA re-extend, then LCC violation cleared, continue countdown.

NOTES:

(7) OAA can support nominal extend (30 seconds max) or retract (105 - 140 seconds) if GN2 pressure is above 2000 psi (reference GSE-10) and one accumulator level is normal.

NOTES: (Continued)

(8) There are four hydraulic accumulators that are used to extend or retract the OAA. Each accumulator can hold 10 gallons of hydraulic fluid. The OAA Accumulator Level Switches only register when the accumulator is full of hydraulic fluid.

	Accumulator	Level Switch
#1	A101321	A101314
#2	A101322	A101316
#3	A101323	A101318
#4	A101324	A101320

REDLINE DERIVATION: CRITICALITY:

(9) a. SSID Intent Summary - The purpose of this requirement is to ensure adequate hydraulic fluid volume to retract and/or re-extend the OAA. The OAA Accumulator Level Switches are a means of measuring the volume of fluid in each of the four hydraulic accumulators. The output for each switch is split into a Primary and Secondary MSID indication using independent Hardware Interface Modules (HIMs) and Launch Processing System (LPS) paths.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - OAA Accumulator Level Switches remotely measure the amount of hydraulic fluid in the hydraulic accumulators. The minimum redline of ON means that the respective accumulator is completely full of hydraulic fluid.

d. Time Period - The accumulators are charged at approximately T-2 hours and are at stable values until OAA Retract at T-7 minutes, 30 seconds. After OAA retract the accumulators are recharged and are at stable values at approximately T-3 minutes and committed for launch at T-31 seconds.

e. Requirements - Prior to retract, two accumulators indicating NORMAL are required to ensure a complete retract/extend cycle. Following retract, one accumulator indicating NORMAL is required to ensure an emergency extension. Either the Primary or Secondary MSID's may be used to verify the required accumulator volume measurements.

f. Preplanned Contingency Procedures - Procedures exist to manually recharge the hydraulic accumulators and/or verify sufficient fluid volume exists for OAA re-extend by data extrapolation.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Improper level indications on more than two accumulators (before retract) suggest that the hydraulic accumulators are not within normal operating volume parameters and may not support a normal OAA retraction or extension within the required time frames.

CONSEQUENCES OF EXCEEDING REDLINE: (Continued)

(11) Retract/extend can be accomplished with hydraulic pressure supply from the Hydraulic Charging Unit (HCU), without any accumulators, provided the hydraulic system does not have a gross external leak. However, extend time may be greater than 30 seconds without stored accumulator pressure (ref OMRS G51FEGPAO.012 for Pad A, or G61FEGPAO.012 for Pad B).
(12) Loss of safe Crew Egress Route from Orbiter to FSS if OAA is not Extended and Locked.

CAUSES OF EXCEEDING REDLINE:

(13) Fault in hydraulic fill system, or leaking accumulators.
(14) Gross external leak in the hydraulic system.
(15) Instrumentation failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: GSE SUBSYSTEM: ARMS

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LCC VIOLATION CALL: OAA Retract Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GSAX7621E	OAA Pri Fully Rtr Sw-Retracted	2	ON	NA	Event	CI
GSAX7622E	OAA Sec Fully Rtr Sw-Retracted	of	ON	NA	Event	CI
GSAH7831A	OAA Position Indication	3	NA	2 (2)	Deg	CI
	OR					
GSAX7626E	OAA Pri Fully Rtr Sw-Retracted	2	ON	NA	Event	CI
GSAX7627E	OAA Sec Fully Rtr Sw-Retracted	of	ON	NA	Event	CI
GSAH7836A	OAA Position Indication	3	NA	2 (2)	Deg	CI

TIME PERIOD:

(1) From OAA Retract Indication (approx T-5 minutes) to Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) Using Operational Television (OTV), verify the Orbiter Access Arm (OAA) is overlapping the skid weldment by at least 5 feet. If OAA position is acceptable, LCC violation cleared, continue countdown.

NOTES:

(3) OAA retracted switches A103 and A105 indicate if the OAA is fully retracted on the latchback assembly. OAA position indicator A130006 monitors the rotational position of the OAA.

REDLINE DERIVATION: CRITICALITY:

(4) a. SSID Intent Summary - The purpose of this requirement is to ensure the OAA is safely retracted to avoid potential interference with the shuttle vehicle during liftoff. There are two retract switches and one position indicator that monitor the position of the OAA. The output for each device is split into two MSID indications (Primary and Secondary) using independent Hardware Interface Modules (HIMs) and Launch Processing System (LPS) paths.

b. Voting Logic - Two of three measurements required to verify OAA retraction.

c. Minimum and Maximum Redline Development - The OAA Primary and Secondary Fully Retract Switch is activated when the OAA is fully retracted. The minimum redline requirement of ON means the OAA has been fully retracted. There is not a maximum redline requirement for the

REDLINE DERIVATION: (Continued)

retract switch. The OAA Position Indicator maximum redline requirement of 2 degrees corresponds to a sufficiently retracted OAA which will not contact the vehicle during launch. There is not a minimum redline requirement for this measurement.

d. Time Period - The OAA is retracted at T-7 minutes, 30 seconds and should be fully retracted at approximately T-5 minutes. The end time of T-10 seconds protects against inadvertent OAA extension which could potentially contact the orbiter during lift-off.

e. Requirements - NA

f. Preplanned Contingency Procedures - Visual observation using OTV cameras can be used to determine if the OAA position is acceptable. The OAA is sufficiently retracted to avoid contact with the vehicle when it overlaps the skid weldment by at least 5 feet.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) The OAA may be at rest, away from the latchback assembly, and could potentially result in vehicle interference during lift-off.

CAUSES OF EXCEEDING REDLINE:

(6) OAA may not be fully retracted.
(7) Failure of switches A103 and A105 or potentiometer A130006.
(8) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
UNITS-->	deg								
GSAH7831A	0.28	0	70						
GSAH7836A	0.28	0	70						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: GSE SUBSYSTEM: ARMS

LCC VIOLATION CALL: GOX Vent Arm Retract Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GSAX8221E	6308A103 Retract Switch No.1	2	ON	NA	Event	CI
GSAX8222E	6308A102 Retract Switch No.2	of	ON	NA	Event	CI
GSAH8191A	A133566 Arm Position Indication	3	NA	2 (2)	Deg	CI
	OR					
GSAX8226E	6308A103 Retract Switch No.1	2	ON	NA	Event	CI
GSAX8227E	6308A102 Retract Switch No.2	of	ON	NA	Event	CI
GSAH8196A	A133566 Arm Position Indication	3	NA	2 (2)	Deg	CI

TIME PERIOD:

(1) Approximately T-40 seconds to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) Using Operational Television (OTV), verify GOX Vent Arm (GVA) hood is entirely overlapping the Seal Access Platform. If GVA position is acceptable, LCC violation cleared, continue countdown.

NOTES:

(3) GVA retracted switches A102 and A103 indicate if the GVA is fully retracted on the latchback assembly. GVA position indicator A133566 monitors the rotational position of the GVA.

(4) If prior to retract (T-2min 50sec), the GVA Hydraulic GN2 pressure indications both fail (transducer and switch), while 2 of 3 hydraulic accumulators indicate OK (indicating sufficient hydraulic supply), the Hydraulic Charging Unit may be used to assist GVA retraction by opening the Hydraulic Supply Valve (A133472). ref: S0007.500.

REDLINE DERIVATION: CRITICALITY: 3

(5) a. SSID Intent Summary - The purpose of this requirement is to ensure the GVA is safely retracted to avoid potential interference with the shuttle vehicle during liftoff. Monitoring of the retract indications confirms successful GVA retraction. Fault tolerance is provided by two retract switches and one position indicator that monitor the position of the GVA. 2 of 3 indications are required to verify GVA position. Additional fault protection is provided by the output for each switch being split into two MSID indications (Primary and Secondary) using independent Hardware Interface Modules (HIMs) and Launch Processing System (LPS) paths.

REDLINE DERIVATION: (Continued)

b. Voting Logic - Two of three measurements from either HIM/LPS path are required to verify the GVA is fully retracted and clear of the vehicle. Redundancy is provided by using two separate switch assemblies that are side by side on the Arm latchback.

c. Minimum and Maximum Redline Development - The GVA Primary and Secondary Fully Retract Switch is activated when the GVA is fully retracted. The minimum redline requirement of ON means the GVA has been fully retracted. There is not a maximum redline requirement for the retract switch. The GVA Position Indicator maximum redline requirement of 2 degrees corresponds to a sufficiently retracted GVA which will not contact the vehicle during launch. There is not a minimum redline requirement for this measurement.

d. Time Period - LCC monitoring effectivity starts at approximately T-40 seconds to allow for all nominal, or contingency, automated operations to complete, if required (ie. switching from primary to secondary systems for Hood raise and Arm retract). The ending time effectivity of T-31 seconds is appropriate because after successful retraction, the GVA is mechanically fixed via a locking mechanism and hydraulically locked in retract mode to prevent any possibility of inadvertent re-extension.

e. Requirements - N/A

f. Preplanned Contingency Procedures - Visual observation using OTV cameras can be used to determine if the GVA position is acceptable for launch. The GVA is sufficiently retracted to avoid contact with the vehicle when the GVA hood completely overlaps the Seal Access Platform.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) The GVA may be at rest, away from the latchback assembly, and could potentially result in vehicle interference during lift-off.
(7) Reference Launch and Landing Hazard Report LL-0125 (Impact/Collision of the GOX Vent Arm Hood with the External Tank due to undetected structural damage could result in loss of life/vehicle)

CAUSES OF EXCEEDING REDLINE:

(8) GVA may not be fully retracted.
(9) Failure of switches A102, A103 or potentiometer A133566.
(10) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	deg								
GSAH8191A	0.292	0	73						
GSAH8196A	0.292	0	73						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: GSE SUBSYSTEM: LACC

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LCC VIOLATION CALL: Sound Suppression Water Valve Actuation Pressure Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GWDPPT01A	SS Pneu Press Trans PT1 Status	1 of	1200	1700	psig	CI
GWDPPT02A	SS Pneu Press Trans PT2 Status	2	1200	1700	psig	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) To Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) Complex Control Center (CCC) monitors comparable measurements.
(3) Control transferred from CCC to FR at T-9 hours, 15 minutes.

REDLINE DERIVATION: CRITICALITY:

(4) Below minimum redline, 48" Sound Suppression (SS) valves cannot be opened per pad testing.
(5) Above maximum redline, 48" valves may be damaged (relief valve setting is 1705 psig).
(6) Nominal operating pressure is 1500 psig.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Component failure (above maximum redline).
(8) If 48" valves fail to open, possible damage to vehicle and payload (below minimum redline).

CAUSES OF EXCEEDING REDLINE:

(9) Failure of redundant GN2 supply system.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	psig								
GWDPPT01A	12	0	3000						
GWDPPT02A	12	0	3000						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: GSE SUBSYSTEM: ARMS

LCC VIOLATION CALL: Sound Suppression Water Tank Level Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GWDQPT83A	SS Tank Water Level Status	1 of	258.2	NA (5)	Ft	CI
GWDQPT84A	SS Tank Water Level Status	2(2)	258.2	NA (5)	Ft	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) For failure of both measurements, use overflow capability to determine tank level.

NOTES:

(3) Complex Control Center (CCC) monitors comparable measurements.
(4) Control transferred from CCC to Firing Room (FR) at T-9 hours, 15 minutes.
(5) Maximum redline not applicable because of the presence of overflow capability of the SS water tank.

REDLINE DERIVATION: CRITICALITY:

(6) Minimum level required to supply the sound suppression water system and to guarantee full water flow for the time period duration from SSME start thru SRB ignition and lift-off.
(7) Nominal value is 260 ft.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Minimum redline indicates loss of SS water (possible damage to vehicle and payload).

CAUSES OF EXCEEDING REDLINE:

(9) Leaking 48" SS valve.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	ft								
GWDQPT83A	1.35	0	270						
GWDQPT84A	1.35	0	270						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: GSE SUBSYSTEM: ARMS

LCC VIOLATION CALL: Firing Room/Launch Processing System Command Bus Control Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GWDXPT24E	PTCR FR SS Cmd Bus On Ind	1 of	ON	NA	Event	DI
GWDXPT26E	PTCR FR SS Cmd Bus On Ind	2	ON	NA	Event	DI

TIME PERIOD:

(1) Verify after initiation of FR Cmd Bus "On" (T-50 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) If unable to verify Sound Suppression Firing Room Command Bus is ON, console operator may attempt to send the bus on commands and/or cycle the Prelift-off vent valves in order to verify the command bus is ON. Reference OMI S0007, Volume V, Sound Suppression FR Command Bus Failure. If the command bus is verified operational, LCC violation cleared, continue countdown.

NOTES:

(3) Complex Control Center (CCC) monitors comparable measurements.
(4) Busses commanded on by GLS at T-1 minute, 15 seconds.

REDLINE DERIVATION: CRITICALITY:

(5) Firing Room (FR) must have FR Cmd Bus ON to initiate sound suppression valve commands that occur at T-28 seconds (prelift-off vent valves) and T-16 seconds (prelift-off valves and postlift-off vent valves).

CONSEQUENCES OF EXCEEDING REDLINE:

(6) FR cannot open 48" prelift-off valves; possible damage to vehicle and payload.

CAUSES OF EXCEEDING REDLINE:

(7) Hardware malfunction.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: GSE SUBSYSTEM: ARMS

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LCC VIOLATION CALL: Sound Suppression Solenoid Power Bus Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GWDXPT29E	SS Sol Pwr Bus On Ind	1 of	ON	NA	Event	CI
GWDXPT53E	SS Sol Pwr Bus On Ind	2	ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go For RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) If unable to verify Sound Suppression Solenoid Power Bus is ON, console operator may attempt to send the bus on commands and/or cycle the Pre-lift-off vent valves in order to verify the power bus is ON. Reference OMI S0007, Volume V, Sound Suppression Solenoid Power Bus Failure. If the solenoid power bus is verified operational, LCC violation cleared, continue countdown.

NOTES:

(3) Control transferred from Complex Control Center (CCC) to Firing Room (FR) at T-9 hours, 15 minutes.
(4) CCC monitors comparable measurements.

REDLINE DERIVATION: CRITICALITY:

(5) Solenoid valves require solenoid power bus ON for operation at T-28 sec (prelift-off vent valves), T-16 sec (prelift-off valves and postlift-off vent valves), and T-0 (postlift-off valves).

CONSEQUENCES OF EXCEEDING REDLINE:

(6) 48" prelift-off and postlift-off valves would not come open, possible damage to vehicle and payload.
(7) Loss of T-0 water will result in an acoustic increase of 1 dB to 3 dB with resulting potential life impact on avionics boxes, elevons, body flap, vertical stabilizer and a potential violation of NSTS 07700 Volume XIV, Space Shuttle System Payload Accommodations.

CAUSES OF EXCEEDING REDLINE:

(8) Hardwire malfunction.
(9) Circuit breaker malfunction.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: GSE SUBSYSTEM: ARMS

LCC VIOLATION CALL: Sound Suppression Postlift-off Vent Valve Open Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GWDXPT55E	SS Postlftf Vent Vlv SV8 Op Ind	2	ON	NA	Event	DI
GWDXPT56E	SS Postliftoff Vent Vlv SV9 Op Ind	of	ON	NA	Event	DI
GWDXPT57E	SS Pstlftf Vent Vlv SV10 Op Ind	3	ON	NA	Event	DI

TIME PERIOD:

(1) Verify Prior To Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) Post L/O vent valves are commanded ON by GLS at T-16 seconds.
(3) Complex Control Center (CCC) monitors comparable measurements.

REDLINE DERIVATION: CRITICALITY:

(4) 48" postlift-off sound suppression valves cannot be opened without venting close pressure through at least two valves, per Pad A testing.
(5) Loss of T-0 water will result in an acoustic increase of 1 db to 3 db with resulting potential life impact on avionics boxes, elevons, body flap, vertical stabilizer and a potential violation of Volume XIV, Payload Bay Design Environment.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) 48" postlift-off sound suppression valves fail to open with possible damage to vehicle/payload.

CAUSES OF EXCEEDING REDLINE:

(7) Component failure.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: GSE SUBSYSTEM: ARMS

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LCC VIOLATION CALL: Sound Suppression Prelift-off Valves Open Indication Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GWDXPT70E	SS Preliftoff Vlv-LS V27 Op Ind	2	ON	NA	Event	DI
GWDXPT72E	SS Preliftoff Vlv-LS V26 Op Ind	of	ON	NA	Event	DI
GWDXPT74E	SS Preliftoff Vlv-LS V25 Op Ind	3	ON	NA	Event	DI

TIME PERIOD:

(1) Verify Prior To Go For SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) Prelift-off valves commanded on at T-16 seconds.
(3) Complex Control Center (CCC) monitors comparable measurements.

REDLINE DERIVATION: CRITICALITY:

(4) Two valves open allows the Sound Suppression system to meet flow requirements.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Possible damage to vehicle and payload.

CAUSES OF EXCEEDING REDLINE:

(6) GN2 pressure below minimum required for valve actuation.
(7) Failure of hydraulic portion of valve actuator.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: GSE SUBSYSTEM: ARMS

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LCC VIOLATION CALL: ETVAS Lanyard PIC Voltage Anomaly | EMERG COND: Yellow

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GMSV5603A	Sys A ETVAS Lanyard PIC Cap Volts	1 of	35.7	NA	Volts	CI
GMSV7603A	Sys A ETVAS Lanyard PIC Cap Volts	2	35.7	NA	Volts	CI
GMSV6603A	Sys B ETVAS Lanyard PIC Cap Volts	1 of	35.7	NA	Volts	CI
GMSV8603A	Sys B ETVAS Lanyard PIC Cap Volts	2	35.7	NA	Volts	CI

TIME PERIOD:

(1) From H2 Burn PIC Charge (T-50 seconds) to SRB Ignition (T-0)

REQUIREMENTS: FIGURES/TABLES:

(2) The PIC System must be up for launch with total functional redundancy mandatory.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) Command to charge H2 Burn PIC issued at T-55 seconds. SRB Ignition Command from RSLS fires the ETVAS Lanyard.

REDLINE DERIVATION: CRITICALITY:

(4) The Avionics Integration Panel has determined this minimum value to be all time all fire minimum voltage.
(5) The nominal value is approximately 38.3 volts.

CONSEQUENCES OF EXCEEDING REDLINE:

CAUSES OF EXCEEDING REDLINE:

(6) PIC card failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	Vdc								
GMSV5603A	0.163	0	40.75						
GMSV7603A	0.163	0	40.75						
GMSV6603A	0.163	0	40.75						
GMSV8603A	0.163	0	40.75						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: GSE SUBSYSTEM: EPP

Orbiter/ET LH2 Disconnect Purge

(THIS REQUIREMENT HAS BEEN DELETED)

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LCC VIOLATION CALL: SRB Aft Skirt GN2 Purge Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GHYP8014A	Aft skirt purge GN2 press Pri	1 of	(2)	NA	psig	CI
GHYP8015A	Aft skirt purge GN2 press Sec	2	(2)	NA	psig	CI

TIME PERIOD:

(1) From activation of SRB Aft Skirt Purge (approximately T-15 minutes) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) Verify the purge has been at either 90 psig or greater for at least 7 consecutive minutes or 30 psig or greater for at least 10 consecutive minutes. Monitoring is not required after this criteria is satisfied.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) The trickle purge hand valve is manually opened at the pad during S0007 pre-operations and remains open until post operations securing.
(4) A126583 is the primary GN2 pressure transducer.
(5) A506905 is the secondary GN2 pressure transducer.
(6) Reference LCC SRM-07 and BTVC-15 for SRB Aft Skirt Purge associated requirements for SRB Aft Skirt thermal conditioning.

REDLINE DERIVATION: CRITICALITY: 1R

(7) a. SSID Intent Summary - The intent of this SSID is to ensure the SRB Aft Skirt oxygen content is less than four percent by volume (industry standard for inert environments) prior to HPU start. This will reduce the possibility of a fire in the SRB Aft Skirt due to external leakage of any Thrust Vector Control fluids or hydrogen gas intrusion. This inert environment is obtained by activation of the SRB Aft Skirt GN2 purge at approximately T-15 minutes per OMRS S00FM0.430 (File 2, Vol. 1) and by verifying per this SSID that minimum pressure and associated continuous purge duration time is met. This purge may be either a high flow rate (90 psig minimum pressure, 7 minutes minimum duration) purge or a low flow rate (30 psig minimum pressure, 10 minutes minimum duration) purge. The high flow rate purge is preferred. Either flow rate is controlled by a primary or secondary remotely operated valve. A GN2 trickle purge supplements the high or low flow purge at all times and if the high and low flow purge is lost after verification of LCC requirements the necessary inert environment is maintainable by the trickle purge for a minimum of 1 hour based on test data. The system is zero fault tolerant for a failed CLOSED A126575 Normally OPEN solenoid valve if the failure were to occur prior to verification of Requirement

REDLINE DERIVATION: (Continued)

(2) since a failure would result in loss of both high and low flow purges. Following verification of Requirement (2) the system is single fault tolerant for this same failure due to the ability of the trickle purge to continue to maintain the inert environment after loss of high and low purges (requires multiple failures).

b. Voting Logic - Purge pressure output is monitored by two independent pressure transducers downstream of the purge control valves. If one transducer fails the remaining transducer will still provide adequate purge monitoring capability. Failure of both transducers, with one outside of expected range and LCC limits and one failure indicating within nominal pressure ranges and LCC limits, is not considered credible.

c. Minimum and Maximum Redline Development - The minimum pressure of 30 psig is the minimum ICD pressure required to assure a low flow GN2 purge of 35 - 45 lb/min, and the minimum pressure of 90 psig is the minimum ICD pressure required to assure a high flow purge of 75 - 85 lb/min (reference ICD-2-0A002).

d. Time Effectivity - The GN2 purge is activated at approximately T-15 minutes and will inert the aft skirt to less than 0.5% oxygen within 10 minutes. Once the 0.5% oxygen content has been achieved, the trickle purge will maintain the inert environment for up to a one hour duration which satisfies the intent of the LCC. The LCC ends at T-31 seconds to allow the maximum time to meet the purge requirements to inert the SRB aft skirt. A subsequent failure would not have an impact since the trickle purge is able to maintain the inert environment until HPU start at T-28 seconds and through the remainder of the launch countdown.

e. Requirements - The pressure associated with the minimum consecutive minutes in high flow purge (7 minutes) or low flow purge (10 minutes) were developed from SRB Aft Skirt Purge Testing (Reference SRB test report 90ENR-0193) and reflect the time required to obtain a 0.5% oxygen environment (4% Oxygen and below is considered an inert/noncombustible atmosphere by industry standards) with a 1.4 time factor of safety included. Verification that the purge has been in effect long enough to obtain the no greater than 0.5% Oxygen environment in the aft skirt ensures that the GN2 trickle purge will maintain that environment below the maximum allowable Oxygen concentration of 4% for at least one hour if the high and low flow purges were subsequently lost.

f. Preplanned Contingency Procedures - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Inability to achieve an inert aft skirt environment prior to HPU activation.
(9) Reference Integrated Hazard Report ISPR-05

CAUSES OF EXCEEDING REDLINE:

(10) Clogged filter.
(11) Failure/loss of control capability of 2 of 2 high flow supply valves (A126576 and A126577) and 2 of 2 low flow supply valves (A126598 and A126599).
(12) Uncommanded closure of main supply valve (A126575).
(13) Loss of SRB Aft Skirt Purge panel 150 and 750 psig GN2 supply.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
UNITS-->	psig								
GHYP8014A	1.2	0	300						
GHYP8015A	1.2	0	300						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: GSE SUBSYSTEM: BHYD

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LCC VIOLATION CALL: SRB Ignition Overpressure Water Bag Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	LH & RH SRB Primary Hole Water Bag Level		(2)	NA		DI
NA	LH & RH SRB Secondary Hole Water Bag Level		(3)	NA		DI

TIME PERIOD:

(1) Verify minimum requirements at T-3 hours

REQUIREMENTS: FIGURES/TABLES: 39-01

(2) All 22 primary water bags must be full (5). (Ref. Figure 39-01.)
(3) All segments in each of the 40 secondary water bags must be full (5). The allowed exceptions are specified in Figure 39-01.

PREPLANNED CONTINGENCY PROCEDURE:

(4) Refill water bags per (2) & (3) if the source of leakage can be determined and repaired.

NOTES:

(5) Full water bag level is overflowing down to approximately 2 inches below the lowest point of the top of the liner.

REDLINE DERIVATION: CRITICALITY:

(6) To suppress the effect of the pressure pulse generated during the SRB ignition transient.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) The SRB ignition pressure pulse, without the minimum required suppression, exert transient forces on the orbiter wings and elevons which approach structural limits.

CAUSES OF EXCEEDING REDLINE:

(8) Water bag leakage.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Facility SUBSYSTEM: GSE

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LCC VIOLATION CALL: Surface Wind Limits | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	WIND DIRECTION					
NA	000-062 DEGREES		NA	23	Knots	CI
NA	063-064 DEGREES		NA	24	Knots	CI
NA	065-067 DEGREES		NA	25	Knots	CI
NA	068-069 DEGREES		NA	26	Knots	CI
NA	070-071 DEGREES		NA	27	Knots	CI
NA	072-073 DEGREES		NA	28	Knots	CI
NA	074 DEGREES		NA	29	Knots	CI
NA	075-076 DEGREES		NA	30	Knots	CI
NA	077 DEGREES		NA	31	Knots	CI
NA	078 DEGREES		NA	32	Knots	CI
NA	079 DEGREES		NA	33	Knots	CI
NA	080-100 DEGREES		NA	34	Knots	CI
NA	101-110 DEGREES		NA	31	Knots	CI
NA	111-120 DEGREES		NA	30	Knots	CI
NA	121-134 DEGREES		NA	29	Knots	CI
NA	135-140 DEGREES		NA	28	Knots	CI
NA	141-152 DEGREES		NA	27	Knots	CI
NA	153-157 DEGREES		NA	26	Knots	CI
NA	158-163 DEGREES		NA	25	Knots	CI
NA	164-196 DEGREES		NA	24	Knots	CI
NA	197-202 DEGREES		NA	25	Knots	CI
NA	203-223 DEGREES		NA	26	Knots	CI
NA	224-229 DEGREES		NA	27	Knots	CI
NA	230-233 DEGREES		NA	28	Knots	CI
NA	234-236 DEGREES		NA	29	Knots	CI
NA	237-239 DEGREES		NA	30	Knots	CI
NA	240-241 DEGREES		NA	31	Knots	CI
NA	242-244 DEGREES		NA	32	Knots	CI
NA	245-340 DEGREES		NA	34	Knots	CI
NA	341 DEGREES		NA	33	Knots	CI
NA	342 DEGREES		NA	32	Knots	CI
NA	343 DEGREES		NA	31	Knots	CI
NA	344-345 DEGREES		NA	30	Knots	CI
NA	346 DEGREES		NA	29	Knots	CI
NA	347-348 DEGREES		NA	28	Knots	CI
NA	349-350 DEGREES		NA	27	Knots	CI
NA	351-352 DEGREES		NA	26	Knots	CI
NA	353-355 DEGREES		NA	25	Knots	CI
NA	356-357 DEGREES		NA	24	Knots	CI
NA	358-359 DEGREES		NA	23	Knots	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for APU Start (T-5 minutes)

REQUIREMENTS: FIGURES/TABLES: Tables GSE-24.01,.02,.03

(2) During the hold at T-9 minutes, the Launch Weather Officer will provide the forecasted winds for the active launch pad through T-0. If the forecast violates any maximum redline in the Measurement/Requirement Table above, then LCC violation confirmed, No Go for launch.
(3) If real time events cause the Launch Weather Officer to revise the forecasted winds after T-9 minutes but prior to T-5 minutes, and the revised forecast violates any maximum redline in the Measurement/Requirement Table above, then LCC violation confirmed, No Go for launch.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) The wind limits in the Measurement/Requirement Table contain the wind speed/direction limits not to be exceeded at time of launch. The table was created by using the limiting wind speed/direction from RSRM Case Buckle Load, ET Vent Line VJ Pipe and Pivot Shaft Safety Factors and ET Vent Umbilical to Structure and to Vehicle Clearances. These limits are shown in Table GSE-24.01, GSE-24.02 and GSE-24.03.
(5) Forecasts are formulated using all available meteorological sensors and assets available to the Launch Weather Officer. Wind tower sensors at pads A and B (camera sites 3 and 6) are selectively used such that the data represents the most consistent wind velocity effect on the Space Shuttle Vehicle (SSV).
(6) Real time wind information for both pads A and B is available on Operational Television (OTV) Channel 189 (this channel monitors the Cape Weather display for pad winds).
(7) Real time wind information for the active pad only is available via Launch Processing System (LPS). Measurement Stimulus Identification (MSIDs) KMTLn001A and KMTLn002A represent wind speeds at pad camera sites 6 and 3 respectively, MSIDs KMTHn001A and KMTHn002A represent wind directions at pad camera sites 6 and 3 respectively. The LPS Test Configuration Identifier Document (TCID) patch determines which MSIDs are available ("n" may be either "A" or "D").

REDLINE DERIVATION: CRITICALITY:

(8) a. SSID Intent Summary - This SSID provides wind speed vs. directional limits in order to protect both vehicle flight hardware, and Pad Fixed Service Structure hardware. Specifically, the Case Buckle Load Wind Limits (Ref. Table GSE-24.01) ensure that wind speeds coupled with SSV on pad motion induced by SSME ignition do not reduce the factor of safety for RSRM case buckling to below 1.4. Meeting this requirement envelopes all vehicle hardware. The ET Vent Line Vacuum Jacket (VJ) Pipe and Pivot Shaft Wind Limits (Ref. Table GSE-24.02) and the ET Vent Line Umbilical Structure and Vehicle Clearance Wind Limits (Ref. Table GSE-24.03) ensure, at umbilical separation, that wind speeds coupled with SSV on pad motion induced by SSME ignition at umbilical separation do not cause the ETVAS capture envelope to be exceeded during umbilical

REDLINE DERIVATION: (Continued)

retraction, leading to possible generation of uncontained debris. Additionally, the ETVAS VJ pipe pivot shaft and pivot plate Factor of Safety for material yield are maintained at Program approved values. This SSID also ensures that ETVAS to left hand RSRM clearances satisfy program liftoff certification clearance requirements during static lanyard release mode.

b. Voting Logic - N/A

c. Minimum and Maximum Redline Development - This SSID provides limits that protect flight hardware and ground support hardware from hazardous failures due to wind loading effects at T-0. The maximum winds limits referenced in this SSID are for peak winds at elevation per NSTS 07700 Vol. X Book 2 - Design Peak Winds 4.1.2.1.1. The peak ground wind speed is referenced to the 18.3m level (60 feet above natural grade) and corrected for winds at the ETVAS 195 foot elevation. The Case Buckle Load Wind Limits are based on NSTS 07700, Vol. X Book 2, Appendix 10.10 and NSTS 07700, Vol. X, Book 1, paragraph 3.2.2.1.5.2.e, that provides exceptions to the NSTS 07700 Vol. X, Book 2 requirements in order to maintain an RSRM factor of safety of 1.4 for case buckling due to the block II SSME upgrade. The ETVAS Retract Load Wind Limits are based on actual test data and ADAMS software modeling. The limits ensure that potential wind loads applied to the ETVAS during retraction can not exceed the system's capability to retract the umbilical without structural contact, will not cause VJ pipe, pivot shaft and pivot plate factors of safety on yield to be exceeded, and will ensure clearances between flight hardware and ground support hardware are maintained. The wind limits for RSRM Case Buckle, ET Vent Arm Assembly Retract and Vehicle Clearance of ET Vent Arm Assembly can be found in Tables GSE-24.01, GSE-24.02 and GSE-24.03 respectively.

d. Time Period - The starting time period selected ensures monitoring of wind speed and direction from the beginning of ET Cryo Tanking at T-6 hours by the Launch Weather Officer. The ending time period ensures that the wind speed and direction forecast through T-0, that is presented to the launch team during the T-9 minute hold, remains valid through T-5 minutes and counting. T-5 minutes is an acceptable ending effectivity because holding at T-5 minutes represents the last time that the Launch Director will ever have a forecasted wind discussion with the Launch Weather Officer. After T-5 minutes there is no longer the capability for the Launch Weather Officer to forecast the pad winds as the wind evaluation from that point until T-0 becomes real time.

e. Requirements - The requirements in this SSID ensure that the Launch Weather Officer and the Launch Director communicate the forecasted winds for the active launch pad at the appropriate times during the last portion of the launch countdown to protect flight and ground hardware from damage. Requirement (2) ensures that the forecasted wind report at T-9 minutes provides the Launch Director with the information required to commit the launch team to count down past T-9 minutes. Requirement (3) provides the Launch Weather Officer the last possible

REDLINE DERIVATION: (Continued)

opportunity to revise the forecasted winds for the active launch pad.

f. Preplanned Contingency Procedure - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(9) SSV on pad motion induced by SSME ignition and wind forces will exert loads on the SSV that will exceed design certification and approach structural limits of RSRM.
(10) SSV on pad motion induced by SSME ignition and wind loads on the ETVAS would cause capture mechanism envelope to be exceeded. This failure could result in hard impact during ETVAS retraction leading to generation of debris which could impact the vehicle during launch.
(11) SSV on pad motion induced by SSME ignition and wind loads on the ETVAS would cause unacceptable loads to be transferred into the VJ pipe, pivot shaft and pivot plate reducing the factor of safety on yield below Program agreed to limits.
(12) SSV ascent profile and wind loads on the ETVAS could cause contact between the ETVAS and the left SRB during static lanyard release mode. This failure could result in debris generation and a catastrophic failure of the left SRB.
(13) Reference: Integrated Hazard Reports INEV-01 and IVLD-01

CAUSES OF EXCEEDING REDLINE:

(14) Greater than allowable ground wind environment.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
n = 1 AND 2 FOR CAMERA SITE 6 AND 3 RESPECTIVELY									
UNITS-->	knots								
KMTLA00nA	0.24	0.00	60.0						
UNITS-->	deg								
KMTHA00nA	2.16	0.00	540.0						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Launch and Landing SUBSYSTEM: GSE

Wind Direction		Minimum	Maximum	Units
000-100	Degrees	NA	34	Knots
101-110	Degrees	NA	31	Knots
111-120	Degrees	NA	30	Knots
121-134	Degrees	NA	29	Knots
135-140	Degrees	NA	28	Knots
141-152	Degrees	NA	27	Knots
153-157	Degrees	NA	26	Knots
158-163	Degrees	NA	25	Knots
164-196	Degrees	NA	24	Knots
197-202	Degrees	NA	25	Knots
203-207	Degrees	NA	26	Knots
208-211	Degrees	NA	27	Knots
212-214	Degrees	NA	28	Knots
215-216	Degrees	NA	29	Knots
217-219	Degrees	NA	30	Knots
220-221	Degrees	NA	31	Knots
222-223	Degrees	NA	32	Knots
224-225	Degrees	NA	33	Knots
226-000	Degrees	NA	34	Knots

Table GSE-24.01 – Wind Limits for RSRM Case Buckle

Wind Direction		Minimum	Maximum	Units
000-062	Degrees	NA	23	Knots
063-064	Degrees	NA	24	Knots
065-067	Degrees	NA	25	Knots
068-069	Degrees	NA	26	Knots
070-071	Degrees	NA	27	Knots
072-073	Degrees	NA	28	Knots
074	Degrees	NA	29	Knots
075-076	Degrees	NA	30	Knots
077	Degrees	NA	31	Knots
078	Degrees	NA	32	Knots
079	Degrees	NA	33	Knots
080-179	Degrees	NA	34	Knots
180-181	Degrees	NA	33	Knots
182-183	Degrees	NA	32	Knots
184-187	Degrees	NA	31	Knots
188-190	Degrees	NA	30	Knots
191-196	Degrees	NA	29	Knots
197-223	Degrees	NA	28	Knots
224-229	Degrees	NA	29	Knots
230-232	Degrees	NA	30	Knots
233-236	Degrees	NA	31	Knots
237-238	Degrees	NA	32	Knots
239-240	Degrees	NA	33	Knots
241-340	Degrees	NA	34	Knots
341	Degrees	NA	33	Knots
342	Degrees	NA	32	Knots
343	Degrees	NA	31	Knots
344-345	Degrees	NA	30	Knots
346	Degrees	NA	29	Knots
347-348	Degrees	NA	28	Knots
349-350	Degrees	NA	27	Knots
351-352	Degrees	NA	26	Knots
353-355	Degrees	NA	25	Knots
356-357	Degrees	NA	24	Knots
358-359	Degrees	NA	23	Knots

Table GSE-24.02 – Wind Limits for ET Vent Arm Assembly Retract

Wind Direction		Minimum	Maximum	Units
000-002	Degrees	NA	28	Knots
003-006	Degrees	NA	27	Knots
007-010	Degrees	NA	26	Knots
011-016	Degrees	NA	25	Knots
017-043	Degrees	NA	24	Knots
044-049	Degrees	NA	25	Knots
050-053	Degrees	NA	26	Knots
054-057	Degrees	NA	27	Knots
058-060	Degrees	NA	28	Knots
061-062	Degrees	NA	29	Knots
063-064	Degrees	NA	30	Knots
065-066	Degrees	NA	31	Knots
067-068	Degrees	NA	32	Knots
069-070	Degrees	NA	33	Knots
071-175	Degrees	NA	34	Knots
176-178	Degrees	NA	32	Knots
179-180	Degrees	NA	31	Knots
181-183	Degrees	NA	30	Knots
184-186	Degrees	NA	29	Knots
187-190	Degrees	NA	28	Knots
191-196	Degrees	NA	27	Knots
197-223	Degrees	NA	26	Knots
224-229	Degrees	NA	27	Knots
230-233	Degrees	NA	28	Knots
234-236	Degrees	NA	29	Knots
237-239	Degrees	NA	30	Knots
240-241	Degrees	NA	31	Knots
242-244	Degrees	NA	32	Knots
245-349	Degrees	NA	34	Knots
350-351	Degrees	NA	33	Knots
352-353	Degrees	NA	32	Knots
354-355	Degrees	NA	31	Knots
356-357	Degrees	NA	30	Knots
358-359	Degrees	NA	29	Knots

Table GSE-24.03 – Wind Limits for Vehicle Clearance of ET Vent Arm Assembly

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LCC VIOLATION CALL: Launch Release PIC Fire 1 Anomaly | EMERG COND: Yellow (6)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GMSX1003E	Sys A TSM FIRE 1 SW A ON IND		OFF	NA	Event	CI
GMSX2003E	Sys B TSM FIRE 1 SW A ON IND		OFF	NA	Event	CI
GMSX1004E	Sys A TSM FIRE 1 SW B ON IND		OFF	NA	Event	CI
GMSX2004E	Sys B TSM FIRE 1 SW B ON IND		OFF	NA	Event	CI
GMSX1007E	Sys A HDP FIRE 1 SW A ON IND		OFF	NA	Event	CI
GMSX2007E	Sys B HDP FIRE 1 SW A ON IND		OFF	NA	Event	CI
GMSX1008E	Sys A HDP FIRE 1 SW B ON IND		OFF	NA	Event	CI
GMSX2008E	Sys B HDP FIRE 1 SW B ON IND		OFF	NA	Event	CI
GMSX5606E	Sys A ETVAS LNYRD PIC F1 SW A ON		OFF	NA	Event	CI
GMSX6606E	Sys B ETVAS LNYRD PIC F1 SW A ON		OFF	NA	Event	CI
GMSX5607E	Sys A ETVAS LNYRD PIC F1 SW B ON		OFF	NA	Event	CI
GMSX6607E	Sys B ETVAS LNYRD PIC F1 SW B ON		OFF	NA	Event	CI

TIME PERIOD:

(1) From System activation (T-4 Hours) to Go for SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(2) The ETVAS Lanyard circuits are armed at T-55 seconds and the HDP, TSM and ETVAS circuits at T-18 seconds. The HDP, ETVAS and ETVAS Lanyard PICs are fired at SRB ignition (T-0 seconds) and the TSM PICs at T-0 + 40 msec.
(3) For any premature Fire 1 indication ON, a MEC Preflight and OPS Bite will be performed (baseline data) and power down of the GSE PIC Racks (redundant safing), prior to initiating a countdown Cutoff/Recycle.

REDLINE DERIVATION: CRITICALITY: 1R

(4) An erroneous F1 output will reduce redundancy protection. This will apply a Fire 1 signal to the associated PICs and will enable the associated Fire 2 signal. If the PIC card is armed, only a Fire 2 signal is necessary to discharge the PIC and fire the associated ordnance.
(5) Prevention of a premature pyrotechnic ignition which may result in loss of flight vehicle and crew.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Yellow condition exists with a premature FIRE 1 indication ON prior to PIC arming which reduces safety margin. After PIC arming the possibility for a premature NASA Standard Initiator (NSI) Firing could result in:
A) An early/partial release of the Holddown Post system resulting in the loss of the Shuttle vehicle and crew.
B) An early/partial release of the Tail Service Mast system resulting in the loss of all command and monitor functions.
C) An early/partial release of the External Tank Vent Arm System resulting in the loss of the ET control and monitor functions.
D) An early/partial release of the ETVAS Lanyard system resulting in separation of the ET Ground Umbilical Carrier Plate (GUCP).

CAUSES OF EXCEEDING REDLINE:

(7) PIC Rack component failure.
MEC failure.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: GSE SUBSYSTEM: EPD

LCC VIOLATION CALL: Photo Optical Control System Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
N/A	Photo Optical Control System		(2)	N/A	N/A	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for GLS Start (T-9 minutes).

REQUIREMENTS: FIGURES/TABLES:

(2) Complete loss of Photo Optical Control System (POCS) capability to issue the camera START command to the fixed high speed cameras at the active pad is unacceptable (i.e., all of the fixed high speed cameras will fail to start due to the POCS failure).

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) POCS functional health with respect to its ability to issue the camera START command to the suite of fixed high speed ground cameras at the active pad is a complex task and requires expert interpretation of POCS performance and functional anomalies.

REDLINE DERIVATION: CRITICALITY: 3

(4) a. SSID Intent Summary - This SSID ensures that failures of the POCS or supporting systems that result in total inability of POCS to issue the fixed high speed camera START commands for the active pad will result in an LCC violation and constrain launch. This requirement is intended solely to protect for POCS failures that would prevent recording of launch/ascent imagery from the entire suite of fixed high speed cameras at the active pad.

b. Voting Logic - N/A.

c. Redline Development - This requirement ensures monitoring of the POCS for any failure that will result in total loss of the ability to issue the camera START command to the fixed high speed cameras.

d. Time Period - The POCS system is configured and stable prior to T-6 hrs and per LCC guidelines is committed to launch at T-9 minutes. Violations after T-9 minutes and counting will be reported but will not constrain launch.

e. Requirements - See Redline Development above.

f. Preplanned Contingency Procedures - N/A.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Inability of the POCS to issue the START command for fixed high speed camera for the active pad, would result in a total loss of fixed high speed ground based launch and ascent imagery. Loss of this imagery would not impact current flight safety since the Orbiter de-orbit and entry decision is not based on ground based launch or ascent imagery. However, violation does increase the risk of undetected performance or configuration anomalies that may affect safety of flight for subsequent missions. A secondary effect of this violation is that, in an emergency, the ability of the NASA Test Director (NTD) to initiate the subset of these cameras that are designated as emergency cameras, used to document emergencies at the pad, will be lost.

CAUSES OF EXCEEDING REDLINE:

(6) Processing Control Center (PCC) Facility Power failure combined with Uninterruptible Power Supply (UPS) failure.
(7) Multiple POCS equipment failures.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: LL SUBSYSTEM: GSE

LCC VIOLATION CALL: GOX Vent Hood Purge Termination Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GSAP9101A	A140347 NE Seal Press	2	NA	0.296	psig	DI
GSAP9111A	A140348 SW Seal Press	of	NA	0.296	psig	DI
GSAP9091A	A135915 Plenum Press	3	NA	0.296	psig	DI
	OR					
GSAP9106A	A140347 NE Seal Press	2	NA	0.296	psig	DI
GSAP9116A	A140348 SW Seal Press	of	NA	0.296	psig	DI
GSAP9096A	A135915 Plenum Press	3	NA	0.296	psig	DI

TIME PERIOD:

(1) Verify prior to GOX Vent Hood lift (approx T-2 minutes 30 seconds).

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) Using either LPS indications of zero pressure at both GN2 regulators (A135910 (GSAP9071A & GSAP9076A) and A135911 (GSAP9081A & GSAP9086A)) or Operational Television (OTV) verification of visible slack seals, is an acceptable indication of GN2 flow termination. Upon verification of purge termination, the GOX Vent Hood will be lifted and the GOX Vent Arm retracted by Launch Processing System (LPS) commands per OMI S0007.500 and OMI G2158. LCC violation cleared, continue countdown.

(3) If purge has not terminated, further termination attempts may be performed with LPS commands per OMI S0007.500 and OMI G2158. Upon verification of purge termination, the GOX Vent Hood will be lifted and the GOX Vent Arm retracted by LPS commands per OMI S0007.500 and OMI G2158. LCC violation cleared, continue countdown.

NOTES:

(4) The two seal pressure transducers A347 and A348 directly indicate GN2 purge pressure within the GOX Vent Seals. Pressure transducer A915 indicates GN2 purge pressure within the plenum which directly feeds the seals and is a direct representation of seal pressures.

REDLINE DERIVATION: CRITICALITY: 1

(5) a. SSID Intent Summary - The purpose of this requirement is to ensure that the GOX Vent GN2 purge pressures have dropped sufficiently to cause no damage to the ET TPS during GOX Vent Hood raising. The output of each transducer is split into two function designator indications using independent Hardware Interface Modules (HIMs) and LPS paths.

b. Voting Logic - Two of three measurements required to verify GOX Vent

REDLINE DERIVATION: (Continued)

Purge termination.

c. Minimum and Maximum Redline Development - The maximum redline requirement of 0.296 psig is derived from seal pressure operational requirements of 0.3 to 0.5 psig (8.3 to 13.8 inches of water). Pressures below this operational requirement have been verified to not cause any ET Thermal Protection System (TPS) damage that is an ascent debris concern for any element. There is not a minimum redline requirement for this measurement.

d. Time Period - This is a one-time verification prior to raising the GOX Vent Hood. Failure of this verification will result in not raising the GVA Hood and a hold at T-31 seconds.

e. Requirements - NA

f. Preplanned Contingency Procedures - LPS verification of alternate pressure measurements or visual observation using OTV cameras can be used to determine if the GOX Vent Seal purge pressures have been terminated. LPS commands can be initiated to close alternate control valves and terminate purge. Indications of zero pressure or visibly slack seals are acceptable indications of purge termination.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Inability to terminate purge will result in not raising the GOX Vent Hood or retracting the GOX Vent Arm.

CAUSES OF EXCEEDING REDLINE:

(7) Failure of GN2 control valves to cycle closed.
(8) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	psig								
GSAP9101A	0.004	0	1						
GSAP9106A	0.004	0	1						
GSAP9111A	0.004	0	1						
GSAP9116A	0.004	0	1						
GSAP9091A	0.008	0	2						
GSAP9096A	0.008	0	2						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: GSE SUBSYSTEM: LACC

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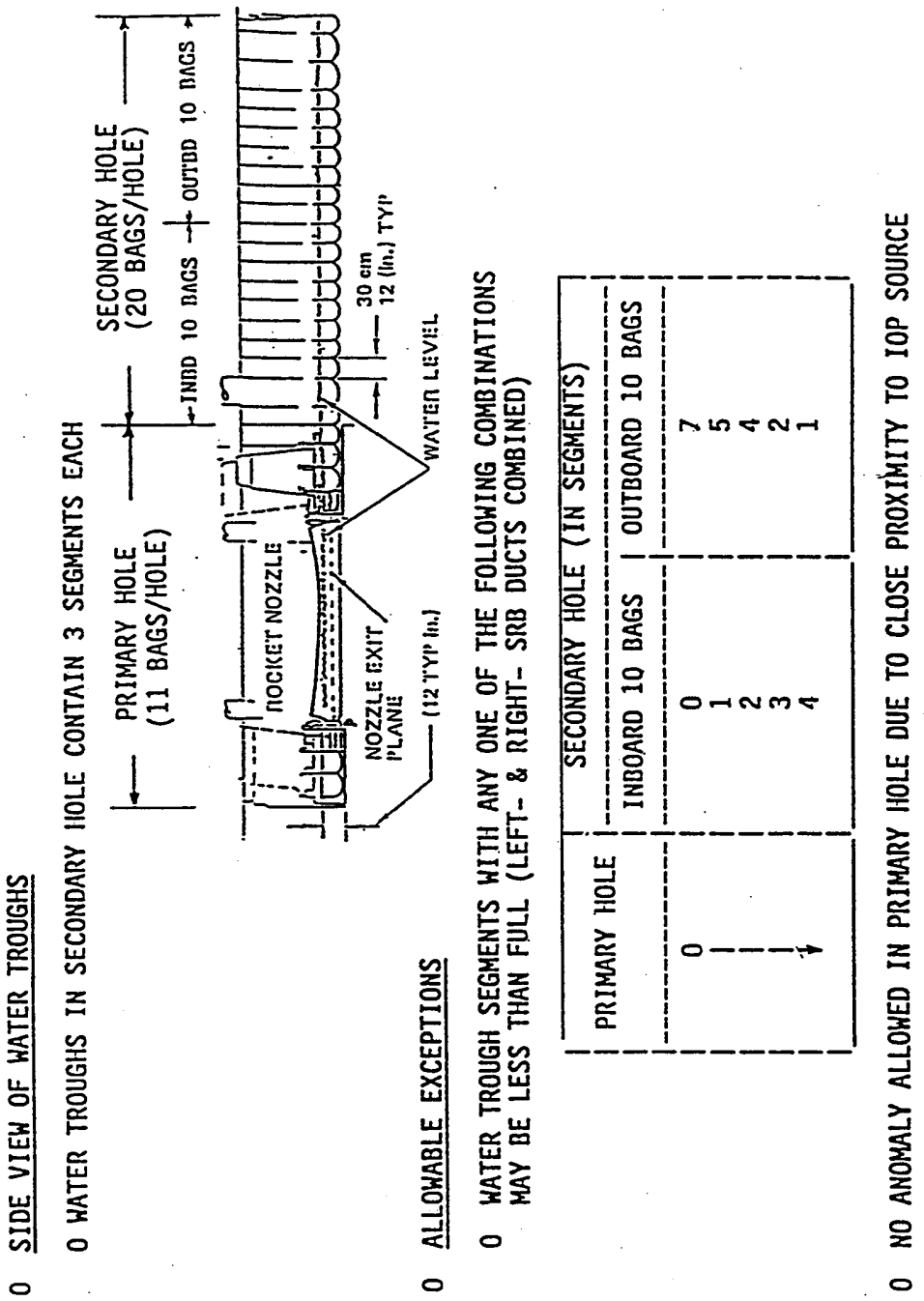

Figure 39-01 SRB Ignition Overpressure Water Bag System

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LH2 ORB/ET DISCONNECT CAVITY PURGE PRESSURE ANOMALY

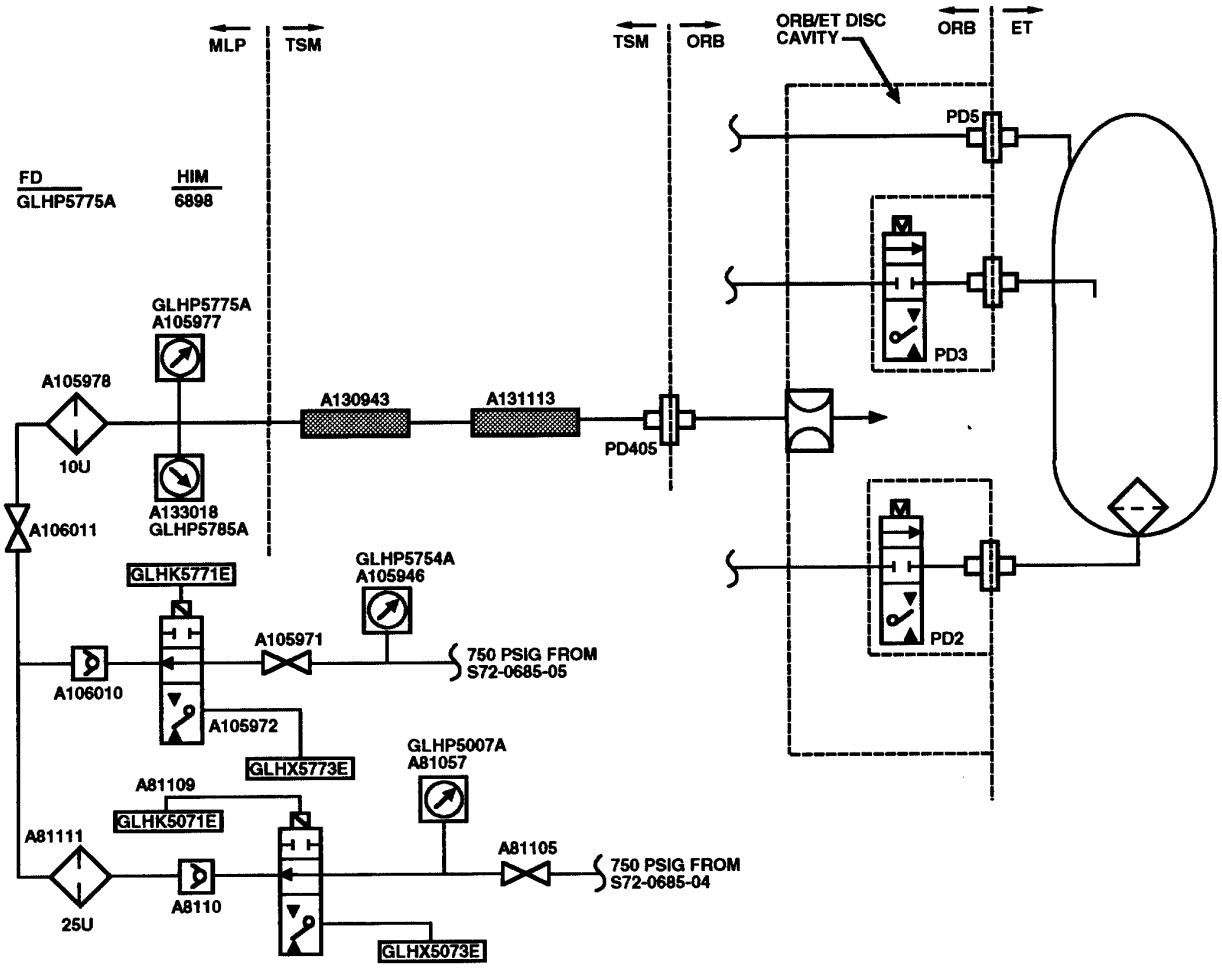

Figure 39-02 LH2 Orbiter/ET Disconnect Cavity Purge Pressure

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Maximum Allowable Surface Wind Vectors

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SECTION 40

HAZARDOUS GAS DETECTION SYSTEM

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SECTION 40: HAZARDOUS GAS DETECTION SYSTEM

SSID No.	Description/Violation Call	Page
HAZ-01	Hazardous Gas Detection System Anomaly	40-01.1
HAZ-02	Aft Compartment Helium Concentration Anomaly	40-02.1
HAZ-03	Aft Compartment Hydrogen Concentration Anomaly	40-03.1
HAZ-04	ET Intertank Hydrogen Concentration Anomaly	40-04.1
HAZ-05	Mid Fuselage and Payload Bay Hydrogen Concentration Anomaly	40-05.1
HAZ-05a	ET, Mid, P/L, Aft Hydrogen Conc (T-31 sec) (REQUIREMENT DELETED)	40-05a.1
HAZ-06	Aft Compartment Oxygen Concentration Anomaly	40-06.1
HAZ-07	ET Intertank Oxygen Concentration Anomaly	40-07.1
HAZ-08	Mid Fuselage and Payload Bay Oxygen Concentration Anomaly	40-08.1
HAZ-09	Excessive Hydrogen Concentration At ET Ground Umbilical Carrier Assembly	40-09.1
HAZ-10	Excessive Hydrogen Concentration At LH2 T-0 Umbilical Carrier Plate Cavity	40-10.1
HAZ-11	Excessive Hydrogen Concentration At T-0 8-inch Fill and Drain Line Purge Shroud	40-11.1
HAZ-12	Excessive Hydrogen Concentration at Orbiter/ET Disconnect	40-12.1
HAZ-13	Excessive Hydrogen Concentration Inside LH2 TSM	40-13.1
HAZ-FG01	Figure 40-01 Haz Gas Detection System Schematic (HGDS 2000)	40-FG01.1
HAZ-FG02	Figure 40-02 Hazardous Gas Detection System Hydrogen, Oxygen and Helium Concentration Limits (REQUIREMENT DELETED)	40-FG02.1

SECTION 40: HAZARDOUS GAS DETECTION SYSTEM (CONTINUED)

SSID No.	Description/Violation Call	Page
HAZ-FG03	Figure 40-03 Hydrogen Leak Detector Sensor Overall Location	40-FG03.1
HAZ-FG04	Figure 40-04 HGDS Ranges and Resolution	40-FG04.1

LCC VIOLATION CALL: Hazardous Gas Detection System Anomaly | EMERG COND: Yellow (10)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	HazGas Detection System A: HGDSA	(2)	NA	NA	NA	CI
NA	HazGas Detection System B: HGDSB	(2)	NA	NA	NA	CI
NA	Hydrogen Umbilical Mass Spec:HUMS	(2)	NA	NA	NA	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (approximately T-6 hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES: Figure 40-01

(2) 2 of 3 Hazardous Gas Detection Systems (HGDSs) are required functional to initiate ET Cryo Tanking. 1 of 3 HGDSs required after start of ET Cryo Tanking (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) If tanking is initiated with only 2 of 3 HGDSs functional and one of the remaining HGDSs fails, evaluate validity of remaining system. If system is fully functional, LCC violation cleared, continue countdown. Other than the 1 of 3 system requirement, waivers are not required for those compartments that cannot be monitored due to unavailability of instruments.

NOTES:

(4) HGDSs are not continuous monitoring instruments and are used at operator discretion or by direction of launch team. Time sharing of the available HGDS subsystems is required in order to monitor the four vehicle compartments (ET Intertank, Payload Bay, Mid Fuselage, and Aft Compartment).
HGDSA and HGDSB are identical systems sharing one redundant sample delivery system. Either system may be used as the primary system based on performance.

(5) Command and control for all three systems (HGDSA, HGDSB and HUMS) is by dedicated workstations and not by LPS. Operators will use raw or unvoted measurements from the HGDS 2000 workstations when making LCC calls. Failure of the HGDS 2000 or HUMS data streams into the LPS does not constitute an LCC violation.

(6) When using the HGDSA, HGDSB, or HUMS HGDS, confirmation of a leak is defined as two successive indications on a single system or corroborating data from multiple systems.

(7) The HGDSs are complex analytical instruments requiring expert operator interpretation of the data. Do not automate these measurements.

NOTES: (Continued)

(8) Implementation of this SSID is accomplished by the Hazardous Gas Detection System (HGDS) which consists of three subsystems: HGDSA, HGDSB, and HUMS. Normal compartment sampling by the HGDS prior to T-9 minutes and counting is per OMRSD S00FA0.435 and is switched manually to look at all compartments. After T-9 minutes, the NOMINAL compartment sampling is as follows:

TIME PERIOD	HGDSA	HGDSB	HUMS
T-9 min to T-7 min	Aft	Payload Bay	ET/IT
T-7 min to T-5 min	Aft	Mid-body	ET/IT
T-5 min to T-0 min	Aft	Aft	ET/IT

In general, the Aft Compartment is the highest priority after T-5 minutes and will be monitored by two instruments if available.

REDLINE DERIVATION: CRITICALITY: 1S

(9) This system is required to provide indication of O2, H2, Ar or He leaks in specified areas of the Shuttle and LH2 TSM associated with fire (integration hazards 070 and 071).

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Loss of ability to monitor for H2, O2, Ar, or He in Payload Bay, Midbody, ET Intertank, Orbiter Aft and LH2 TSM with the HGDSA, HGDSB or HUMS.

CAUSES OF EXCEEDING REDLINE:

(11) Multiple facility system failures.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO		SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO		SHEET	ZONE

ELEMENT: GSE SUBSYSTEM: Haz Gas

LCC VIOLATION CALL: Aft Compartment Helium Concentration Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	Aft Helium Concentration	NA	NA	12,000	ppm	CI

TIME PERIOD:

(1) From T-3 hours and counting to Go for GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES: Figure 40-01, -04

(2) Exceeding Maximum Helium concentration limit indicates a potential out-of-spec component leakage and requires leak evaluation. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Subtract the pre-cryo Aft Helium concentration obtained in S00FA0.225 (C-5) from the steady state exceedance value and calculate the remaining helium concentration.
- If the remainder is less than 8,000 ppm and positive flow can be visually verified from one or more LH2 Orb/ET cavity external exit ports, then LCC violation cleared, continue countdown.
- If the remainder is equal to or greater than 8,000 ppm and no Block II SSMEs are installed, perform the Helium fill termination decay test per OMI S1004 (OMRSD S00FF0.240). If OMRS requirement is satisfied and positive flow can be visually verified from one or more LH2 Orb/ET cavity external exit ports, then LCC violation cleared, continue countdown.

NOTES:

(4) For IUS and EDO missions, the PLB GN2 purge rate may be reduced during the T-9 minute hold from approximately 230 lbs/min to approximately 170 lbs/min resulting in a reduction in the Aft Compartment purge flowrate. As a result of the purge reduction, the concentration level obtained after purge reduction for IUS and EDO missions is expected to show approximately 16 percent increase above the level obtained prior to purge reduction. Concentration changes for other unique payload purge requirements will be assessed on an as-needed basis. (This note does not modify LCC redline limits contained in this SSID).

(5) A Helium system integrity check is performed during bottle pressurization for flight (T-11 hour hold) per S00FF0.070.

(6) The HGDSs are complex analytical instruments requiring expert operator interpretation of the data. Do not automate these measurements.

(7) Advisory System reference measurements are represented in LPS as follows:

MSID	DESCRIPTION	BIT VALUE	PCM LOW	PCM HIGH	UNITS
GGAXAFTHE	Sys A Aft He	0.1	-500	50000	ppm
GGBXAFTHE	Sys B Aft He	0.1	-500	50000	ppm
GHMR0009T	0-5 Pct He Gas Conc Range	0.025	-1.25	5	pct

REDLINE DERIVATION: CRITICALITY: 1

(8) Redline development:

Historical background concentration prior to pressurization for flight, including contribution by SSME LPFTP discharge duct Helium barrier purge and LH2 Orb/ET cavity purge	2000-7000 ppm
Predicted background increase from SSME hydraulic actuator venting	2000 ppm
Allowable MPS leakage after pressurization for flight	8000 ppm
Redline	12000 ppm

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Ascent with unacceptable MPS system Helium leakage may result in premature SSME shutdown due to HPOTP intermediate seal purge pressure redline exceedance, inability to close prevalves at MECO (Crit 1 for LO2), inability to perform propellant dump and vacuum inert, or premature depletion of Aft Compartment inerting Helium during RTLS or TAL aborts.
(10) Possible loss of the ground Helium purge in the LH2 Orb/ET cavity with resulting ice formation on the disconnect mechanism or a temperature exceedance on the monoball electrical connectors.

CAUSES OF EXCEEDING REDLINE:

(11) A leak in the MPS/SSME Helium system.
(12) Leakage into the Aft Compartment from the LH2 T-0 and/or ET/Orbiter umbilical purges.
(13) Leakage from a payload.
(14) HGDS sample line QD leakage.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Orbiter SUBSYSTEM: MPS

LCC VIOLATION CALL: Aft Compartment Hydrogen Concentration Anomaly | EMERG COND: Yellow (16)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	Aft Hydrogen Concentration	NA	NA	(2)	ppm	CI

TIME PERIOD:

(1) From Start of compartment GN2 purge initiation plus 30 minutes to Go for RSLS Start (T-31 seconds).

REQUIREMENTS: FIGURES/TABLES: Figure 40-01, -04

(2) Redline dependent on Time Period: Maximum Redline

A. From Start of compartment GN2 purge initiation plus 30 minutes to Start of ET Cryo Tanking (approx T-6 hours): (3)

B. From Start of ET Cryo Tanking (approx T-6 hours) to Start of LH2 Replenish (approx T-3 hours): 600 ppm

C. From Start of LH2 Replenish (approx T-3 hours) to Start of LH2 Prepress (approx T-1 minute 46 seconds): 150 ppm

D. From Start of LH2 Prepress (approx T-1 minute 46 seconds) to T-31 seconds: 240 ppm (4A,B)

Exceeding Maximum Redline indicates potential out-of-spec component leakage and requires leak evaluation.

(3) There should be no positive Hydrogen concentration increase. (11)

PREPLANNED CONTINGENCY PROCEDURE:

(4) A. Between start of LH2 Prepress and T-31 seconds, hold at T-31 seconds for a 30-second minimum assessment period, or longer as required. If the Hydrogen concentration falls below the Transient Curve Table, then LCC violation cleared, continue countdown.

B. For holds at T-31 seconds for reasons other than violation of this SSID, prior to continuing countdown, verify Hydrogen concentration is under the Transient Curve Table limits. If concentrations go above the Transient Curve Table limits, LCC violation confirmed, No Go for launch.

Transient Curve Table:

Duration of hold	Acceptable value	Duration of hold	Acceptable value
0:00-0:30	340 ppm	3:30-4:00	580 ppm
0:30-1:00	420 ppm	4:00-4:30	580 ppm
1:00-1:30	470 ppm	4:30-5:00	590 ppm
1:30-2:00	510 ppm	5:00-5:30	590 ppm
2:00-2:30	530 ppm	5:30-6:00	590 ppm
2:30-3:00	550 ppm	6:00-6:30	600 ppm
3:00-3:30	570 ppm	6:30-7:00	600 ppm

NOTES:

(5) For out-of-spec leakage with confirmed LCC violation, perform the following safing/leak Isolation:
Secure PRSD reactant gas supply line per OMI V1040.002.
- If the Hydrogen concentration decreases, leak is isolated to PRSD system.
- If Hydrogen concentration does not decrease, perform MPS leak isolation test per OMI S1004 (OMRSD S00E00.579).

(6) For IUS and EDO missions, the PLB GN2 purge rate may be reduced during the T-9 minute hold from approximately 230 lbs/min to approximately 170 lbs/min resulting in a reduction in the Aft Compartment purge flowrate. As a result of the purge reduction, the concentration level obtained after purge reduction for IUS and EDO missions is expected to show approximately 16 percent increase above the level obtained prior to purge reduction. Concentration changes for other unique payload purge requirements will be assessed on an as-needed basis. (This note does not modify LCC redline limits contained in this SSID.)

(7) 10,000 ppm is 25% of the lower flammable limit for Hydrogen and Oxygen. This provides a 4:1 safety factor for Hydrogen ground safety leak evaluation.

(8) With a total Aft Compartment GN2 purge flow rate of 220 lbs/min, an increase in Aft Compartment Hydrogen concentration of 375 ppm in 8 seconds is indicative of the initiation of a 23,000 scim leak.

(9) The HGDSs are complex analytical instruments requiring expert operator interpretation of the data. Do not automate these measurements.

(10) Advisory System reference measurements are represented in LPS as follows:

MSID	DESCRIPTION	BIT VALUE	PCM LOW	PCM HIGH	UNITS
GGAXAFTH2	Sys A Aft H2	0.1	-500	50000	ppm
GGBXAFTH2	Sys B Aft H2	0.1	-500	50000	ppm
GHMR0005T	0-1 Pct H2 Gas Conc Range	0.005	-0.25	1	pct

REDLINE DERIVATION: CRITICALITY: 1

(11) "Positive Hydrogen concentration increase" is defined as a test average (Aft) exceeding the established background (zero gas) in excess of 3-sigma. Calculate sigma with respect to established background.

(12) Any indicated leakage prior to ET Cryo Tanking is outside PRSD system experience base.

(13) The 600 ppm concentration limit up to start of LH2 replenish is intended to screen out-of-family leaks and is based on the historical maximum concentration levels that have been successfully flown. It is independent of leak source location.

(14) The 150 ppm concentration limit is based on the following assumptions:

In-flight flammability limit	57,000 scim
Max in-flight leakage detected by sample bottles (STS-41)	34,000 scim
Allowable in-flight leakage	23,000 scim

A worst case assumption that a 23,000 scim in-flight leak is solely located in a portion of the MPS that is subjected to high pressure during flight results in a 150 ppm HGDS reading during replenish.

REDLINE DERIVATION: (Continued)

(15) The 240 ppm concentration limit during LH2 Prepress is based on a transient analysis (which assumes a 220 lbs/min total Aft Compartment purge and 16 seconds transport time in the HGDS) of the maximum allowable leak that would reach equilibrium at 600 ppm. If 240 ppm is exceeded at T-31 seconds, then the leak may be greater than allowable. The minimum assessment period allows additional time to confirm that the leak is below the transient curve table for the 600 ppm steady state leak.

CONSEQUENCES OF EXCEEDING REDLINE:

(16) Initiation of ET Cryo Tanking with a PRSD leak.
(17) Flammable concentration during ascent or launching with an undefined out-of-spec leak.
(18) Launch with potential crack in SSME or MPS hardware in excess of critical flaw size.

CAUSES OF EXCEEDING REDLINE:

(19) MPS or PRSD H2 leak.
(20) Compartment purge system malfunction.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: GSE SUBSYSTEM: Haz Gas

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LCC VIOLATION CALL: ET Intertank Hydrogen Concentration Anomaly | EMERG COND: Yellow (8)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	ET/IT Hydrogen Concentration	NA	NA	(2)	ppm	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (approximately T-6 hours) to APU Start (T-5 minutes and counting)

REQUIREMENTS: FIGURES/TABLES: Figure 40-01, -04

(2) There should be no positive hydrogen concentration increase. Positive hydrogen concentration increase is defined as a test average exceeding the established background in excess of 3-sigma. Calculate sigma with respect to established background. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) A. If violation occurs during Slow Fill or Fast Fill then stop flow, then close ET vent valve and monitor hydrogen concentration as described in paragraph 3B.

B. If violation occurs during or after Topping, then continue to Stable Replenish, close ET vent valve, and monitor as follows:

- If hydrogen concentration increases as ullage pressure increases (per paragraphs A or B), then LCC violation confirmed, No Go for launch.
- If hydrogen concentration does not increase as ullage pressure increases (per paragraphs A or B), then hydrogen concentration can be attributed to vent duct area leakage.
  - Vent duct area leaks resulting in a concentration of 597 ppm or less are acceptable, LCC violation cleared, continue countdown.
  - Vent duct area leaks resulting in a concentration greater than 597 ppm are not acceptable. LCC violation confirmed, No Go for launch.

NOTES:

(4) 10,000 ppm is 25% of the Lower Flammable Limit (40,000 ppm) for hydrogen by volume in air (ground safety limit). This provides a safety factor above 4:1 for hydrogen leak evaluation should an oxygen leak occur or air intrusion occur. The 10,000 ppm ground safety limit is established in the Florida Safety Operating Plan (FSOP) 6100, Vol II, paragraph 2.6.5.1(1).

(5) The Hazardous Gas Detection Systems (HGDSs) are complex analytical instruments requiring expert operator interpretation of the data. Do not automate these measurements.

(6) Advisory System reference measurements are represented in LPS as follows:

MSID	DESCRIPTION	BIT VALUE	PCM LOW	PCM HIGH	UNITS
GGAXETIH2	Sys A ET IT H2	0.1	-500	50000	ppm
GGBXETIH2	Sys B ET IT H2	0.1	-500	50000	ppm
GHMR0005T	0-1 Pct H2 Gas Conc Range	0.005	-0.25	1	pct

REDLINE DERIVATION: CRITICALITY: 1

(7) a. SSID Intent Summary - The HGDS is used to verify there is no positive hydrogen concentration increase within the ET Intertank from the start of LH2 load to T-5 minutes and counting. Within this time period the ET LH2 tank is pressurized and loaded with cryogenics. Any potential for component or subsystem hydrogen leakage into the ET Intertank would be expected to manifest itself during this timeframe. Satisfaction of this LCC redline assures no unacceptable hydrogen leakage into the Intertank will take place during Terminal Count.

b. Voting Logic - n/a

c. Minimum and/or Maximum Redline Development - Reference paragraph (7)e. below.

d. Time Period - There is the potential for hydrogen leakage into the ET Intertank at any time after the start of LH2 load. Depending on the leak source the potential will change as the tank is pressurized and thermally cycled. A termination point of T-5 minutes and counting allows verification of no positive increase in ET Intertank hydrogen concentration subsequent to the tank being pressurized to elevated pressures representative of Terminal Count and following long term exposure to cryogenics. Satisfaction of this LCC assures acceptable performance from the hydrogen tank, subsystems and components within the ET Intertank during terminal count.

e. Requirements - Specification limit for ET Intertank hydrogen leakage is 7.2 scim. This is equivalent to 3 ppm in Replenish and 8 ppm with the tank pressurized and is close to the measurement threshold of the HGDS. "Positive hydrogen concentration increase" is defined as a test average exceeding the established background in excess of 3-sigma. Sigma is calculated with respect to established background. The HGDS will utilize one of the three mass spectrometer systems available to verify satisfaction of this LCC per the requirements set forth in LCC HAZ-01.

f. Preplanned Contingency Procedures - In the event of a verified positive hydrogen concentration increase within the ET Intertank, procedures are designed to determine if the leakage is upstream or downstream of the ET vent valve. This is accomplished by configuring the tank with the ET vent valve closed and observing if the Intertank hydrogen concentration increases or decreases as the pressure in the tank increases. A decrease in concentration indicates the leak is within the vent duct downstream of the ET vent valve. The ET vent valve is closed at LH2 Term Replenish and remains closed through ET separation. Leakage from the vent duct will have no effect during Terminal Count or ascent. Vent duct leaks resulting in concentrations not exceeding 597 ppm can be tolerated. The LCC violation is cleared and will result in a recommendation to continue the countdown. Any leakage from upstream of the ET vent valve will result in a recommendation of "No Go".

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Flammable hydrogen concentration during ascent or launching with an undefined out-of-spec hydrogen leak.
(9) Reference Integrated Hazard Reports IMPS-04, IMPS-09 and ISPR-02.

CAUSES OF EXCEEDING REDLINE:

(10) ET GH2 vent duct leakage.
(11) Tank ullage space leakage (including vent valve and wall penetrations).
(12) Tank leakage (liquid space with no tank wall penetrations).
(13) Compartment purge system malfunction.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Launch and Landing SUBSYSTEM: Haz Gas

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LCC VIOLATION CALL: Mid Fuselage and Payload Bay Hydrogen Concentration Anomaly | EMERG COND: Yellow (9)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	Payload Bay Hydrogen Concentration	NA	NA	(2)	ppm	CI
NA	Midbody Hydrogen Concentration	NA	NA	(2)	ppm	CI

TIME PERIOD:

(1) From Start of compartments GN2 purge initiation plus 30 minutes to Go for GLS Start (T-9 minutes and counting).

REQUIREMENTS: FIGURES/TABLES: Figure 40-01, -04

(2) Any positive Hydrogen concentration increase indicates a potential out-of-spec component leakage and requires leak evaluation. (3,7)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Perform PRSD Integrity Check per OMI S0007 Vol 4 (OMRSD V45CH0.030), if OMRS requirement is satisfied, LCC violation cleared, continue countdown.

NOTES:

(4) 10,000 ppm is 25% of the lower flammable limit for Hydrogen and Oxygen. This provides a 4:1 safety factor for Hydrogen ground safety for leak evaluation.
(5) The HGDSs are complex analytical instruments requiring expert operator interpretation of the data. Do not automate these measurements.
(6) Advisory System reference measurements are represented in LPS as follows:

MSID	DESCRIPTION	BIT VALUE	PCM LOW	PCM HIGH	UNITS
GGAXPLBH2	Sys A Payload Bay H2	0.1	-500	50000	ppm
GGBXPLBH2	Sys B Payload Bay H2	0.1	-500	50000	ppm
GGAXMIDH2	Sys A Midbody H2	0.1	-500	50000	ppm
GGBXMIDH2	Sys B Midbody H2	0.1	-500	50000	ppm
GHMR0005T	0-1 Pct H2 Gas Conc Range	0.005	-0.25	1	pct

REDLINE DERIVATION: CRITICALITY: 1

(7) "Positive Hydrogen concentration increase" is defined as a test average (Mid-body or Payload Bay) exceeding the established background (zero gas) in excess of 3-sigma. Calculate sigma with respect to established background.
(8) Any indicated leakage is outside PRSD system experience base.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Flammable concentration during ascent or launching with an undefined out-of-spec leak.

CAUSES OF EXCEEDING REDLINE:

(10) PRSD H2 leak.
(11) Compartment purge system malfunction.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: GSE SUBSYSTEM: Haz Gas

ET, Mid, P/L, Aft Hydrogen Conc (T-31 sec)

(THIS REQUIREMENT HAS BEEN DELETED)

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LCC VIOLATION CALL: Aft Compartment Oxygen Concentration Anomaly | EMERG COND: Yellow (12)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	Aft Oxygen Concentration	NA	NA	500	ppm	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (approximately T-6 hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES: Figure 40-01, -04

(2) Exceeding Maximum limit indicates a potential out-of-spec component leakage and requires leak evaluation. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) - If violation occurs due to late cabin vent (after L-17 mins), perform Late Cabin Vent Contingency option per OMI S0007 Vol 2. If Oxygen concentration is less than 500 ppm and Midbody/Payload Bay Oxygen concentration is decreasing by Go for GLS Start (T-9 minutes), then LCC violation cleared, continue countdown.
- For violations not associated with late cabin vent, LCC violation confirmed, No Go for launch. (4)

NOTES:

(4) For out-of-spec leakage with confirmed LCC violation, perform the following safing/leak Isolation:
Secure PRSD reactant gas supply line per OMI V1040.002.
- If the Oxygen concentration decreases, leak is isolated to PRSD system.
- If Oxygen concentration does not decrease, perform leak isolation test per OMI S1003 (OMRSD S00E00.020).

(5) ET Cryo Tanking may begin when the Orbiter compartment GN2 purge requirements of OMRSD S00FB0.050 have been satisfied. Additionally, V45CH0.030 requires that the Midbody and Payload Bay O2 concentrations be less than 500 ppm prior to the PRSD Integrity Check which occurs prior to ET Cryo Loading. The Aft Compartment O2 concentration is normally well below 500 ppm at this time.

(6) For IUS and EDO missions, the PLB GN2 purge rate may be reduced during the T-9 minute hold from approximately 230 lbs/min to approximately 170 lbs/min resulting in a reduction in the Aft Compartment purge flowrate. As a result of the purge reduction, the concentration level obtained after purge reduction for IUS and EDO missions is expected to show approximately 16 percent increase above the level obtained prior to purge reduction. Concentration changes for other unique payload purge requirements will be assessed on an as-needed basis. (This note does not modify LCC redline limits contained in this SSID).

NOTES: (Continued)

(7) Cabin leak check venting at approximately T-1 hour will result in Oxygen levels of 1,200 to 1,500 ppm in the PLB. Purge-flow mixing carries a significant concentration of Argon and this Oxygen into the Midbody and Aft Compartment.
(8) 10,000 ppm is 25% of the lower flammable limit for Hydrogen and Oxygen. This provides a 4:1 safety factor for Hydrogen ground safety for leak evaluation.
(9) The HGDSs are complex analytical instruments requiring expert operator interpretation of the data. Do not automate these measurements.
(10) Advisory System reference measurements are represented in LPS as follows:

MSID	DESCRIPTION	BIT VALUE	PCM LOW	PCM HIGH	UNITS
GGAXAFTO2	Sys A Aft O2	0.1	-500	50000	ppm
GGBXAFTO2	Sys B Aft O2	0.1	-500	50000	ppm
GHMR0019T	0-1 Pct O2 Gas Conc Range	0.005	-0.25	1	pct

REDLINE DERIVATION: CRITICALITY: 1

(11) The maximum concentration limit is based on previous HGDS resolution capability and management judgment, and are in excess of the historical mean + 3-sigma (90 percent confidence level) which was 377 ppm for STS-26 through STS-43. Also, since air ingestion during flight is the major contributor to Aft Compartment O2 concentration, low O2 system leakage is necessary to prevent exceeding the flammability limit during ascent when the system O2 leakage combines with the flight ingested O2.

CONSEQUENCES OF EXCEEDING REDLINE:

(12) Shuttle Vehicle will not be properly inerted for ET Cryo Tanking or ascent. A Hydrogen leak could then yield a flammable mixture.
(13) Oxygen enriched environments can significantly increase material flammability, therefore, material incompatibility may exist.
(14) Launch with potential crack in SSME or MPS hardware in excess of critical flaw size.

CAUSES OF EXCEEDING REDLINE:

(15) Oxygen leak.
(16) Air/O2 intrusion due to loss of, or ineffective GN2 purge.
(17) HGDS sample line leak.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: GSE SUBSYSTEM: Haz Gas

LCC VIOLATION CALL: ET Intertank Oxygen Concentration Anomaly | EMERG COND: Yellow (10)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	ET/IT Oxygen Concentration	NA	NA	(2)	ppm	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (approximately T-6 hours) to APU Start (T-5 minutes and counting)

REQUIREMENTS: FIGURES/TABLES: Figure 40-01, -04

(2) There should be no positive oxygen concentration increase during ET Cryo Tanking. Positive oxygen concentration increase is defined as a test average exceeding the established background in excess of 3-sigma. Calculate sigma with respect to established background. (3)

PREPLANNED CONTINGENCY PROCEDURE:

(3) A. If violation occurs prior to or during Slow Fill, then continue to Fast Fill and monitor oxygen concentration during ET vent valve cycling as described in paragraph (3)C.

B. If violation occurs during Fast Fill, then cycle ET vent valve and allow ET LO2 ullage pressure to increase. Do not exceed 16 PSIG. Monitor oxygen concentration while ET vent valve is closed as described in paragraph (3)C.

C. If violation occurs during or after Topping, then continue to Stable Replenish. Cycle ET vent valve and allow ET LO2 ullage pressure to increase. Do not exceed 16 PSIG. Monitor oxygen concentration while vent valve is closed.

- If oxygen concentration increases as ullage pressure increases (per paragraphs A., B. or C.), then LCC violation confirmed, No Go for launch.
- If oxygen concentration does not increase as ullage pressure increases (per paragraphs A., B. or C.), then an oxygen concentration below 10,000 ppm attributed to air intrusion is acceptable. LCC violation cleared, continue countdown.

NOTES:

(4) ET Cryo Tanking may begin when Orbiter Compartment GN2 purge requirements of OMRSD S00FB0.050 have been satisfied and the ET/IT oxygen concentration is less than 10,000 ppm. (Ref OMRSD T41FL0.040)

(5) Air intrusion is calculated using 22.43/1 oxygen to argon ratio. The ET intertank GN2 purge argon background will be subtracted as a correction factor.

(6) 10,000 ppm is approximately 25% of the Minimum Oxygen Content (MOC of 41,000 ppm) for an oxygen-hydrogen mixture with an ignition source for a flame to propagate. This provides an additional safety factor for oxygen leak evaluation should a hydrogen leak also occur. The 41,000 ppm MOC is

NOTES: (Continued)

established in the Ignition and Thermal Hazards of Selected Aerospace Fluids RD-WSTF-0001, Section II.E.1.c.iii.c for hydrogen.

(7) The Hazardous Gas Detection Systems (HGDSs) are complex analytical instruments requiring expert operator interpretation of the data. Do not automate these measurements.

(8) Advisory System reference measurements are represented in LPS as follows:

MSID	DESCRIPTION	BIT VALUE	PCM LOW	PCM HIGH	UNITS
GGAXETIO2	Sys A ET IT O2	0.1	-500	50000	ppm
GGBXETIO2	Sys B ET IT O2	0.1	-500	50000	ppm
GHMR0019T	0-1 Pct O2 Gas Conc Range	0.005	-0.25	1	pct

REDLINE DERIVATION: CRITICALITY: 1

(9) a. SSID Intent Summary - The HGDS is used to verify there is no positive oxygen concentration increase within the ET Intertank from the start of LO2 load to T-5 minutes and counting. Within this time period the LO2 tank is pressurized and loaded with cryogenics. Any potential for component or subsystem oxygen leakage into the ET Intertank would be expected to manifest itself during this timeframe. Satisfaction of this LCC assures no unacceptable oxygen leakage into the Intertank will take place during Terminal Count.

b. Voting Logic - n/a

c. Minimum and/or Maximum Redline Development - Reference paragraph (9)e. below.

d. Time Period - There is the potential for oxygen leakage into the ET Intertank at any time after the start of LO2 Orbiter MPS Chilldown. The LO2 hardware within the ET Intertank consists of the aft dome and LO2 17" feedline. There are two bolted flanges in the feedline assembly and one 1/8" K-seal port in the dome. This area is filled with liquid early in the LO2 loading process and remains sub-cooled.

Head pressure on a potential leak source will be increasing throughout LO2 load. Final static head pressure during Replenish on this portion of the LO2 system varies between 20 and 30 psig, depending on height in the tank. The maximum additional pressure applied during loading operations is approximately 8 psig. This takes place at the end of Fast Fill/beginning of Topping. The head pressure is established at that point resulting in a maximum pressure of approximately 28 to 38 psig being applied.

All LO2 17" feedline flanged joints and penetrations are at the bottom of the tank and see the higher end of this pressure range. The additional 14.5 psi (Ref. LCC ET-06 range, 19.3-22.5 psig) applied during LO2 prepress is not a significant increase in pressure above that seen during load and replenish operations. Given the low number of cryogenic joints, constant head pressure and the sub-cooled environment, any potential for leakage should manifest itself prior to Terminal

REDLINE DERIVATION: (Continued)

Count. A termination point of T-5 minutes and counting allows verification of no positive increase in ET Intertank oxygen concentration following long term exposure to head pressure and cryogenic temperatures. Satisfaction of this LCC assures acceptable performance from the oxygen tank, subsystems and components within the Intertank during Terminal Count.

e. Requirements - Specification ET Intertank leakage is 16.8 scim. This is equivalent to 7 ppm in Replenish and 8 ppm with the tank pressurized and is close to the measurement threshold of the HGDS. "Positive oxygen concentration increase" is defined as a test average (ET/IT) exceeding the established background in excess of 3-sigma. Calculate sigma with respect to established background. The HGDS will utilize one of the three mass spectrometer systems available to verify satisfaction of this LCC per the requirements set forth in LCC HAZ-01.

f. Preplanned Contingency Procedures - In the event of a verified positive oxygen concentration increase within the ET Intertank, procedures are designed to determine if the oxygen source is propellant leakage or air intrusion. This is accomplished by configuring the tank with the ET LO2 vent valve closed and observing if the Intertank oxygen concentration increases with the pressure in the ET LO2 tank. No change associated with the elevated ET LO2 tank pressure indicates the oxygen concentration is air intrusion. Air intrusion up to 10,000 ppm is acceptable. The LCC violation is cleared and will result in a recommendation to continue the countdown. An increase in concentration indicates the leak source is from the ET LO2 tank or components and will result in a recommendation of "No Go".

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Shuttle Vehicle will not be properly inerted for ET Cryo Tanking or ascent. A hydrogen leak could then yield a flammable mixture.
(11) Reference Integrated Hazard Reports IMPS-04, IMPS-12 and ISPR-02.

CAUSES OF EXCEEDING REDLINE:

(12) Oxygen leak in the ET Intertank.
(13) Air/O2 intrusion due to loss of, or ineffective ET Intertank GN2 purge.
(14) HGDS sample line leak.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Launch and Landing SUBSYSTEM: Haz Gas

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LCC VIOLATION CALL: Mid Fuselage and Payload Bay Oxygen Concentration Anomaly | EMERG COND: Yellow (11)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	Payload Bay Oxygen Concentration	NA	NA	(2)	ppm	CI
NA	Midbody Oxygen Concentration	NA	NA	(2)	ppm	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (approximately T-6 hours) to Go for GLS Start (T-9 minutes and counting).

REQUIREMENTS: FIGURES/TABLES: Figure 40-01, -04

(2) Any positive Oxygen concentration increase during ET Cryo Tanking indicates a potential out-of-spec component leakage and requires leak evaluation. (3, 9)

PREPLANNED CONTINGENCY PROCEDURE:

(3) Perform PRSD Integrity Check per OMI S0007 Vol 4 (OMRSD V45CH0.030), if OMRS is satisfied, LCC violation cleared, continue countdown.

NOTES:

(4) ET Cryo Tanking may begin when the Orbiter Compartment GN2 purge requirements of OMRSD S00FB0.050 have been satisfied. Additionally, V45CH0.030 requires that the Midbody and Payload Bay O2 concentrations be less than 500 ppm prior to the PRSD Integrity Check which occurs prior to ET Cryo Loading. The Aft Compartment O2 concentration is normally well below 500 ppm at this time.

(5) Cabin leak check venting at approximately T-1 hour will result in Oxygen levels of 1,200 to 1,500 ppm in the PLB. Purge-flow mixing carries a significant concentration of Argon and this Oxygen into the Midbody and Aft Compartment.

(6) 10,000 ppm is 25% of the lower flammable limit for Hydrogen and Oxygen. This provides a 4:1 safety factor for Hydrogen ground safety for leak evaluation.

(7) The HGDSs are complex analytical instruments requiring expert operator interpretation of the data. Do not automate these measurements.

(8) Advisory System reference measurements are represented in LPS as follows:

MSID	DESCRIPTION	BIT VALUE	PCM LOW	PCM HIGH	UNITS
GGAXPLBO2	Sys A Payload Bay O2	0.1	-500	50000	ppm
GGBXPLBO2	Sys B Payload Bay O2	0.1	-500	50000	ppm
GGAXMIDO2	Sys A Midbody O2	0.1	-500	50000	ppm
GGBXMIDO2	Sys B Midbody O2	0.1	-500	50000	ppm
GHMR0019T	0-1 Pct O2 Gas Conc Range	0.005	-0.25	1	pct

REDLINE DERIVATION: CRITICALITY: 1

(9) "Positive Oxygen concentration increase" is defined as a test average (Midbody or Payload Bay) exceeding the established background (zero gas) in excess of 3-sigma. Calculate sigma with respect to established background.
(10) Any indication of leakage is outside the PRSD system experience base.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Shuttle Vehicle will not be properly inerted for ET Cryo Tanking or ascent. A Hydrogen leak could then yield a flammable mixture.
(12) Oxygen enriched environments can significantly increase material flammability, therefore, material incompatibility may exist.

CAUSES OF EXCEEDING REDLINE:

(13) Oxygen leak.
(14) Air/O2 intrusion due to loss of, or ineffective GN2 purge.
(15) HGDS sample line leak.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: GSE SUBSYSTEM: Haz Gas

LCC VIOLATION CALL: Excessive Hydrogen Concentration At ET Ground Umbilical Carrier Assembly | EMERG COND: Yellow (10)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GLHR7047A	LD23 Pri H2 Concentration	(2)	NA	(3)	ppm	CI
GLHR7049A	LD25 Pri H2 Concentration	(2)	NA	(3)	ppm	CI
GLHR9047A	LD23 Sec H2 Concentration	(2)	NA	(3)	ppm	CI
GLHR9049A	LD25 Sec H2 Concentration	(2)	NA	(3)	ppm	CI
NA	Mass Spectrometer (HUMS) LD23/25	(4)	NA	(3)	ppm	BU

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Start of LH2 Terminate Replenish (T-1 minute 57 seconds)

REQUIREMENTS: FIGURES/TABLES: Figures 40-01 & -03

(2) Violation acceptable if instrumentation failure is confirmed. (5)
(3) Limit is 40,000 ppm hydrogen (GH2). If the oxygen (GO2) concentration in the Ground Umbilical Carrier Plate (GUCP) cavity reaches 40,000 ppm as measured by the Hydrogen Umbilical Mass Spectrometer (HUMS), or if the HUMS is unable to monitor leak detector (LD) LD23 and LD25 sample lines for GO2, then the maximum redline limit shall be reduced to 10,000 ppm GH2.
(4) Use HUMS as backup monitoring in the event of confirmed instrumentation failure of all four leak detector measurements (LD23 Pri & Sec and LD25 Pri & Sec). (5)

PREPLANNED CONTINGENCY PROCEDURE:

(5) For suspected instrumentation failure, perform "RLDS Calibration Gas Check for Hydrogen Leakage" per OMI S0007.500 to verify validity of data from LD23 or LD25. If violated measurements fail the Remote Leak Detector System (RLDS) calibration check, then LCC violation cleared, continue countdown.
(6) Reference OMI S1004 Emergency Instructions for the ET vent umbilical quick disconnect (QD) leakage isolation procedure.

NOTES:

(7) LD23 and LD25 monitor the GUCP cavity.
(8) HUMS monitors one area at a time and is used at operator discretion or by direction of the launch team. HUMS is also used for instrumentation verification and sampling integrity.

REDLINE DERIVATION: CRITICALITY: 1

(9) a. SSID Intent Summary - Hydrogen leak detectors are used at this location to measure GH2 leakage into the GUCP cavity. GH2 leakage past the ET GH2 vent 7-inch QD seal mixes with the GUCP cavity Helium (GHe) purge, is picked up by a sample port and transported to the leak detectors and/or HUMS for analysis. The GUCP cavity vents directly to ambient air through a gap in the interface seal. GH2 in flammable

REDLINE DERIVATION: (Continued)

concentrations internal to the GUCP cavity or external to the GUCP interface presents a risk of fire/explosion in those locations.

b. Voting Logic - N/A

c. Redline Development - Maximum redline of 40,000 ppm GH2 concentration has been established to protect potential flammability concerns of a vented GH2/GHe gas mixture as follows:

Flammable concentration of GH2/GHe mixture in air	50,000 ppm
Instrumentation tolerance	10,000 ppm
Redline	40,000 ppm

Alternate redline of 10,000 ppm GH2 is based on the ground safety limit established in Florida Safety Operating Plan (FSOP) 6100, Vol. II, para 2.6.5.1(1) which states that at atmospheric pressure, the flammable range of hydrogen is approximately 4 percent (pct) to 74 pct by volume of hydrogen in air. The safety limit is 25 pct of the lower flammability limit or 1 pct (10,000 ppm) by volume. FSOP 6100, Vol. II, paragraph 2.6.5.1(4) further states that if the oxygen concentration within a GSE umbilical reaches 4 pct or greater (due to air intrusion), the GSE umbilical leak detector GH2 limit will be reduced from 40,000 ppm to 10,000 ppm.

d. Time Period - Start time effectivity was chosen based on the time when hydrogen is first introduced to the ET. End time effectivity is based on termination of hydrogen flow through the ET GH2 vent 7-inch QD at T-1 minute 57 seconds when the ET LH2 vent valve is closed to pressurize ET for flight.

e. Requirements - LD23, LD25 or HUMS data is required to monitor the GUCP cavity to ensure GH2 leakage does not exceed a concentration which would become flammable. The HUMS system serves as a backup to fixed leak detectors LD23 and LD25. HUMS is also used to verify GO2 concentration in the purged cavity has not exceeded 40,000 ppm due to air intrusion. If the GO2 limit is exceeded or if HUMS is unavailable, the alternate redline limit is to be used.

f. Preplanned Contingency Procedures - The preplanned contingency procedure verifies the validity of data from LD23 and LD25. Hydrogen leak detectors LD23 and LD25 are calibrated to be accurate in a helium background but readings can be distorted by air or nitrogen intrusion into the system. HUMS can be used to discern the components of the sampled gas and determine actual GH2 concentrations if some air is present. In addition, secondary data paths exist for LD23 and LD25 which can be used in the event a Hardware Interface Module (HIM) or HIM card failure occurs which invalidates the primary data path.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Possible hydrogen fire/explosion at the ET GUCP.

CAUSES OF EXCEEDING REDLINE:

(11) Hazardous Warning System sample line (LD23/LD25) failure.
(12) ET vent umbilical GH2 leak.
(13) Loss of purge gas to ET GUCP.
(14) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	ppm								
GLHR7047A	300	-15000	60000						
GLHR7049A	300	-15000	60000						
GLHR9047A	300	-15000	60000						
GLHR9049A	300	-15000	60000						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Launch and Landing SUBSYSTEM: Haz

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LCC VIOLATION CALL: Excessive Hydrogen Concentration At LH2 T-0 Umbilical Carrier Plate Cavity | EMERG COND: Yellow (12)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GLHR7057A	LD28 Pri H2 Concentration	(2)	NA	(3)	ppm	CI
GLHR7067A	LD32 Pri H2 Concentration	(2)	NA	(3)	ppm	CI
GLHR9057A	LD28 Sec H2 Concentration	(2)	NA	(3)	ppm	CI
GLHR9067A	LD32 Sec H2 Concentration	(2)	NA	(3)	ppm	CI
NA	Mass Spectrometer (HUMS) LD28/32	(4)	NA	(3)	ppm	BU

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES: Figures 40-01 & -03

(2) Violation acceptable if instrumentation failure is confirmed. (5)
(3) Redline for leak detector (LD) is dependent on LH2 T-0 Umbilical Carrier Plate Cavity background gas concentrations and Hydrogen Umbilical Mass Spectrometer (HUMS) availability:
   A. For Helium (GHe) 80% to 100% and Oxygen (GO2)less than 4%, then the Hydrogen (GH2) redline is 40,000 PPM. (5)
   B. For GHe 70% to less than 80% and GO2 less than 4%, then the GH2 redline is 36,000 PPM. (6)
   C. For GHe 60% to less than 70% and GO2 less than 4%, then the GH2 redline is 34,000 PPM. (6)
   D. For GHe 50% to less than 60% and GO2 less than 4%, then the GH2 redline is 32,000 PPM. (6)
   E. For loss of HUMS GO2 monitoring or GO2 greater than 4%, then the maximum GH2 redline limit shall be reduced to 10,000 PPM.
(4) Use HUMS as backup monitoring in the event of confirmed instrumentation failure of all four leak detector measurements (LD28 Pri & Sec and LD32 Pri & Sec). (5)

PREPLANNED CONTINGENCY PROCEDURE:

(5) For suspected instrumentation failure perform "RLDS Calibration Gas Check for Hydrogen Leakage" per OMI S0007.500 to verify validity of data from LD28 or LD32. If violated measurements fail the Remote Leak Detector System (RLDS) calibration gas check, then LCC violation cleared, continue countdown.
(6) For GH2 LCC violation with GHe less than 80% and GO2 less than 4%, then perform HUMS GH2 analysis. If HUMS GH2 analysis verifies GH2 less than 40,000 PPM, then LCC violation cleared, continue countdown.
(7) Reference OMI S1004 Emergency Instructions for the T-0 umbilical leakage isolation procedure.
(8) Reference OMI V1040.003 for Power Reactant Storage and Distribution (PRSD) safing procedures.

NOTES:

(9) LD28 and LD32 monitor the LH2 T-0 Umbilical Carrier Plate cavity.
(10) HUMS monitors one area at a time and is used at operator discretion or by direction of the launch team. HUMS is also used for instrumentation verification and sampling integrity.

REDLINE DERIVATION: CRITICALITY: 1

(11) a. SSID Intent Summary - Hydrogen leak detectors are used at this location to measure GH2 leakage into the T-0 Umbilical Carrier Plate cavity. GH2 leakage past the 8-inch Fill and Drain line Quick Disconnect (QD) seal, Main Propulsion System (MPS) High Point Bleed line QD or PRSD Ground Reactant Supply line QD mixes with the T-0 Umbilical Carrier Plate cavity helium (GHe) purge, is picked up by a sample port and transported to the leak detectors and/or HUMS for detection. The T-0 Umbilical Carrier Plate cavity vents directly to ambient air at the interface seal and GH2 leakage in flammable concentrations internal to the T-0 umbilical Carrier Plate cavity or external to the T-0 Umbilical Carrier Plate interface presents a risk of fire/explosion at the T-0 umbilical interface.

b. Voting Logic - N/A

c. Redline Development - Maximum redline of 40,000 ppm GH2 concentration has been established to protect potential flammability concerns of a vented GH2/GHe gas mixture as follows:

Flammable concentration of GH2/GHe mixture in air	50,000 ppm
Instrumentation tolerance	10,000 ppm
Redline	40,000 ppm

Alternate redlines are based on LH2 T-0 Umbilical Carrier Plate Cavity helium (GHe) concentration and Orbiter purge nitrogen (GN2) intrusion. Empirical data has determined that decreasing GHe and increasing GN2 into the leak detector sample reduces the LD's ability to accurately measure GH2. The more GN2 introduced into the system, the lower the GH2 redline limit.

Alternate redline of 10,000 ppm GH2 is based on the ground safety limit established in Florida Safety Operating Plan (FSOP) 6100, Vol. II, paragraph 2.6.5.1(1) which states that at atmospheric pressure, the flammable range of hydrogen is approximately 4 percent (pct) to 74 pct by volume of hydrogen in air. The safety limit is 25 pct of the lower flammability limit or 1 pct (10,000 ppm) by volume. FSOP 6100, Vol. II, paragraph 2.6.5.1(4) further states that if the oxygen concentration within a GSE umbilical reaches 4 pct or greater (due to air intrusion), the GSE umbilical leak detector GH2 limit will be reduced from 40,000 ppm to 10,000 ppm.

d. Time Period - Start time effectivity was chosen based on the time when hydrogen is first introduced to the ET. End time effectivity is based

REDLINE DERIVATION: (Continued)

on termination of hydrogen flow to the T-0 Umbilical Carrier Plate just after T-31 seconds when PV22 MPS High Point Bleed valve is closed for flight.

e. Requirements - LD28, LD32 or HUMS data is required to monitor the T-0 Umbilical Carrier Plate Cavity to ensure GH2 leakage does not exceed a concentration which would become flammable. The HUMS system serves as a backup to fixed leak detectors LD28 and LD32. HUMS is also used to verify GO2 concentration in the purged cavity has not exceeded 40,000 ppm due to air intrusion. If the GO2 limit is exceeded or if HUMS is unavailable, the alternate 10,000 ppm redline limit is to be used.

f. Preplanned Contingency Procedures - The preplanned contingency procedure verifies the validity of data from LD28 and LD32. Hydrogen leak detectors LD28 and LD32 are calibrated to be accurate in a 100% helium background but readings can be distorted by air or nitrogen intrusion into the system. HUMS can be used to discern the components of the sampled gas and determine actual GH2 concentrations if air or GN2 is present. In addition, secondary data paths exist for LD28 and LD32 which can be used in the event a Hardware Interface Module (HIM) or HIM card failure occurs which invalidates the primary data path.

CONSEQUENCES OF EXCEEDING REDLINE:

(12) Possible hydrogen fire/explosion at the T-0 umbilical.
(13) Reference Integrated Hazard Reports IMPS-04 and IMPS-09.

CAUSES OF EXCEEDING REDLINE:

(14) Hazardous Warning System sample line (LD28/LD32) failure.
(15) MPS GH2 leak.
(16) Loss of T-0 Umbilical Carrier Plate cavity GHe purge.
(17) GH2 leak at 8-inch Fill and Drain line.
(18) GH2 leak at MPS High Point Bleed line.
(19) PRSD reactant line GH2 leak.
(20) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	ppm								
GLHR7057A	300	-15000	60000						
GLHR7067A	300	-15000	60000						
GLHR9057A	300	-15000	60000						
GLHR9067A	300	-15000	60000						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Launch and Landing SUBSYSTEM: Haz

LCC VIOLATION CALL: Excessive Hydrogen Concentration At T-0 8-inch Fill and Drain Line Purge Shroud | EMERG COND: Yellow (10)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GLHR7078A	LD56 Pri H2 Concentration	(2)	NA	(3)	ppm	CI
GLHR7079A	LD57 Pri H2 Concentration	(2)	NA	(3)	ppm	CI
GLHR9078A	LD56 Sec H2 Concentration	(2)	NA	(3)	ppm	CI
GLHR9079A	LD57 Sec H2 Concentration	(2)	NA	(3)	ppm	CI
NA	Mass Spectrometer (HUMS) LD56/57	(4)	NA	(3)	ppm	BU

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Start of LH2 Terminate Replenish (T-1 minute 57 seconds)

REQUIREMENTS: FIGURES/TABLES: Figures 40-01 & -03

(2) Violation acceptable if instrumentation failure is confirmed. (5)
(3) Limit is 40,000 ppm hydrogen (GH2). If the oxygen (GO2) concentration in the LH2 T-0 8-inch Fill and Drain Line Purge Shroud reaches 40,000 ppm as measured by the Hydrogen Umbilical Mass Spectrometer (HUMS), or if the HUMS is unable to monitor leak detector (LD) LD56 and LD57 sample lines for GO2, then the maximum redline limit shall be reduced to 10,000 ppm GH2.
(4) Use HUMS as backup monitoring in the event of confirmed instrumentation failure of all four leak detector measurements (LD56 Pri & Sec and LD57 Pri & Sec). (5)

PREPLANNED CONTINGENCY PROCEDURE:

(5) For suspected instrumentation failure perform "RLDS Calibration Gas Check for Hydrogen Leakage" per OMI S0007.500 to verify validity of data from LD56 or LD57. If violated measurements fail the Remote Leak Detector System (RLDS) calibration gas check, then LCC violation cleared, continue countdown.
(6) Reference OMI S1004 Emergency Instructions for the T-0 umbilical leakage isolation procedure.

NOTES:

(7) LD56 and LD57 monitor the T-0 8-inch Fill and Drain Line Purge Shroud.
(8) HUMS monitors one area at a time and is used at operator discretion or by direction of the launch team. HUMS is also used for instrumentation verification and sampling integrity.

REDLINE DERIVATION: CRITICALITY: 1

(9) a. SSID Intent Summary - Hydrogen leak detectors are used at this location to measure hydrogen leakage into the T-0 8-inch Fill and Drain Line Purge Shroud cavity. GH2 leakage past the 8-inch Fill and Drain line flexhose/8-inch Quick Disconnect (QD) Raco Seal or Drain Assist Purge line connection mixes with the purge shroud helium (GHe) purge, is

REDLINE DERIVATION: (Continued)

picked up by a sample port and transported to the leak detectors and/or HUMS for detection. The purge shroud vents directly to ambient air at the interface seal and GH2 leakage in flammable concentrations internal or external to the purge shroud presents a risk of fire/explosion at the T-0 umbilical.

b. Voting Logic - N/A

c. Redline Development - Maximum redline of 40,000 ppm GH2 concentration has been established to protect potential flammability concerns of a vented GH2/GHe gas mixture as follows:

Flammable concentration of GH2/GHe mixture in air	50,000 ppm
Instrumentation tolerance	10,000 ppm
Redline	40,000 ppm

Alternate redline of 10,000 ppm GH2 is based on the ground safety limit established in Florida Safety Operating Plan (FSOP) 6100, Vol. II, paragraph 2.6.5.1(1) which states that at atmospheric pressure, the flammable range of hydrogen is approximately 4 percent (pct) to 74 pct by volume of hydrogen in air. The safety limit is 25 pct of the lower flammability limit or 1 pct (10,000 ppm) by volume. FSOP 6100, Vol. II, paragraph 2.6.5.1(4) further states that if the oxygen concentration within a GSE umbilical reaches 4 pct or greater (due to air intrusion), the GSE umbilical leak detector GH2 limit will be reduced from 40,000 ppm to 10,000 ppm.

d. Time Period - Start time effectivity was chosen based on the time when hydrogen is first introduced to the ET. End time effectivity is based on termination of hydrogen flow to the T-0 8-inch Fill and Drain line interface at T-1 minute 57 seconds when LH2 ET replenish is terminated for flight.

e. Requirements - LD56, LD57 or HUMS data are required to monitor the T-0 8-inch Fill and Drain Line Purge Shroud to ensure GH2 leakage does not exceed a concentration which would become flammable. The HUMS system serves as a backup to fixed leak detectors LD56 and LD57. HUMS is also used to verify GO2 concentration in the purged cavity has not exceeded 40,000 ppm due to air intrusion. If the GO2 limit is exceeded or if HUMS is available, the alternate redline limit is to be used.

f. Preplanned Contingency Procedures - The preplanned contingency procedure verifies the validity of data from LD56 and LD57. Hydrogen leak detectors LD56 and LD57 are calibrated to be accurate in a helium background but readings can be distorted by air or nitrogen intrusion into the system. HUMS can be used to discern the components of the sampled gas and determine actual GH2 concentrations if some air is present. In addition, secondary data paths exist for LD56 and LD57 which can be used in the event a Hardware Interface Module (HIM) or HIM card failure occurs which invalidates the primary data path.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Possible hydrogen fire/explosion at the LH2 T-0 8-inch Fill and Drain Line Purge Shroud.

CAUSES OF EXCEEDING REDLINE:

(11) Hazardous Warning System sample line (LD56/LD57) failure.
(12) Loss of 8-inch Fill and Drain Line Purge Shroud purge.
(13) GH2 leak at Drain Assist Purge filter.
(14) Raco seal or debris plate GH2 leak.
(15) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

	BIT	PCM RANGE		HW C&W		BACKUP C&W		BFS SM	
MSID	VALUE	LOW	HIGH	MIN	MAX	MIN	MAX	MIN	MAX
UNITS-->	ppm								
GLHR7078A	300	-15000	60000						
GLHR7079A	300	-15000	60000						
GLHR9078A	300	-15000	60000						
GLHR9079A	300	-15000	60000						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Launch and Landing SUBSYSTEM: Haz

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LCC VIOLATION CALL: Excessive Hydrogen Concentration at Orbiter/ET Disconnect | EMERG COND: Yellow (12)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GLHR7088A	LD54 PRI H2 Concentration	(2,3)	NA	(4)	ppm	CI
GLHR7098A	LD55 PRI H2 Concentration	(2,3)	NA	(4)	ppm	CI
GLHR9088A	LD54 Sec H2 Concentration	(2,3)	NA	(4)	ppm	CI
GLHR9098A	LD55 Sec H2 Concentration	(2,3)	NA	(4)	ppm	CI
NA	HGDS Mass Spectrometer	(5)	NA	(4)	ppm	BU

TIME PERIOD:

(1) From Start of ET Cryo Tanking (approximately T-6 hours) to LD54 and LD55 sense line removal (during hold at T-3 hours)

REQUIREMENTS: FIGURES/TABLES: Figures 40-01 & -03

(2) No requirement if leak detector (LD) LD54 and LD55 sense lines have not been reinstalled after a previous launch attempt.
(3) Violation acceptable if instrumentation failure is confirmed. (6)
(4) No hydrogen (GH2) concentration greater than 10,000 ppm steady state. If intermittent or erratic readings occur, the data will be evaluated over a 10 minute period to determine the actual GH2 concentration.
(5) Use Hazardous Gas Detection System (HGDS) mass spectrometer as backup monitoring in the event of confirmed instrumentation failure of all four leak detector measurements (LD54 Pri & Sec and LD55 Pri & Sec). (6)

PREPLANNED CONTINGENCY PROCEDURE:

(6) Monitor LD54 and LD55 sample lines (if functional) using HGDS mass spectrometer. If all functional sample lines indicate 10,000 ppm or less, then LCC violation cleared, continue countdown.
(7) Reference OMI S1004 for Orbiter/ET disconnect leak isolation procedure.

NOTES:

(8) LD54 and LD55 are located adjacent to each other, 3 to 5 inches forward (-X) of the upper helium (GHe) purge hole exit, 4 to 8 inches inboard (+Y) of the upper GHe purge hole exit, 1 to 5 inches below (-Z) of the upper GHe purge hole exit.
(9) Once LD54 and LD55 sample lines are removed they will not be reinstalled unless directed by the Mission Management Team. (-Y Orbiter Weather Protection access is required).
(10) HGDS mass spectrometers monitor one area at a time and are used at operator discretion or by direction of the launch team. HGDS mass spectrometers are also used for instrumentation verification and sampling integrity.

REDLINE DERIVATION: CRITICALITY: 1

(11) a. SSID Intent Summary - Hydrogen leak detectors are used at this location to measure GH2 leakage from the LH2 Orbiter/ET Umbilical Carrier Plate.

REDLINE DERIVATION: (Continued)

GH2 leakage past the 17-inch Fill and Drain line or 4-inch Recirc line connection vents outside the Orbiter/ET Carrier Plate near the location of LD54 and LD55 sense lines, and is transported to the leak detectors and/or HGDS for detection. The Orbiter/ET Umbilical Carrier Plate cavity vents directly to ambient air at the purge hole exits and GH2 leakage in flammable concentrations internal or external to the LH2 Orbiter/ET Umbilical Carrier Plate presents a risk of fire/explosion at the Orbiter/ET umbilical interface.

b. Voting Logic - N/A

c. Redlines - Maximum redline of 10,000 ppm GH2 concentration is a level indicating significant GH2 leakage and is the ground safety limit for GH2 in open air. The lower flammability limit of GH2 is 40,000 ppm by volume in open air.

d. Time Period - Start time effectivity was chosen based on the time when hydrogen is first introduced to the ET. End time effectivity is based on last ground crew availability to remove the sense lines attached to the ET aft strut.

e. Requirements - LD54, LD55 or HGDS mass spectrometer data are required to monitor the Orbiter/ET Umbilical Carrier Plate to ensure GH2 leakage does not exceed a concentration which would become flammable. The HGDS mass spectrometer system serves as a backup to fixed leak detectors LD54 and LD55.

f. Preplanned Contingency Procedures - The preplanned contingency procedure verifies the validity of data from LD54 and LD55. Hydrogen leak detectors LD54 and LD55 are calibrated to be accurate in an air background but readings can be distorted by helium intrusion into the system. HGDS mass spectrometer can be used to discern the components of the sampled gas and determine actual GH2 concentrations if some helium is present. In addition, secondary data paths exist for LD54 and LD55 which can be used in the event a Hardware Interface Module (HIM) or HIM card failure occurs which invalidates the primary data path.

CONSEQUENCES OF EXCEEDING REDLINE:

(12) Possible hydrogen fire/explosion at the LH2 Orbiter/ET disconnect.

CAUSES OF EXCEEDING REDLINE:

(13) GH2 leak at LH2 Orbiter/ET disconnect.
(14) Excessive helium due to Orbiter/ET Umbilical Carrier Plate purge leakage.
(15) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	ppm								
GLHR7088A	200	-10000	40000						
GLHR7098A	200	-10000	40000						
GLHR9088A	200	-10000	40000						
GLHR9098A	200	-10000	40000						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Launch and Landing SUBSYSTEM: Haz

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LCC VIOLATION CALL: Excessive Hydrogen Concentration Inside LH2 TSM | EMERG COND: Yellow (11)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
GLHR7058A	LD29 Pri H2 Concentration	(2)	NA	(3)	ppm	CI
GLHR7059A	LD30 Pri H2 Concentration	(2)	NA	(3)	ppm	CI
GLHR9058A	LD29 Sec H2 Concentration	(2)	NA	(3)	ppm	CI
GLHR9059A	LD30 Sec H2 Concentration	(2)	NA	(3)	ppm	CI
NA	HGDS Mass Spectrometer	(4)	NA	(3)	ppm	BU

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES: Figures 40-01 &-03

(2) Violation acceptable if instrumentation failure is confirmed. (5)
(3) No hydrogen (GH2) concentration greater than 10,000 ppm.
(4) Use Hazardous Gas Detection System (HGDS) mass spectrometer as backup monitoring in the event of confirmed instrumentation failure of all four leak detector (LD) measurements (LD29 Pri & Sec and LD30 Pri & Sec). (5)

PREPLANNED CONTINGENCY PROCEDURE:

(5) Monitor LD29, LD30 or Tail Service Mast (TSM) hood sample lines (if functional) using HGDS mass spectrometer. If all functional sample lines indicate 10,000 ppm or less, then LCC violation cleared, continue countdown.
(6) Reference OMI S1004 Emergency Instructions for the LH2 system TSM leakage isolation procedure.
(7) Reference OMI V1040.003 for Power Reactant Storage and Distribution (PRSD) safing procedures.

NOTES:

(8) LD29 monitors the LH2 8-inch Fill and Drain line flexhose joint at the bottom of the TSM and LD30 monitors the TSM hood (top).
(9) HGDS mass spectrometers monitor one area at a time and are used at operator discretion or by direction of the launch team. HGDS mass spectrometers are also used for instrumentation verification and sampling integrity.

REDLINE DERIVATION: CRITICALITY: 1

(10) a. SSID Intent Summary - Hydrogen leak detectors are used at these locations to measure GH2 leakage from the LH2 Fill and Drain line, Main Propulsion System (MPS) High Point Bleed line, or PRSD Ground Reactant Supply line components inside the LH2 TSM. GH2 leakage inside the LH2 TSM can be detected by LD29 in the base of the TSM or by LD30 and a HGDS sense line in the hood of the TSM. The components in the LH2 TSM vent directly into the TSM and although the TSM is under a

REDLINE DERIVATION: (Continued)

nitrogen purge, GH2 leakage in flammable concentrations presents a risk of fire/explosion at the TSM near the T-0 umbilical interface.

b. Voting Logic - N/A

c. Redlines - Maximum redline of 10,000 ppm GH2 concentration is a level indicating significant GH2 leakage and is the ground safety limit for GH2 in open air. The lower flammability limit of GH2 is 40,000 ppm by volume in open air.

d. Time Period - Start time effectivity was chosen based on the time when hydrogen is first introduced to the ET. End time effectivity is based on termination of hydrogen flow through the TSM lines just after T-31 seconds when PV22 MPS High Point Bleed valve is closed for flight.

e. Requirements - LD29, LD30 or HGDS mass spectrometer data is required to monitor the interior space of the LH2 TSM to ensure GH2 leakage does not exceed a concentration which would become flammable. The HGDS mass spectrometer system serves as a backup to fixed leak detectors LD29 and LD30.

f. Preplanned Contingency Procedures - The preplanned contingency procedure verifies the validity of data from LD29 and LD30. Hydrogen leak detectors LD29 and LD30 are calibrated to be accurate in a nitrogen background but readings can be distorted by helium intrusion in the system. HGDS mass spectrometer can be used to discern the components of the sampled gas and determine actual GH2 concentrations if helium is present. In addition, secondary data paths exist for LD29 and LD30 which can be used in the event a Hardware Interface Module (HIM) or HIM card failure occurs which invalidates the primary data path.

CONSEQUENCES OF EXCEEDING REDLINE:

(11) Possible hydrogen fire/explosion in the LH2 TSM.

CAUSES OF EXCEEDING REDLINE:

(12) GH2 leak at 8-inch Fill and Drain line.
(13) GH2 leak at MPS High Point Bleed line.
(14) PRSD Reactant line GH2 leak.
(15) Instrumentation failure.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	ppm								
GLHR7058A	200	-10000	40000						
GLHR7059A	200	-10000	40000						
GLHR9058A	200	-10000	40000						
GLHR9059A	200	-10000	40000						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Launch and Landing SUBSYSTEM: Haz

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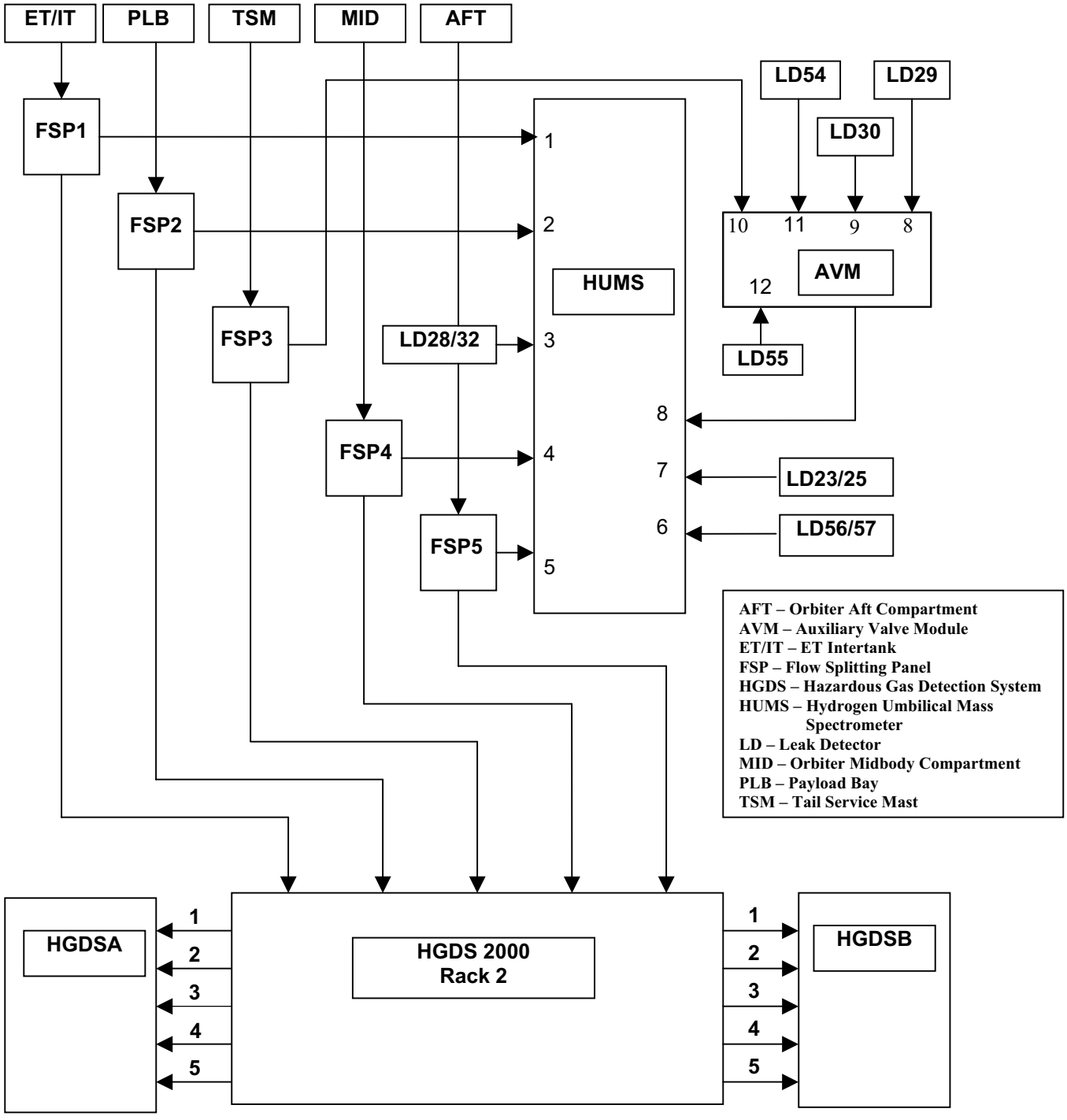

Figure 40-01 Haz Gas Detection System Schematic

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Figure 40-02 Hazardous Gas Detection System Hydrogen, Oxygen and Helium Concentration Limits

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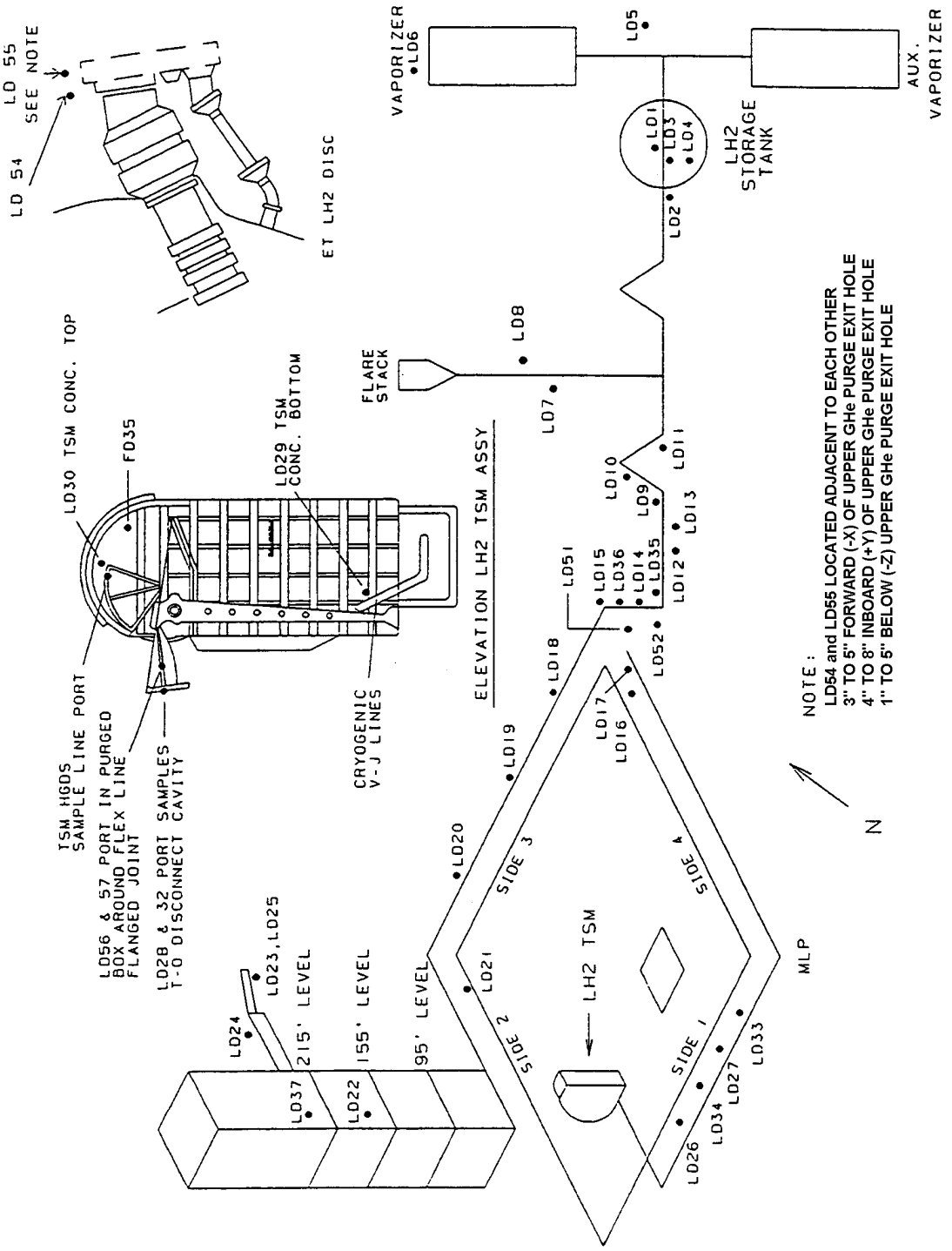

Figure 40-03 Hydrogen Leak Detector Sensor Overall Location

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	HGDS A & B					
Gas	HGDS A MSID	HGDS B MSID	Range (PPM)	Precision (PPM)	Location	Ref LCC
Hydrogen	GGAXG1PPM	GGBXG1PPM	-500 to 50,000	.1		
Hydrogen	GGAXETIH2	GGBXETIH2	-500 to 50,000	.1	ET/IT	HAZ-04
Hydrogen	GGAXPLBH2	GGBXPLBH2	-500 to 50,000	.1	PLB	HAZ-05
Hydrogen	GGAXTSMH2	GGBXTSMH2	-500 to 50,000	.1	TSM	
Hydrogen	GGAXMIDH2	GGBXMIDH2	-500 to 50,000	.1	MID	HAZ-05
Hydrogen	GGAXAFTH2	GGBXAFTH2	-500 to 50,000	.1	AFT	HAZ-03
Helium	GGAXG2PPM	GGBXG2PPM	-500 to 50,000	.1		
Helium	GGAXETIHE	GGBXETIHE	-500 to 50,000	.1	ET/IT	
Helium	GGAXPLBHE	GGBXPLBHE	-500 to 50,000	.1	PLB	
Helium	GGAXTSMHE	GGBXTSMHE	-500 to 50,000	.1	TSM	
Helium	GGAXMIDHE	GGBXMIDHE	-500 to 50,000	.1	MID	
Helium	GGAXAFTHE	GGBXAFTHE	-500 to 50,000	.1	AFT	HAZ-02
Oxygen	GGAXG4PPM	GGBXG4PPM	-500 to 50,000	.1		
Oxygen	GGAXETIO2	GGBXETIO2	-500 to 50,000	.1	ET/IT	HAZ-07
Oxygen	GGAXPLBO2	GGBXPLBO2	-500 to 50,000	.1	PLB	HAZ-08
Oxygen	GGAXTSMO2	GGBXTSMO2	-500 to 50,000	.1	TSM	
Oxygen	GGAXMIDO2	GGBXMIDO2	-500 to 50,000	.1	MID	HAZ-08
Oxygen	GGAXAFTO2	GGBXAFTO2	-500 to 50,000	.1	AFT	HAZ-06
Argon	GGAXG5PPM	GGBXG5PPM	-500 to 50,000	.1		
Argon	GGAXETIAR	GGBXETIAR	-500 to 50,000	.1	ET/IT	
Argon	GGAXPLBAR	GGBXPLBAR	-500 to 50,000	.1	PLB	
Argon	GGAXTSMAR	GGBXTSMAR	-500 to 50,000	.1	TSM	
Argon	GGAXMIDAR	GGBXMIDAR	-500 to 50,000	.1	MID	
Argon	GGAXAFTAR	GGBXAFTAR	-500 to 50,000	.1	AFT	
Nitrogen	GGAXG3PPM	GGBXG3PPM	-500 to 50,000	.1		

Figure 40-04 HGDS Ranges and Resolution

		HUMS	
Gas	**MSID**	**Range (PPM)**	**Resolution (PPM)**
Hydrogen	GHMR0005T	-2,500 to 10,000	50
Hydrogen	GHMR0004T	-12,500 to 50,000	250
Hydrogen	GHMR0003T	-25,000 to 100,000	500
Helium	GHMR0010T	-2,500 to 10,000	50
Helium	GHMR0009T	-12,500 to 50,000	250
Helium	GHMR0008T	-25,000 to 100,000	500
Helium	GHMR0007T	-125,000 to 500,000	2,500
Helium	GHMR0006T	-250,000 to 1,000,000	5,000
Oxygen	GHMR0019T	-2,500 to 10,000	50
Oxygen	GHMR0018T	-12,500 to 50,000	250
Oxygen	GHMR0017T	-25,000 to 100,000	500
Oxygen	GHMR0016T	-62,500 to 250,000	1,250
Argon	GHMR0023T	-50 to 200	1
Argon	GHMR0022T	-250 to 1,000	5
Argon	GHMR0021T	-1,250 to 5,000	25
Argon	GHMR0020T	-2,500 to 10,000	50
Nitrogen	GHMR0015T	-2,500 to 10,000	50
Nitrogen	GHMR0014T	-12,500 to 50,000	250
Nitrogen	GHMR0013T	-25,000 to 100,000	500
Nitrogen	GHMR0012T	-125,000 to 500,000	2,500
Nitrogen	GHMR0011T	-250,000 to 1,000,000	5,000

Figure 40-04 HGDS Ranges and Resolutions

SECTION 41

LAUNCH PROCESSING SYSTEM

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SECTION 41: LAUNCH PROCESSING SYSTEM

SSID No.	Description/Violation Call	Page
LPS-01	Master Console Anomaly (REQUIREMENT DELETED)	41-01.1
LPS-02	Integration Console Anomaly	41-02.1
LPS-03	Backup Console Anomaly	41-03.1
LPS-04	Operations Console (C1) (Payload) Anomaly (REQUIREMENT DELETED)	41-04.1
LPS-05	Operations Console (C2) (Comm, Nav, Mech and Payload EPDC) Anomaly (REQUIREMENT DELETED)	41-05.1
LPS-06	Operations Console (C3) (LOX, MPL and SSME) Anomaly	41-06.1
LPS-07	Operations Console (C4) (LH2 and MPS) Anomaly	41-07.1
LPS-08	Operations Console (C5) (ECLSS and RSS) (REQUIREMENT DELETED)	41-08.1
LPS-09	Operations Console (C6) (PVD, FCP and PRSD) (REQUIREMENT DELETED)	41-09.1
LPS-10	Operations Console (C7) (OMS/RCS, OAA, GVA and Sound Suppression Water) Anomaly (REQUIREMENT DELETED)	41-10.1
LPS-11	Operations Console (C8) (APU and HYD) Anomaly (REQUIREMENT DELETED)	41-11.1
LPS-12	Operations Console (C9) (HGDS and Orbiter Instrumentation) Anomaly (REQUIREMENT DELETED)	41-12.1
LPS-13	Operations Console (C10) (EPDC) Anomaly (REQUIREMENT DELETED)	41-13.1
LPS-14	Operations Console (C11) (GNC) Anomaly (REQUIREMENT DELETED)	41-14.1
LPS-15	Operations Console (C12) (DPS and SSMEC) Anomaly (REQUIREMENT DELETED)	41-15.1

SECTION 41: LAUNCH PROCESSING SYSTEM (CONTINUED)

SSID No.	Description/Violation Call	Page
LPS-16	Common Data Buffer Anomaly (REQUIREMENT DELETED)	41-16.1
LPS-17	Launch Data Bus (LDB) Anomaly	41-17.1
LPS-18	GPC PCM Front End Processor (FEP) Anomaly	41-18.1
LPS-19	OI PCM Front End Processor (FEP) Anomaly	41-19.1
LPS-20	GS1 Front End Processor (FEP) Anomaly	41-20.1
LPS-21	GS2 Front End Processor (FEP) Anomaly	41-21.1
LPS-22	Time Code Generator Anomaly (REQUIREMENT DELETED)	41-22.1
LPS-23	Processor Data Recorder Anomaly (REQUIREMENT DELETED)	41-23.1
LPS-24	Remote Control Video Switcher/Video Data Assembly (REQUIREMENT DELETED)	41-24.1
LPS-25	GS3 Front End Processor (FEP) Anomaly	41-25.1

Master Console Anomaly

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LCC VIOLATION CALL: Integration Console Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
SINTGGO	Integration Console Go Mode		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to SRB Ignition (T-0)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) Integration console failure prior to T-5 minutes: Test engineers move to Backup and Master consoles per LPS recovery procedures (ref. OMI S0007 Vol. 5).

NOTES:

(3) Automatic cutoff and safing will result if the Integration console fails after T-9 minutes and counting.
(4) Launch window time permitting, the GLS will be reinitialized at the Backup console. After T-5 minutes, a recycle to T-20 minutes is required.

REDLINE DERIVATION: CRITICALITY: 1S

(5) The Ground Launch Sequencer is resident in the Integration and Backup consoles.
(6) The Integration console performs CCMS integrity/health monitoring in the event of a Master console failure.
(7) In the event of an Integration console failure after T-9 minutes, Backup console software will perform automatic flight and ground systems safing.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Loss of capability to perform critical time related functions with the GLS after T-5 minutes.

CAUSES OF EXCEEDING REDLINE:

(9) Failure of subsystem or its I/O devices which prevents performing GLS.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Launch and Landing SUBSYSTEM: LPS

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LCC VIOLATION CALL: Backup Console Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
SBKUPGO	Backup Type II Console Go Mode		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to SRB Ignition (T-0)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) Backup console failure prior to T-5 minutes: Test engineers move to Master or Spare console per LPS recovery procedures (ref. OMI S0007 Vol. 5).

NOTES:

(3) If the Backup console is configured as the "mainline console" and it fails prior to T-9 minutes, a countdown Hold will result. After T-9 minutes, a cutoff will result.
(4) If the console is configured as the GLS Backup console and it fails prior to T-5 minutes, a countdown Hold will result. After T-5 minutes, a cutoff will result.

REDLINE DERIVATION: CRITICALITY: 1S

(5) The Backup console performs interrupt processing of Launch Commit Criteria (LCC) parameters for flight and ground systems.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Loss of capability to monitor LCC measurements.

CAUSES OF EXCEEDING REDLINE:

(7) Failure of subsystem or its I/O devices preventing monitoring/processing LCC interrupts.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Launch and Landing SUBSYSTEM: LPS

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Operations Console (C1) (Payload) Anomaly

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Operations Console (C2) (Comm, Nav, Mech and Payload EPDC) Anomaly

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LCC VIOLATION CALL: Operations Console (C3) (LOX, MPL and SSME) Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
SC3GO	Operations Console #3 Go Mode		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) To Go for SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) For failure of Operations Console #3: Test engineers move to Spare console; interim monitoring provided per LPS recovery procedures (ref. OMIs S0007 Vol. 5 and S1003).

NOTES:

REDLINE DERIVATION: CRITICALITY: 1S

(3) LO2 Propellant loading and ET prepressurization software is resident solely at this console.
(4) The capability to perform ET ullage pressurization during SSME start is active through T-0.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Operations Console #3 (LOX and SSME) failure after T-31 seconds may result in degradation of ullage pressure and GLS/RSLS breakout because of loss of SSME ENGINE READY or pad abort because of SSME turbo pump low Net Positive Suction Pressure (NPSP). For a console failure, the Master console will perform LOX revert and the GLS will initiate a hold (prior to T-31 seconds) or a breakout/safing and recycle (after T-31 seconds until T-10 seconds).
(6) Operations Console #3 (LOX, MPL, and SSME) failure after LO2 drainback (T-4 minutes 55 seconds) will result in revert and recycle to T-20 minutes to reestablish LO2 flight mass and stable replenish.

CAUSES OF EXCEEDING REDLINE:

(7) Failure of console CPU and I/O LRUs.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Launch and Landing SUBSYSTEM: LPS

LCC VIOLATION CALL: Operations Console (C4) (LH2 and MPS) Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
SC4GO	Operations Console #4 Go Mode		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) For failure of Operations Console #4: Test engineers move to Spare console; interim monitoring provided per LPS recovery procedures (ref. OMIs S0007 Vol. 5 and S1004).

NOTES:

REDLINE DERIVATION: CRITICALITY: 1S

(3) LH2 Propellant loading and ET prepressurization software is resident solely at this console.
(4) The capability to perform ET ullage pressurization during SSME start is active through T-0.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Operations Console #4 (LH2 and MPS) failure after T-31 seconds may result in degradation of ullage pressure and GLS/RSLS breakout because of loss of SSME ENGINE READY or pad abort because of SSME turbo pump low Net Positive Suction Pressure (NPSP). For a console failure, the Master console will perform LH2 stopflow and the GLS will initiate a hold (prior to T-31 seconds) or a breakout/safing and recycle (after T-31 seconds until T-10 seconds).

CAUSES OF EXCEEDING REDLINE:

(6) Failure of console CPU and I/O LRUs.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Launch and Landing SUBSYSTEM: LPS

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Operations Console (C5) (ECLSS and RSS)

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Operations Console (C6) (PVD, FCP and PRSD)

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Operations Console (C7) (OMS/RCS, OAA, GVA and Sound Suppression Water) Anomaly

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Operations Console (C8) (APU and HYD) Anomaly

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Operations Console (C9) (HGDS and Orbiter Instrumentation) Anomaly

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Operations Console (C10) (EPDC) Anomaly

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Operations Console (C11) (GNC) Anomaly

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Operations Console (C12) (DPS and SSMEC) Anomaly

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Common Data Buffer Anomaly

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LCC VIOLATION CALL: Launch Data Bus (LDB) Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
SLDBADATAV	LDB FEP Active Data Valid	(1)	ON	NA	Event	CI
SLDBSDATAV	LDB FEP Standby Data Valid	(2)	ON(5)	NA	Event	CI
SLDB1STAT	LDB Bus 1 Active	(2)	(3)	NA	Event	CI
SLDB2STAT	LDB Bus 2 Active	(2)	(3)	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for SSME Start (T-10 seconds).
(2) From Start of ET Cryo Tanking (T-6 hours) to Go for RSLS Start (T-31 seconds).

REQUIREMENTS: FIGURES/TABLES:

(3) 2 of 2 LDB transmission systems required (No unexplained LDB switch). (4)

PREPLANNED CONTINGENCY PROCEDURE:

(4) In the event of an unexplainable bus switch (prior to T-31 seconds), Launch Processing System (LPS) will request a countdown hold. With test team concurrence, Data Processing System (DPS) will command LDB switch back to original bus to ascertain if error condition is unrecoverable (ref. OMI S0007.500).
- If bus switch is successful and polling can be maintained on original LDB, LCC violation cleared, continue countdown.
- If bus switch is not successful, LCC violation confirmed, No Go for launch.

(5) For loss of LDB standby Front End Processor (FEP) prior to T-9 minutes, LPS will configure a new standby FEP (ref. OMI S0007.500). For sucessful configuration of a new standby FEP, LCC violation cleared, continue countdown.

NOTES:

(6) SLDBADATAV measurement is used by LPS and the Ground Launch Sequencer (GLS) to verify operational status of the active LDB FEP.
(7) LPS Type II consoles (Master or Integration) verify operational system integrity of both active and standby LDB FEPs.
(8) A transmission system failure is defined as an unrecoverable error condition which forces the controlling General Purpose Computer (GPC) to select the alternate LDB. This occurs when three successive communication attempts fail between the GPC and the LDB FEP.
(9) Only one LDB at a time will be polling the ground (SLDBxSTAT = ON).
(10) DPS switches to the alternate LDB bus periodically during the countdown to verify functionality of the alternate bus.
(11) If the standby LDB FEP becomes the active LDB FEP, GLS will be notified to position the LDB Safing Panel Switch to the new active LDB FEP position.

REDLINE DERIVATION: CRITICALITY: 1S

(12) a. SSID Intent Summary - The intent of this requirement is to verify the operational status of the active and standby LDB FEPs.

b. Voting Logic - Both LDB buses are required to provide redundancy for critical safing, however, only one bus is active at a time. An unexplained LDB bus switch is a potential indication of a communication error between the GPC and the LDB FEP.

c. Minimum and Maximum Redline Development - The LDB FEP Active/Standby Data Valid measurements must be ON to verify operational system integrity.

d. Time Period - Both active and standby FEPs are required from the Start of ET Cryo Tanking to T-31 seconds to provide redundancy for critical safing as late as possible. For a loss of one launch data bus, T-10 seconds is the last opportunity to issue ground commands to the vehicle.

e. Requirements - The LDB FEP provides the command link (hardline) between the Shuttle and LPS. It has the capability to issue preprogrammed safing sequences to the Shuttle Flight Software (RSLS)/Hardware in the event of a Common Data Buffer (CDBFR) failure. This LCC protects the FEP's capability to issue critical safing sequences by ensuring active and standby pairs until T-31 seconds and at a minimum one active FEP until T-10 seconds.

f. Preplanned Contingency Procedure - The LDB FEP failure PCP provides the steps to recover from the loss of a standby LDB FEP. Recovery of a standby LDB FEP or recovery from the loss of an LDB transmission system component cannot be attempted after T-9 minutes and counting without presenting operational risks due to the manual/intrusive actions which are performed (must enter CDBFR address parameters via the front panel keypad; must change safing panel connectors at the junction box by removing cable for failed FEP and connecting cable for new FEP; removing and replacing Fiber Optic Terminal Equipment (FOTE) receiver or transmitter modules, or summing or splitting amplifiers may cause mechanical interference with adjacent components or result in connector seating mis-alignment). It is also possible that a latent parity error in extended memory of the active LDB FEP could cause the automatic table synchronization operation to fail, resulting in both the active and standby LDB FEPs crashing. The LDB bus switching PCP provides the steps to switch the LDB bus back to the original bus and to establish polling. One time transient errors are deemed acceptable for the LDB transmission system since the system is still able to perform safing functions.

CONSEQUENCES OF EXCEEDING REDLINE:

(13) Loss of communication with GPCs if both FEPs and/or both transmission systems fail.

(14) Loss of the onboard LDB 1 may result in a loss of communications with the Manipulator Controller Interface Unit (FLT deck Remote Manipulator System).

CAUSES OF EXCEEDING REDLINE:

(15) Failure of FEP or transmission system Line Replaceable Units (LRU).

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Launch and Landing SUBSYSTEM: LPS

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LCC VIOLATION CALL: GPC PCM Front End Processor (FEP) Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
SGPCADATAV	GPC FEP Active Data Valid		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to SRB Ignition (T-0).

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) For loss of Active GPC FEP, perform GPCA FEP recovery procedure (Ref S0007.500). For successful recovery of an Active GPC FEP, LCC violation cleared, continue countdown.

NOTES:

(3) All attempts will be made to provide full redundancy of the GSE and launch support hardware as late in the countdown as possible without impact to launch (ref S0007.500).
- If a single GPC FEP failure occurs with adequate time to recover, a spare FEP will be configured to replace the failed FEP.
- If a data source switch from hardline source to RF occurs with adequate time to recover, hardline data will be re-established.

(4) SGPCADATAV measurement is used by the GLS to verify operational status of the active GPC FEP.

(5) LPS Type II consoles (Master or Integration) verify operational system integrity of both active and standby GPC FEPs.

(6) The FEP tables are checkpointed periodically to save a "known good" data set if required for subsequent reload. Checkpoints are performed at the following intervals: T-6H (prior to start of tanking), approximately T-3H (end of tanking), T-1H, and T-9M. GPC FEP table data can be re-loaded with the latest checkpointed data set if active GPC FEP tables are compromised.

REDLINE DERIVATION: CRITICALITY: 1S

(7) a. SSID Intent Summary - The intent of this SSID is to verify operational integrity of the active GPC FEP from T-6H through T-0. The GPC FEP provides the data interface (downlist) link between the Shuttle and the LPS. It complements the LDB (command link) by providing insight into actions initiated by ground command/flight software or subsystem configuration. The SGPCADATAV measurement is a direct indicator of active GPC FEP health and operational functionality, and indicates data is valid and being properly processed.

The GPC FEP is required to process the downlist in order for the

REDLINE DERIVATION: (Continued)

ground to maintain insight into the state of the vehicle including detecting vehicle fault conditions and LCC violations, synchronizing onboard and ground countdown sequences, safing the vehicle in event of abort or scrub, and detecting and responding to emergency conditions. Loss of the GPCA FEP will impact the ground's ability to perform these vital functions. Data from the GPC FEP is used to provide current configuration and status to the GLS.

Fault tolerance is accommodated by operating the GPC FEPs in an active/standby pair configuration, with the standby FEP assuming the active FEP role in the event of failure of the active FEP. LPS will maintain this active/standby configuration unless it is operationally appropriate to continue countdown without a standby GPC FEP. This is an acceptable configuration based on the limited time remaining in the countdown, coupled with the low probability of an additional GPC FEP subsystem failure.

b. Voting Logic - N/A

c. Minimum and/or Maximum Redline Development

Minimum Redline: ON

The measurement is a discrete System Status Pseudo Function Designator that is maintained by LPS System Integrity and monitored by both Master and Integration Consoles.

The minimum ON redline state indicates the FEP is receiving and decommutating either PASS AREA 1 downlist data, BFS AREA 2 downlist data, or both.

A change in the state of the SGPCADATAV discrete FD from ON to OFF indicates the FEP cannot process both PASS Area 1 and BFS Area 2. This will result in the FEP terminating updates of PASS and BFS data and LPS losing visibility of PASS and BFS downlisted MSIDs.

A change in the state of the SGPCADATAV discrete FD from ON to OFF indicates a failure of the FEP subsystem, or consecutive synchronization errors caused by downlist signal degradation due to a data path or on-board data generation anomaly.

There is no maximum redline state.

d. Time Period - The SGPCADATAV discrete System Status Pseudo Function Designator is required to be in the ON state from the start of Cryo Tanking at T-6H through T-0. This provides end users with downlist data integrity which is required to properly synchronize the ground and onboard countdown sequences, perform LCC verifications, perform post scrub/abort safing, and detect and respond to potential hazards and emergency conditions throughout terminal countdown.

REDLINE DERIVATION: (Continued)

e. Requirements - N/A

f. Preplanned Contingency Procedures - For loss of active GPC FEP, perform GPCA FEP Recovery Procedure (Ref S0007.500). This procedure replaces a failed active GPC FEP with a spare FEP. For successful recovery of an active GPC FEP, LCC violation cleared, continue countdown.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Loss of capability to monitor vehicle GPC PCM measurements.

CAUSES OF EXCEEDING REDLINE:

(9) Failure of FEP subsystem.
(10) Consecutive synchronization errors caused by downlist signal degradation due to data path or on-board data generation anomaly.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Launch and Landing SUBSYSTEM: LPS

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LCC VIOLATION CALL: OI PCM Front End Processor (FEP) Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
SOIADATAV	OI FEP Active Data Valid		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for SSME Start (T-10 seconds).

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) For loss of Active OI FEP, perform FEP recovery procedure (Ref S0007.500). For successful recovery of an Active OI FEP, LCC violation cleared, continue countdown.

NOTES:

(3) All attempts will be made to provide full redundancy of the GSE and launch support hardware as late in the countdown as possible without impact to launch (ref S0007.500).
- If a single OI FEP failure occurs with adequate time to recover, a spare FEP will be configured to replace the failed standby FEP.
- If a data source switch from hardline source to RF occurs with adequate time to recover, hardline data will be re-established.

(4) SOIADATAV measurement is used by the GLS to verify operational status of the active OI FEP.

(5) LPS Type II consoles (Master or Integration) verify operational system integrity of both active and standby OI FEPs.

(6) The FEP tables are Checkpointed periodically to save a "known good" data set if required for subsequent reload. Checkpoints are performed at the following intervals: T-6 hours (prior to start of tanking), approx T-3 hours (end of tanking), and T-1 hour. FEP table data can be re-loaded to the latest checkpointed load if both FEP tables are compromised.

REDLINE DERIVATION: CRITICALITY: 1S

(7) a. SSID Intent Summary - The intent of this SSID is to verify operational integrity of the active OI FEP from T-6H through T-10S. The OI FEP provides the data interface (downlink) link between the Shuttle and the LPS. It complements the LDB (command link) by providing insight into actions initiated by ground command/flight software or subsystem configuration. The SOIADATAV measurement is a direct indicator of active OI FEP health and operational functionality, and indicates data is valid and being properly processed.

The OI FEP is required to process the downlink in order for the

REDLINE DERIVATION: (Continued)

ground to maintain insight into the state of the vehicle including detecting vehicle fault conditions and LCC violations, synchronizing onboard and ground countdown sequences, safing the vehicle in event of abort or scrub, and detecting and responding to emergency conditions. Loss of the OIA FEP will impact the ground's ability to perform these vital functions. Data from the OI FEP is used to provide current configuration and status to the GLS.

Fault tolerance is accommodated by operating the OI FEPs in an active/standby pair configuration, with the standby FEP assuming the active FEP role in the event of failure of the active FEP. LPS will maintain this active/standby configuration unless it is operationally appropriate to continue countdown without a standby OI FEP. This is an acceptable configuration based on the limited time remaining in the countdown, coupled with the low probability of an additional OI FEP subsystem failure.

b. Voting Logic - N/A

c. Minimum and/or Maximum Redline Development

Minimum Redline: ON

The measurement is a discrete System Status Pseudo Function Designator that is maintained by LPS System Integrity and monitored by both Master and Integration Consoles.

The minimum ON redline state indicates the FEP is receiving and decommutating OI AREA 0 downlink data.

A change in the state of the SOIADATAV discrete FD from ON to OFF indicates the FEP cannot process OI Area 0. This will result in the FEP terminating updates of OI data and LPS losing visibility of OI downlisted MSIDs.

A change in the state of the SOIADATAV discrete FD from ON to OFF indicates a failure of the FEP subsystem, or consecutive synchronization errors caused by downlink signal degradation due to a data path or on-board data generation anomaly.

There is no maximum redline state.

d. Time Period - The SOIADATAV discrete System Status Pseudo Function Designator is required to be in the ON state from the start of Cryo Tanking at T-6H through T-10S. This provides end users with downlink data integrity which is required to properly synchronize the ground and onboard countdown sequences, perform LCC verifications, perform post scrub/abort safing, and detect and respond to potential hazards and emergency conditions throughout terminal countdown. The ending effectivity of T-10 seconds is appropriate as after this

REDLINE DERIVATION: (Continued)

point in launch countdown all mandatory data required to ensure the vehicle is in an acceptable configuration for flight is processed via the GPC FEP.

e. Requirements - N/A

f. Preplanned Contingency Procedures - For loss of active OI FEP, perform OIA FEP Recovery Procedure (Ref S0007.500). This procedure replaces a failed active OI FEP with a spare FEP. For successful recovery of an active OI FEP, LCC violation cleared, continue countdown.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) Loss of capability to monitor 128 kbs OI PCM measurements from vehicle.

CAUSES OF EXCEEDING REDLINE:

(9) Failure of FEP subsystem.
(10) Consecutive synchronization errors caused by downlink signal degradation due to data path or on-board data generation anomaly.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Launch and Landing SUBSYSTEM: LPS

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LCC VIOLATION CALL: GS1 Front End Processor (FEP) Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
SGS1ADATAV	GSE FEP #1 Active Data Valid		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to SRB Ignition (T-0).

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) For loss of Active GS1 FEP, perform FEP recovery procedure (Ref S0007 Vol 5). For successful recovery of an Active GS1 FEP, LCC violation cleared, continue countdown.

NOTES:

(3) All attempts will be made to provide full redundancy of the GSE and launch support hardware as late in the countdown as possible without impact to launch (ref S0007 Vol 5).
- If a single GS1 FEP failure occurs with adequate time to recover, a spare FEP will be configured to replace the failed standby FEP.

(4) During FEP switchover, data will be stale for up to 3.5 seconds.
(5) Transmission system is not redundant.
(6) SGS1ADATAV measurement is used by the LPS/GLS to verify operational status of the active GS1 FEP.
(7) LPS Type II consoles (Master or Integration) verify operational system integrity of both active and standby GS1 FEPs.

REDLINE DERIVATION: CRITICALITY: 1S

(8) GS1 FEP provides capability for command and monitoring of launch critical functions (e.g., ground PIC ordnance, Fire/Leak detection, sound suppression pre/post liftoff and ET propellant pressurization).
(9) Data from the GS1 FEP table is used to provide current configuration and status to the GLS.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Loss of capability to issue commands or to monitor measurements on GSE Ground Data Bus 1/21 (PAD) and 4/24 (MLP).

CAUSES OF EXCEEDING REDLINE:

(11) Failure of FEP CPU or I/O LRUs.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Launch and Landing SUBSYSTEM: LPS

LCC VIOLATION CALL: GS2 Front End Processor (FEP) Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
SGS2ADATAV	GSE FEP #2 Active Data Valid		ON	NA	Event	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to SRB Ignition (T-0).

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) For loss of Active GS2 FEP, perform FEP recovery procedure (Ref S0007 Vol 5). For successful recovery of an Active GS2 FEP, LCC violation cleared, continue countdown.

NOTES:

(3) All attempts will be made to provide full redundancy of the GSE and launch support hardware as late in the countdown as possible without impact to launch (ref S0007 Vol 5).
- If a single GS2 FEP failure occurs with adequate time to recover, a spare FEP will be configured to replace the failed standby FEP.

(4) During FEP switchover, data will be stale for up to 3.5 seconds.
(5) Transmission system is not redundant.
(6) SGS2ADATAV measurement is used by the LPS/GLS to verify operational status of the active GS2 FEP.
(7) LPS Type II consoles (Master or Integration) verify operational system integrity of both active and standby GS2 FEPs.

REDLINE DERIVATION: CRITICALITY: 1S

(8) GS2 FEP provides capability for command and monitoring of launch critical functions (e.g., ground PIC ordnance, Fire/Leak detection, sound suppression pre/post liftoff and ET propellant pressurization).
(9) Data from the GS2 FEP table is used to provide current configuration and status to the GLS.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Loss of capability to issue commands or to monitor measurements on GSE Ground Data Bus 3/23 (PAD) and 5/25 (MLP).

CAUSES OF EXCEEDING REDLINE:

(11) Failure of FEP CPU and I/O LRUs.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Launch and Landing SUBSYSTEM: LPS

Time Code Generator Anomaly

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Processor Data Recorder Anomaly

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Remote Control Video Switcher/Video Data Assembly

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LCC VIOLATION CALL: GS3 Front End Processor (FEP) Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
SGS3ADATAV	GSE FEP #3 Active Data Valid		ON	NA		CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to SRB Ignition (T-0).

REQUIREMENTS: FIGURES/TABLES:

PREPLANNED CONTINGENCY PROCEDURE:

(2) For loss of Active GS3 FEP, perform FEP recovery procedure (Ref S0007 Vol 5). For successful recovery of an Active GS3 FEP, LCC violation cleared, continue countdown.

NOTES:

(3) All attempts will be made to provide full redundancy of the GSE and launch support hardware as late in the countdown as possible without impact to launch (ref S0007 Vol 5).
- If a single GS3 FEP failure occurs with adequate time to recover, a spare FEP will be configured to replace the failed standby FEP.

(4) During FEP switchover, data will be stale for up to 3.5 seconds.
(5) Transmission system is not redundant.
(6) SGS3ADATAV measurement is used by the LPS/GLS to verify operational status of the active GS3 FEP.
(7) LPS Type II consoles (Master or Integration) verify operational system integrity of both active and standby GS3 FEPs.

REDLINE DERIVATION: CRITICALITY: 1S

(8) GS3 FEP provides capability for command and monitoring of launch critical functions (e.g., ground PIC ordnance, MPS helium bottles fill and LH2 recirculation pumps power).
(9) Data from the GS3 FEP table is used to provide current configuration and status to the GLS.

CONSEQUENCES OF EXCEEDING REDLINE:

(10) Loss of capability to issue commands or to monitor measurements on GSE Ground Data Bus 2/22 (PAD) and 28/29 (MLP).

CAUSES OF EXCEEDING REDLINE:

(11) Failure of FEP CPU and I/O LRUs.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Launch and Landing SUBSYSTEM: LPS

SECTION 42

COMMUNICATIONS

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SECTION 42: COMMUNICATIONS

SSID No.	Description/Violation Call	Page
COM-01	Astrocomm Voice Anomaly	42-01.1
COM-02	Voice Command Channel Anomaly	42-02.1
COM-03	Voice Communication NASA Test Director (NTD) and Flight Director Anomaly	42-03.1
COM-04	Range Safety Officer (RSO) Communications Anomaly	42-04.1

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LCC VIOLATION CALL: Astrocomm Voice Anomaly | EMERG COND: Yellow (4)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	Astrocomm A/G1	1	(2)	NA	NA	CI
NA	Astrocomm A/G2	of	(2)	NA	NA	CI
NA	Astrocomm Icom A	4	(2)	NA	NA	CI
NA	Astrocomm Icom B		(2)	NA	NA	CI

TIME PERIOD:

(1) From Hatch Closeout (T-1 hour 5 minutes) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) System must be functional.
(3) One of four astrocomm channels is required for launch countdown support (Primary channel is A/G 1; backup channels are A/G 2, Icom A, and Icom B, respectively).

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) Total loss of communications with the crew constitutes a condition yellow.

REDLINE DERIVATION: CRITICALITY:

(5) Two-way astrocomm voice channel is required for launch countdown.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Loss of voice with flight crew prior to launch.

CAUSES OF EXCEEDING REDLINE:

(7) Ground equipment malfunction.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Tech Supt SUBSYSTEM: COM

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LCC VIOLATION CALL: Voice Command Channel Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	Comm from SRO (Superintendent of Range Operations) and MILA to NTD					
NA	OIS Channel 232 (Primary)	1 of 3	(2)	NA	NA	CI
NA	OIS Channel 212		(2)	NA	NA	CI
NA	Point-to-Point Telephone		(2)	NA	NA	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for SSME Start (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 3 must be functional.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) Point-to-Point telephones from NTD to SRO and MILA are also available for backup from T-5 hours to SSME Ignition (T-10 seconds).

REDLINE DERIVATION: CRITICALITY:

(4) Voice communication verified, and communications personnel monitor system performance.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Loss of communications for HOLD/CUTOFF calls.

CAUSES OF EXCEEDING REDLINE:

(6) Communications equipment failure.
(7) Circuit failure.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Tech Supt SUBSYSTEM: COM

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LCC VIOLATION CALL: Voice Communication NASA Test Director (NTD) and Flight Director Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	Voice Comm between KSC (NTD) and Flight Director					
NA	OIS Channel 232	1 of 3	(2)	NA	NA	CI
NA	OIS Channel 212 (Astrocomm)		(2)	NA	NA	CI
NA	Flight Director Loop		(2)	NA	NA	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for SSME Ignition (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 3 must be functional.

PREPLANNED CONTINGENCY PROCEDURE:

(3) If OIS Channel 212 is lost, OIS Channel 213, 214, or 215 is to be used as replacement.

NOTES:

(4) Duplicates Flight Rule 3-30D.

REDLINE DERIVATION: CRITICALITY:

(5) Voice communication verified, and communications personnel monitor system.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Loss of communications.

CAUSES OF EXCEEDING REDLINE:

(7) Communications equipment failure.
(8) Circuit failure.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Tech Supt SUBSYSTEM: COM

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LCC VIOLATION CALL: Range Safety Officer (RSO) Communications Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	Voice Comm between RSO and Flight Director/FIDO					
NA	Cape RSO Private Line	1 of 3	(2)	NA	NA	CI
NA	Flight Director Loop	1 of 3	(2)	NA	NA	CI
NA	RSO Circuit	1 of 3	(2)	NA	NA	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for SSME Ignition (T-10 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) 1 of 3 must be functional.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) Duplicates Flight Rule 3-30C.

REDLINE DERIVATION: CRITICALITY:

(4) Voice communication verified, and communications personnel monitor system performance.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Loss of communications to Flight Director to inform him of impending destruct commands.

CAUSES OF EXCEEDING REDLINE:

(6) Communications equipment failure.
(7) Circuit failure.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Tech Supt SUBSYSTEM: COM

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SECTION 43

EGRESS

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SECTION 43: EGRESS

SSID No.	Description/Violation Call	Page
EGR-01	Slidewire System Anomaly	43-01.1
EGR-02	Armored Personnel Carriers Anomaly	43-02.1
EGR-03	Firex Loop & Tank T-3 Pressure Anomaly	43-03.1
EGR-04	Pad Elevators Anomaly	43-04.1
EGR-05	Fire Detection FSS Array Anomaly (REQUIREMENT DELETED)	43-05.1
EGR-06	Fire Detection FSS 175-foot Array Anomaly (REQUIREMENT DELETED)	43-06.1
EGR-07	Fire Detection FSS 195-foot Array Anomaly (REQUIREMENT DELETED)	43-07.1
EGR-08	Fire Detection White Room Array Anomaly (REQUIREMENT DELETED)	43-08.1
EGR-09	Fire Detection OAA Array Anomaly (REQUIREMENT DELETED)	43-09.1

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LCC VIOLATION CALL: Slidewire System Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	Slidewire System operational for astronaut prime egress		(2)	NA	NA	DI

TIME PERIOD:

(1) Verified Operational Prior to Pad Clearing

REQUIREMENTS: FIGURES/TABLES:

(2) Must be operational.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) Slidewire baskets and nets will be verified by (A) LSOC prior to pad clear for cyro load and (B) by astronaut closeout crew prior to leaving pad.

REDLINE DERIVATION: CRITICALITY:

(4) This SSID verifies that baskets are in position at 195-foot level of FSS and deceleration nets are in position at base of system.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Loss of astronaut prime escape route.

CAUSES OF EXCEEDING REDLINE:

(6) Escape baskets not in position at 195-foot level because of wind, etc.
(7) Deceleration nets not in position because of wind.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Tech Supt SUBSYSTEM: EGR

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LCC VIOLATION CALL: Armored Personnel Carriers Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	M113 Armored Personnel Carriers	2 of 4(2)	NA	NA	NA	DI

TIME PERIOD:

(1) Prior to ET Cryo Tanking (T-6 hours) and Prior to Close Out Crew/Ice Team Ingress (T-3 hours) (2,3)

REQUIREMENTS: FIGURES/TABLES:

(2) The two mandatory M-113 Armored Personnel Carriers (APCs) are:
   A. One at the Slidewire bunker (manned during Closeout Crew, Ice Team or Red Crew Pad Entry) verified operational and in position by final pad clearing for cryo load. For use in the event of a slidewire egress by the Flight Crew or Ground Crews.
   B. One at the Blast Danger Area (BDA) roadblock (5-A for pad A and 4-A/B for Pad B) (Manned) verified operational and in position by Closeout Crew/Ice Team ingress. For use by Rescue Team in the event of a slidewire egress.

(3) A. The first backup M113 will be located at the A-11 roadblock (manned) verified operational and in position by final pad clearing for Cryo load.
   B. The second backup M113 will be located at heavy equipment.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) Communications with the M-113 APCs will be via radio.

REDLINE DERIVATION: CRITICALITY:

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Loss of safe astronaut aided rescue capability or Slidewire bunker escape capability.

CAUSES OF EXCEEDING REDLINE:

(6) Mechanical failures on M113 APC vehicles.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Tech Supt SUBSYSTEM: EGR

LCC VIOLATION CALL: Firex Loop & Tank T-3 Pressure Anomaly | EMERG COND: Yellow (9)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	WF0054_FXSTRUCT_PRESSURE (PAD A)	1 of 3	182	NA	psig	CI
NA	WF0052_TANKT3_PRESSURE (PAD A)	1 of 3	182	NA	psig	CI
NA	WF0052_FXLOOP_PRESSURE (PAD A)	1 of 3	182	NA	psig	CI
NA	WF0064_FXSTRUCT_PRESSURE (PAD B)	1 of 3	182	NA	psig	CI
NA	WF0062_TANKT3_PRESSURE (PAD B)	1 of 3	182	NA	psig	CI
NA	WF0062_FXLOOP_PRESSURE (PAD B)	1 of 3	182	NA	psig	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (T-6 hours) to Go for GLS Start (T-9 minutes)

REQUIREMENTS: FIGURES/TABLES:

(2) For LCC verification use the Requirement Table measurements associated with the active Launch Pad only.

PREPLANNED CONTINGENCY PROCEDURE:

(3) If all three Kennedy Complex Control System (KCCS) launch pad Firex pressure measurements in the requirements table indicate less than 182 psig, then use the following Firing Room Firex pressure measurements:

FIRING ROOM FIREX PRESSURE MEASUREMENTS

GWDPPT91A (FX TNK FARM T3 PRESS STAT)
GWDPPT90A (FX STRUCTURES WATER PRESS)

A. If either one of the Firing Room measurements reads a pressure greater than 182 psig, then LCC violation cleared, continue countdown.

B. If neither of the Firing Room Firex pressure measurements indicates a pressure greater than 182 psig, then the analog measurements and discrete indications listed below may be used as evidence of adequate Firex pressure as specified.

NON-LAUNCH PAD FIREX PRESSURE MEASUREMENTS

PAD-A Measurements
WF0054_FXSTRUCT_PRESSURE (PSIG)
WF0052_TANKT3_PRESSURE (PSIG)
WF0052_FXLOOP_PRESSURE (PSIG)

PAD-B Measurements
WF0064_FXSTRUCT_PRESSURE (PSIG)

PREPLANNED CONTINGENCY PROCEDURE: (Continued)

WF0062_TANKT3_PRESSURE (PSIG)
WF0062_FXLOOP_PRESSURE (PSIG)

Pad Pump Station Pressure indications
WP0036_FXMNPRESS_DSCHG (PSIG)
WP0036_PUMP1_RUNIND (ON/OFF)
WP0036_PUMP2_RUNIND (ON/OFF)
WP0036_PUMP3_RUNIND (ON/OFF)
WP0036_PUMP4_RUNIND (ON/OFF)

If any one of the Non-Launch Pad analog measurements indicates a pressure greater than 182 psig, and/or if all of the discrete pump run indications indicate "OFF" (which indicates a pressure greater than 195 psig), then perform Firex Pump Start and Elevated Tank Top-off (reference OMI S0007.500, LCC Workaround for Firex Loop and T-3 Tank Pressure Anomaly) to demonstrate a clear flow path and intact Firex piping. If the elevated tank top-off is successful, then LCC violation cleared, continue countdown.

NOTES:

(4) Firex pressure measurements are monitored in Launch Control Center room 1P9 at the C1 Firex console using the KCCS, and in the Firing Room by CMPL at the C-3 Console. KCCS is the facilities control and monitoring system that replaced the Complex Control Set (CCS).
(5) All referenced measurements are KCCS tags or Firing Room Function Designators, and all measure Firex water pressure.
(6) If no Firex Pump Station diesels pumps are running, it is an indication that the pressure switches used to start the pumps are sensing a pressure greater than 195 psig.
(7) Measurements from the non-launch pad may be used to confirm launch pad Firex pressures because the Firex Pump Station (J7-1388) is the common Firex pumping source for Pads A & B.

REDLINE DERIVATION: CRITICALITY: 1S

(8) a. SSID Intent Summary - These measurements confirm proper operation of the Firex Pump Station Hydro-pneumatic controls. This provides confidence that the Firex pump start controls are operational and will function correctly if Firex water is required for Pad Firex flows:

- Fixed Service Structure (FSS) Firex (includes 195 foot level astronaut egress sprays)
- Rotating Service Structure (RSS) Firex system
- Perimeter Firex (LOX & LH2 areas, Hyper farms, GH2 area)
- Mobile Launch Platform (MLP) Firex (including Orbiter Firex)

b. Voting Logic - The 1 of 3 LCC voting logic presented for the Firex system water pressure accommodates instrumentation error while ensuring that the Firex system controls are functioning correctly to maintain system pressure that may be required for contingency Firex, including

REDLINE DERIVATION: (Continued)

the astronaut egress sprays.

c. Redline Development - The redline limit was narrowed by the amount of the maximum possible instrumentation error to ensure that when the console reading is above the redline, sufficient pressure is present in the system to meet worst-case system demands.

	MIN	MAX
Baseline Requirement	173 psig	N/A
Instrumentation Error (including KCCS)	+9 psig	N/A
	182 psig	

d. Time Period - The Firex system nominal pressure is 220 psig and the system is functionally stable during the countdown prior T-9 minutes, and is therefore committed for launch at T-9 minutes.

e. Requirements - Only the measurements from the active Launch Pad are applicable to this SSID.

f. Preplanned Contingency Requirements - Direction is provided to check backup measurements to confirm instrumentation failure, and to manually start Firex diesel pumps and perform elevated tank top-off from the C-1 water console per S0007.500.

CONSEQUENCES OF EXCEEDING REDLINE:

(9) Insufficient water pressure for adequate Pad Firex flow (e.g., FSS astronaut egress spray, and MLP Orbiter Firex Sprays).

CAUSES OF EXCEEDING REDLINE:

(10) Firex line rupture.
(11) Data path or sensor failure, or Field Interface Controller (FIC) failure.
(12) Failure of Firex Pumping System.

MEASUREMENT INFORMATION TABLE:

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
UNITS-->	psig								
NA	1	0	300						
NA	1	0	300						
NA	1	0	300						
NA	1	0	300						
NA	1	0	300						
NA	1	0	300						

METER/DISPLAY RANGE - MSID: NA LOW: HIGH:

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Tech Supt SUBSYSTEM: EGR

LCC VIOLATION CALL: Pad Elevators Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	Pad FSS Elevators	1 of 2	(2)	NA	NA	DI

TIME PERIOD:

(1) Verify before Closeout Crew Leaves the Pad

REQUIREMENTS: FIGURES/TABLES:

(2) Must be operational and at the pad surface.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) In normal launch configuration, the pad FSS elevators are positioned at the pad surface. Both elevators will have their control power turned off by a switch located at the pad surface. Before either elevator can be used, the switch must be turned back on. If an elevator is non-functional, it may be located at a level other than the pad surface.

REDLINE DERIVATION: CRITICALITY:

(4) The FSS elevators are required at the pad surface to allow emergency personnel access for astronaut aided egress.

CONSEQUENCES OF EXCEEDING REDLINE:

(5) Inability to perform an astronaut aided egress in a safe manner.

CAUSES OF EXCEEDING REDLINE:

(6) Both elevators failing to function.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Tech Supt SUBSYSTEM: EGR

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Fire Detection FSS Array Anomaly

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Fire Detection FSS 175-foot Array Anomaly

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Fire Detection FSS 195-foot Array Anomaly

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Fire Detection White Room Array Anomaly

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Fire Detection OAA Array Anomaly

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SECTION 44

MERRITT ISLAND LAUNCH AREA

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SECTION 44: MERRITT ISLAND LAUNCH AREA

SSID No.	Description/Violation Call	Page
MILA-01	Forward Link System Anomaly	44-01.1
MILA-02	S-Band Return Link System Anomaly	44-02.1
MILA-03	MILA UHF High Gain Tracking System Anomaly	44-03.1

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LCC VIOLATION CALL: Forward Link System Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	MILA S-Band Forward Link System (Cmd/Voice)		(3)	NA	NA	CI
NA	PDL S-Band Forward Link System (Cmd/Voice)	(2)	(3)	NA	NA	CI
NA	PDL UHF Forward Link System (Voice)	(2)	(3)	NA	NA	CI

TIME PERIOD:

(1) From T-1 hours 20 minutes to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) A Forward Link is required to be operational to communicate with the Orbiter during the time MILA S-Band is blocked by the SRB plume. For missions with inclinations greater than 28.5 degrees, 1 of 2 is required. For missions with inclinations of 28.5 degrees or less, PDL Forward Links are not required since the mandatory MILA UHF (Reference LCC SSID MILA-03) is an acceptable alternative.
(3) System must be functional.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) Reference NSTS 12820, Space Shuttle Operational Flight Rules, Volume A, Rule A3.1.1-1, for corresponding requirements.
(5) If PDL is not available during MILA plume, JSC MCC will direct use of MILA uplink.

REDLINE DERIVATION: CRITICALITY:

(6) For missions with inclinations of 28.5 degrees or less, MILA UHF Voice is an acceptable alternative to PDL Forward Link System during MILA plume. (Reference LCC SSID MILA-03.)
(7) A/G 1 or A/G 2 is necessary for TDRS operation.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) No RF Uplink (command, A/G 1,2 and UHF Voice) capability during segments of ascent.

CAUSES OF EXCEEDING REDLINE:

(9) System failure at MILA or PDL or connecting link.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Tech Supt SUBSYSTEM: MILA

LCC VIOLATION CALL: S-Band Return Link System Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	MILA S-Band Return Link System (Tlm/Voice)		(2)	NA	NA	CI
NA	JDI S-Band Return Link System (Tlm/Voice)	1 of 2	(2)	NA	NA	CI
NA	PDL S-Band Return Link System (Tlm/Voice)		(2)	NA	NA	CI

TIME PERIOD:

(1) From T-5 hours 30 minutes to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) System must be functional.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) PDL and JDI data are not reliable until post lift-off.
(4) Either PDL or JDI return link is required during MILA plume.
(5) Return link must be available to the MCC for flight systems monitoring during ascent.
(6) Reference NSTS 12820, Space Shuttle Operational Flight Rules, Volume A, Rule A3.1.1-1, for corresponding requirements.

REDLINE DERIVATION: CRITICALITY:

(7) RF return link data to JSC.

CONSEQUENCES OF EXCEEDING REDLINE:

(8) No RF telemetry to Firing Room (LCC) during plus count.
(9) No RF telemetry to MCC.

CAUSES OF EXCEEDING REDLINE:

(10) System Failure at MILA or PDL or connecting link.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Tech Supt SUBSYSTEM: MILA

LCC VIOLATION CALL: MILA UHF High Gain Tracking System Anomaly | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
NA	MILA UHF High Gain Tracking System	(2)	NA	NA	NA	CI

TIME PERIOD:

(1) From Crew Ingress (T-1 hour 20 minutes) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) MILA UHF High Gain Tracking System must be functional.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) Reference NSTS 12820, Space Shuttle Operational Flight Rules, Volume A, Rule A3.1.1-1, for corresponding requirements.
(4) Refer to SSID: CT-05 for Orbiter related UHF voice anomaly.

REDLINE DERIVATION: CRITICALITY:

(5) Functional system includes at least an 18 dB gain UHF antenna.
(6) UHF is one of two independent communications paths mandatory for ascent and RTLS.

CONSEQUENCES OF EXCEEDING REDLINE:

(7) Loss of redundant voice capabilities.

CAUSES OF EXCEEDING REDLINE:

(8) High Gain UHF Tracking system failure at MILA.

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO SHEET ZONE

ELEMENT: Tech Supt SUBSYSTEM: MILA

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APPENDIX A

ABBREVIATIONS AND ACRONYMS

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APPENDIX A

ABBREVIATIONS AND ACRONYMS

A

A	Amp
A/A	Air to Air
A/D	Analog to Digital
A/E	Assent/Entry
A/G	Air to Ground
A/M	Auto Mode
AA	Abbreviations and Acronyms (SSID); Accelerometer Assembly
AB	Air Base
ABCD	Adiabatic Bubble Compression Detonation
ABS	Ammonia Boiler System
AC	Alternating Current
ACA	Annunciator Control Assembly
acc	Accumulator; Accessories; Accelerometer
accel	Accelerometer
acceln	Acceleration
ACCU	Audio Central Control Unit
accum	Accumulator
accy	Accuracy
ACES	Advanced Crew Escape Suit
ACO	Assembly Checkout
act	Actuator
ACTA	ACTA Inc. 45th Space Wing contractor
actr	Actuator
actv	Active
acum	Accumulator
A-D	Analog to Digital
ADAMS	Automated Dynamic Analysis of Mechanical Systems
Adc	Amperes Direct Current
ADC	Analog to Digital Converter
ADI	Attitude Direction Indicator
ADP	Air Data Probe
ADTA	Air Data Transducer Assembly
AF	Air Force
AFB	Air Force Base
AFD	Aft Flight Deck
AFM	Mechanical Systems (SSID)
AFV	Anti-Flood Valve
AGC	Automatic Gain Control
AHM	Advanced Health Management
AID	Analog Input Differential
airlk	Airlock
AKA	Active Keel Actuator
ALC	Aft Load Controller
alrm	Alarm
alt	Alternate; Altimeter
AMEC	Advanced Master Events Controller
AMI	Alpha/Mach Indicator
amp	Ampere; Amplifier
Amp-Hr	Ampere-Hour

amptd	Amplitude
ant	Antenna
AOA	Abort-Once-Around
APC	Armored Personnel Carrier; Aft Power Controller
APCA	Aft Power Controller Assembly
APCL	Ascent Pocket Checklist
APCU	Auxiliary Power Control Unit
APDS	Androgynous Peripheral Docking System
APDU	Aft Power Distribution Unit
app	Appendix
approx	Approximately
APU	Auxiliary Power Unit (SSID)
Ar	Argon
arcs	Arc seconds
ARCS	Aft Reaction Control System (Subsystem)
ARPCS	Atmospheric Revitalization Pressure Control Subsystem (System)
ARS	Atmospheric Revitalization Subsystem (System)
ASA	Aerosurface Servo Amplifier
ASP	Astronaut Support Personnel
assy	Assembly
ATCS	Active Thermal Control System
atm	Atmosphere
ATO	Abort to Orbit
ATP	Acceptance Test Procedure
att	Attitude
ATU	Audio Terminal Unit
ATVC	Automatic Thrust Vector Control; Ascent Thrust Vector Control
aug	Augment
auth	Authority
aux	Auxiliary
av	Avionics
avail	Available
avg	Average
AVM	Auxiliary Valve Module
avns	Avionics
AVVI	Altitude/Vertical Velocity Indicator

B

B	Binary
B/U	Backup
B/V	Bleed Valve
bat	Battery
BCE	Bus Control Element
bd	Band
BDA	Blast Danger Area
bdyflp	Body Flap
BEI	Booster Electrical and Instrumentation (SSID)
BF	Beat Frequency
BFC	Backup Flight Controller
BFS	Backup Flight System; Backup Flight Control System (SSID)
bh	Bulkhead
bhd	Bulkhead
BHS	Base Heat Shield

BHYD	Booster Hydraulics (Subsystem)
BIP	Bio-Instrumentation Pass-Through
BIT	Built-in Test
BITE	Built-In Test Equipment
bk	Brake
bkup	Backup
bl	Bleed
bld	Bleed
blkhd	Bulkhead
blr	Boiler
blt	Built
blwdwn	Blowdown
bot	Bottle
BP	Barberpole
brc	Bracket
BREC	Booster Recovery Subsystem (SSID)
brg	Bearing
BRSS	Booster Range Safety System (SSID)
BSEP	Booster Separation Subsystem (SSID)
BSM	Booster Separation Motor
BSR	Bite Status Register
Btu	British Thermal Unit
BTU	Bus Terminal Unit
BTVC	Booster Thrust Vector Control Subsystem (SSID)
BU	Backup
bub	Bubble

C

C	Celsius; Command
C&T	Communication(s) and Tracking
C&W	Caution and Warning
C/L	Closed/Latched
C/O	Cut Off
C/P	Cold Plate
C/W	Caution and Warning
cab	Cabin
cal	Calibration
calc	Calculated
cap	Capacitor; Capture
CAP	Control and Applications Processor
CAPRI	Capacitive Reset Integrator
carr	Carrier
cat	Category
CB	Circuit Breaker
C-Band	Compromise-Band (4 - 6 GHz)
cc	Cubic Centimeter
CCA	Communication Carrier Assembly
CCAFS	Cape Canaveral Air Force Station
CCC	Complex Control Center
CCFF	Cape Canaveral Forecast Facility

CCMS	Checkout, Control, and Monitor Subsystem
CCS	Complex Control Set
CCTV	Closed Circuit Television
CCU	Crew Communications Umbilical
CCV	Chamber Coolant Valve
CDBFR	Common Data Buffer
CDC	Countdown Clock
CDR	Commander
CDS	Command and Data System (Spacehab)
CDT	Central Daylight Time
CDW	Command Data Word
CEWL	Centralized Experiment Water Loop
CEWPP	Centralized Experiment Water Pump Package
CGLS	Ground Launch Sequencer Operator
CGSS	Launch Accessories System Engineer
ch	Channel
chan	Channel
chg	Change
CHG	Change Procedures (SSID)
chk	Check
chmbr	Chamber
chnl	Channel
CI	Continuous Interlock
CIL	Critical Items List
CIP	Carrier Integration Plan
circ	Circulation
cl	Close (closed)
cld	Close (closed)
CLD	Current Level Detector
clnt	Coolant
clsd	Close (closed)
CM	Crew Module
cmd	Command
cmds	Commands
CME/V	Command Message Encoder/Verifier
CMG	Control Moment Gyro
CMOS	Complementary Metal Oxide Silicon
cmp	Compartment
CMPL	C Main Propulsion Lead (call sign)
cmprtmnt	Compartment
cmpt	Compartment
cmptd	Computed
cndsr	Condenser
cnt	Count
cntcts	Contacts
cntl	Control
cntlr	Controller
COAS	Course Optical Alignment Sight; Crew(man) Optical Alignment Sight
COLA	Collision Avoidance
com	Communications
COM	Communications (SSID)
comm	Communications

comp	Component; Compensated; Computation
compt	Compartment
Comsec	Communication Security
con	Contact; Control
conc	Concentration
concen	Concentration
concn	Concentration
cond	Condenser; Condition
conf	Confirmation
cont	Container; Continue; Control
contr	Control
conv	Converter
COS	Checkout Station
couplg	Coupling
CPA	Control Panel Assembly; Control Power Assembly
CPM	Cell Performance Monitor
CPU	Central Processing Unit
CR	Change Request; Card Reader
CRC	Cyclic Redundancy Code
CRD	Command Receiver Decoder
CREW	Launch/Landing Window and Crew Restrictions (SSID)
crit	Criticality
CRS	Command Remoting System
CRT	Cathode-Ray Tube
cryo	Cryogenic
CS	Change Sheet (SSID)
CSS	Control Stick Steering
CST	Comprehensive Self Test
CT	Communications and Tracking (SSID)
ctl	Control
ctr	Center
cur	Current
CV	Check Valve
CWC	Contingency Waste Containers
CWE	Caution and Warning Electronics
CWEA	Caution and Warning Electronics Assembly
cycl	Cycle

D

D&C	Display and Control
D/L	Downlink
D/V	Drain Valve
DAP	Digital Autopilot
DAS	Digital Avionics System
dB	Decibel
DBIA	Data Bus Interface Adapter; Data Bus Isolation Amplifier
dBz	dB referenced to drop size (1mmE10/cubic meter)
DC	Direct Current; Display Coupler
dcdr	Decoder
DCFC	Direct Current Firing Circuit
DCID	Direct Current Input Differential

DCP	DEU Control Program
DDC	Dual Diversity Comparator
DDU	Device Driver Unit
dec	Decimal
decom	Decommutate; Decommutator
DED	Data Entry and Display
deg	Degree
del	Delta
dep	Dependent
depl	Deploy
depr	Depress
des	Deselect
det	Detector
detr	Detector
DEU	Display Electronic(s) Unit
DFI	Development Flight Instrumentation
D/H	Degrees per Hour
DI	Discrete Interlock
diff	Differential; Difference
DIR	Document Information Record
disc	Disconnect
disch	Discharge
div	Divider
dk	Deck
DK	Display/Keyboard
dlma	Dilemma
DMU	Data Management Unit
dn	Down
DOD	Department Of Defense
DOL	Discrete Output Low
DOLILU	Day Of Launch Indicator Load Update
DOSS	DOLILU Operational Support System
dP	Differential Pressure
dply	Deploy
DPRCB	Daily Program Requirements Control Board
DPS	Data Processing System (Subsystem) (SSID)
dpy	Deploy
DR	Discrepancy Report
dr	Door; Drain
drn	Drain
DRSD	Digital Range Safety Display
drvr	Driver
DSC	Dedicated Signal Conditioner
dscrs	Discretes
DT	Delayed Time; Differential Time
dT	Differential Temperature
DTV	Digital Television
DU	Display Unit
DV	Dump Valve
DW	Data Word
dwg	Drawing

E

E&I	Electrical & Instrumentation
E1	Engine 1
E2	Engine 2
E3	Engine 3
ECL	Environmental Control and Life Support (SSID)
ECLS	Environmental Control and Life Support
ECLSS	Environmental Control and Life Support Subsystem (System)
ECO	Engine Cutoff
ECS	Environmental Control System (Subsystem)
EDAC	Error Detection and Correction
EDO	Extended Duration Orbiter
EE	End Effector
EECOM	Environmental, Emergency, Consumables Management Officer - MCC-H
EEPROM	Electrically Erasable Programmable Read Only Memory
EGR	Egress (SSID)
EHMS	Emergency Egress/Escape Temperature and Hydrogen Fire Hazard Monitoring Syste
EIU	Engine Interface Unit
elec	Electric
elect	Electric
elev	Elevon; Elevation
ELS	Emergency Landing Site
elvn	Elevon
EMDM	Enhanced MDM
EMEC	Enhanced Master Events Controller
emer	Emergency
emerg	Emergency
EMI	Electromagnetic Interference
EMON	Exception Monitoring
EMU	Extravehicular Mobility Unit
ena	Enable
enb	Enable
enbl	Enable
eng	Engine
EOM	End Of Mission
EOS	Emergency Oxygen System
EPCL	Entry Pocket Check List
EPD&C	Electrical Power Distribution and Control
EPDC	Electrical Power Distribution and Control (SSID)
EPP	Electrical Power/Pyro (Subsystem)
EPS	Electrical Power System
ER	Eastern Range
er	Error
err	Error
ESMC	Eastern Space and Missile Center
ESP	Experiment Sensing Platform
ess	Essential
Esum	Running Energy Sum of Convective Cooling
ET	External Tank Subsystem (SSID)
ETR	Eastern Test Range; Range Safety Criteria (SSID)
ETVAS	External Tank Vent Arm System

ev	Event
EV	ExtraVehicular
EVA	ExtraVehicular Activity
evap	Evaporator
EVCS	ExtraVehicular Communications System
EWR	Eastern Western Range
ex	External
Exh	Exhaust
exp	Experiment
ext	External; Extend
Ez	Electric Field

F

F	Fahrenheit; Forward
F/D	Fill and Drain; Frequency to Digital Converter
F/P	Fuel Pump
FA	Flight Aft
FC	Flight Control; Flight Critical; Fuel Cell
FCA	Flow Control Assembly; Frequency Control and Analysis
FCHL	Flight Control Hydraulics Lab
FCL	Freon Coolant Line (Loop)
FCMS	Fuel Cell Monitoring System
FCO	Flight Control Officer
FCOS	Flight Computer Operating System
FCP	Fuel Cell Powerplant (SSID)
FCS	Flight Control System (Subsystem)
FCV	Flow Control Valve
fd	Feed
FD	Fire Detection; Flight Director; Function Designator
FDA	Fault Detection and Annunciation
fdbk	Feedback
FDC	Failover Decision Control
FDF	Flight Data File
FDI	Failure Detection and Identification
FDIR	Fault Detection Identification (Isolation) and Recovery (Recognition)
fdln	Feedline
FDO	Flight Dynamics Officer - MCC-H
FDRD	Flight Definition and Requirements Document
FEP	Front End Processor
FES	Flash Evaporator System
FEXT	Fire Extinguisher
FF	Flip Flop; Flight Forward
FIC	Field Interface Controller
FID	Flight Implementation Directive; Failure Identifier
FIDO	Flight Dynamics Officer
filt	Filter
FIT	Final Inspection Team
FIV	Fuel Isolation Valve
fl	Fail
FLT	Flight
FM	Frequency Modulation (Modulated)

FMEA	Failure Mode and Effects Analysis
FMSP	FM Signal Processor
FO	Fail Operational
FOM	Figure of Merit
FOR	Flight Operations Review
FOTE	Fiber Optic Terminal Equipment
FPB	Fuel Preburner
FPC	Forward Power Control
FPIP	Fuel Pump Inlet Pressure
FPM	Flow Proportioning Module
FPOV	Fuel Preburner Oxidizer Valve
FPV	Flow Proportion Valve
FPVA	Flow Proportion Valve Assembly
FR	Firing Room; Flight Rule
FRCS	Forward Reaction Control System (subsystem)
freq	Frequency
FRF	Flight Readiness Firing (SSID)
FRL	Fire Rescue Leader
FRR	Flight Readiness Review
FS	Fail Safe; Full Scale; Flight Systems; Fire Suppression
FSCU	Fire Suppression System Firing Circuits
FSM	Fuel System Module; Fuel Supply Module; Fault Summary Message
FSOP	Florida Safety Operating Plan
FSP	Fault Summary Page; Flow Spitting Panel
FSS	Flight System Simulator; Fire Suppression System; Fixed Service Structure
FSUM	Fault Summary Message and Caution and Warning Listings (SSID)
ft	Foot
ftg	Fitting
FTS	Flight Termination System; Fail to Sync
fu	Fuel
fus	Fuselage
fuslg	Fuselage
fwd	Forward
FWD	Forward (SSID)

G

g	Gravity; Ground
G/C	Gyrocompass
gbox	Gearbox
gbx	Gearbox
GC	Ground Controller
GCA	Guidance Coupler Assembly
GCIL	Ground Control Interface Logic
gdline	Guideline
gen	Generate; Generator
GEN	Introduction and General Criteria (SSID)
GG	Gas Generator
GGVM	Gas Generator Valve Module
GH2	Gaseous Hydrogen
GHe	Gaseous Helium
GLS	Ground Launch Sequencer

gmbl	Gimbal
GMEM	General Purpose Computer Memory read/write
GMT	Greenwich Mean Time
GN&C	Guidance, Navigation and Control (Subsystem)
GN2	Gaseous Nitrogen
GNC	Guidance and Navigation Computer; Guidance, Navigation and Control (SSID)
Gnd	Ground
GO2	Gaseous Oxygen
GOX	Gaseous Oxygen
GPC	General Purpose Computer
gpm	Gallons Per Minute
GPS	Global Positioning System
gr	Gear
grnd	Ground
GSE	Ground Support Equipment (SSID)
GSFC	Goddard Space Flight Center
GUCP	Ground Umbilical Carrier Plate
GUID	Guidelines and Definitions (SSID)
GVA	Gox Vent Arm
gyro	Gyroscope

H

H/W	Hardware
H2	Hydrogen
H2O	Water
hab	Habitat; Spacehab
HAINS	High Accuracy Inertial Navigation System
HAZ	Hazardous Gas Detection System (SSID); Hazardous
HCU	Hydraulic Charging Unit
HDP	Hold-down Post
HDR	High Data Rate
HDX	Hardware Dependent Executive
He	Helium
hex	Hexadecimal
HFA	Hab (Spacehab) Fan Assembly
HFE	High Frequency Executive
Hg	Mercury
HGDS	Hazardous Gas Detection System
hi	High
HIM	Hardware Interface Module
HIU	Headset Interface Unit
HOLD	Hold/Cutoff Guidelines (SSID)
horiz	Horizontal
horz	Horizontal
HOSC	Huntsville Operations Support Center (MSFC)
HP	High Power
HPFT	High Pressure Fuel Turbine
HPFTP	High Pressure Fuel Turbopump
HPOT	High Pressure Oxidizer Turbine
HPOTP	High Pressure Oxidizer Turbopump
HPU	Hydraulic Power Unit

hr	Hour
HRS	HIM Relay Status
hsg	Housing
HSI	Horizontal Situation Indicator
ht	Hot
htd	Heated
htr	Heater
htsk	Heat sink
HUD	Head-up Display
HUMS	Hydrogen Umbilical Mass Spectrometer
HX	Heat Exchanger
hyd	Hydraulics
HYD	Hydraulics (SSID)
hydr	Hydraulic(s)
Hz	Hertz (cycles per second)

I

I LOAD	Initialization Load
I/B	Inboard
I/C	Interchanger
I/F	Interface
I/O	Input/Output
Ib	Inboard
ICC	Inter-Computer Communication
ICD	Interface Control Document
ICE	Ice Launch Commit Criteria (SSID)
ich	Interchanger
Icom	Intercommunication System
ICU	Individual Cooling Unit
ID	Identification
IDCA	Inverter Distribution and Control Assembly
IDP	Integrated Display Processor
IEA	Integrated Electronic(s) Assembly
IFM	In-Flight Maintenance
ign	Ignition; Igniter
ILL	Impact Limit Line
IMPL	KSC General LCC Implementation (SSID)
IMSL	Intermediate Seal
IMU	Inertial Measurement Unit
in	Inch; Indicator
inbd	Inbound; Inboard
incn	interconnect
INCO	Integrated Communication Officer - MCC-H, Communication and Instrumentation
ind	Indicator; Indication
inH2O	Inches of Water
inhb	Inhibit
init	Initiate; Initiation
inj	Injector
inrtl	Inertial
INS	Operational Instrumentation (SSID)
inst	Instrumentation

INST	Firing Room Instrumentation System Console Operator Call-Sign
instr	Instrumentation
intcn	Interconnect
inv	Inverter
IOM	Input/Output Module
IOP	Input Output Processor
IOPP	Input-Output Pre-Processor
IP	Instrumentation PCMMU
IPL	Initial Program Load
IPR	Interim Problem Report
IR	Infrared
IRAMS	Inertial Reference Alignment Monitor System
IRIG	Interrange Instrumentation Group
I-Seal	Intermediate Seal
isln	Isolation
iso	Isolation
isol	Isolate; Isolation
ISS	International Space Station
ISSA	International Space Station Assembly
IT	Intertank
ITCU	Impedance Transient Control Unit
ITVC	Intensified Television Camera
IUS	Inertial Upper Stage

J

JDI	Jonathan Dickinson
JDMTA	Jonathan Dickinson Missile Tracking Annex
JSC	Lyndon B. Johnson Space Center

K

K	Expression for Statistical Tolerance Limits
kbit	Kilobit
kbps	Kilobits per second
kbs	Kilobits per second
KCCS	Kennedy Complex Control System
Kf	Material fatigue strength unit of measure
kft	Thousand feet
KLO	KSC Launch Operations
km	Kilometer
KOH	Potassium Hydroxide
krpm	Thousand Revolutions Per Minute
KSC	John F. Kennedy Space Center
Ku-Band	Kurz-under Band (12 -18 GHz)
kW	Kilowatt
kybd	Keyboard

L

L	Left; Low; Launch
L/H	Left-Hand

L/O	Lift-Off
LA	Left Aft
lab	Laboratory
LACC	Launch Accessories (Subsystem)
LAN	Local Area Network
lat	Lateral; Latch
lb	Pound(s)
lbm	Pounds-mass
LCA	Load Controller (Control) Assembly
LCC	Launch Control Center; Launch Commit Criteria
LCC&BD	Launch Commit Criteria and Background Document
LCCWG	LCC Working Group
lch	Latch
Lcked	Locked
LCN	Launch Commit Criteria Change Notice
LCS	Laser Camera System
LD	Launch Director; Leak Detector; LCC Deviation
ld	Load
LDA	Launch Danger Area
LDB	Launch Data Bus
ldg	Landing
LDG	Landing Gear
LDR	Low Data Rate
LDRI	Laser Dynamic Range Imager
LEH	Launch and Entry Helmet
LETF	Launch Equipment Test Facility
lf	Left
LF	Left Forward
LG	Landing Gear
LH	Left-Hand
L-h	Left-Hand
LH2	Liquid Hydrogen
LIB	Left Inboard
LiOH	Lithium Hydroxide
liq	Liquid
lk	Leak
LL	Launch and Landing; Liquid Level
LLCO	Low Level Cutoff
LMC/SC	Launch Master Control/System Control
LMG	Left Main Gear
LMS	LCC Management System
ln	Line
LN2	Liquid Nitrogen
lnyrd	Lanyard
lo	Low
LO2	Liquid Oxygen
LOB	Left Outboard
LOC	List of Changes
LOMS	Left OMS Pod
LOX	Liquid Oxygen
LP	Low Power
LPFP	Low Pressure Fuel Pump

LPFTP	Low Pressure Fuel Turbopump
LPOT	Low Pressure Oxidizer Turbine
LPS	Launch Processing System (SSID)
LPU	Life Preserver Unit
LRD	Landing/Recovery Director
LRU	Line Replacement Unit; Line Replaceable Unit
LS	Limit Switch
LSC	Linear Shaped Charge
LSEAT	Launch Systems Evaluation Advisory Team
LSF	Limit Scale Factor; Laboratory Simulation Facility
LSO	Landing Support Officer
LSCO	Launch Support Operations Contractor
lt	Left
ltch	Latch
Ltr	Letter
lvl	Level
LVLH	Local Vertical Local Horizontal
LW	LCC Waiver
LWO	Launch Weather Officer
lwr	Lower
LWT	Light Weight Tank; Launch Weather Team

M

m	Meter
mA	milli-Ampere
MADS	Modular Auxiliary Data System
mal	Malfunction
malf	Malfunction
man	Manual
mand	Mandatory
manf	Manifold
max	Maximum
MB	Orbiter Body Relative Attitude Misalignment Compensations
MBK	Mid Body Kit
MCA	Motor Control Assembly
MCC	Mission Control Center; Main Combustion Chamber
MCCH	Mission Control Center - Houston
MCC-H	Mission Control Center - Houston
MCDS	Multifunction CRT Display System
MCF	Major Component Failure
MCP	Monitoring and Control Panel
md	Mode
MD	Mission Dependent
MDA	Main Distribution Assembly
MDF	Minimum Duration Flight
MDK	Mid Deck
MDM	Multiplexer/Demultiplexer
MDU	Multifunction Display Unit
ME	Main Engine
meas	Measurement
MEC	Main Engine Controller; Master Events Controller

mech	Mechanical; Mechanism
MECO	Main Engine Cutoff
MEDS	Multifunction Electronic Display Subsystem
MEL	Minimum Equipment List (SSID)
mem	Member
MER	Mission Evaluation Room
MET	Mission Elapsed Time; Master Events Timer
MFE	Mid Frequency Executive
MFV	Main Fuel Valve
MHA	Multiple Headset Adapter
MHz	Mega-hertz
mi	Mile(s)
MIA	Multiplex(er) Interface Adapter
mid	Middle
MIL	Mandatory Instrumentation List (SSID)
MILA	Merritt Island Launch Area (SSID)
min	Minute; Minimum
MIT	Measurement Information Table
MK	NASA Launch Integration Office
MLG	Main Landing Gear
MLP	Mobile Launcher Platform
MLS	Microwave Landing System
MM	Mass Memory
MMACS	Maintenance Management and Control Assembly
MMH	Monomethylhydrazine
MML	Master Measurement(s) List
MMT	Mission Management Team
MMU	Mass Memory Unit; Manned Maneuvering Unit
mn	Main
MNA	Main Bus A
MN A	Main Bus A
MNB	Main Bus B
MN B	Main Bus B
MNC	Main Bus C
MN C	Main Bus C
MOA	Memorandum of Agreement
MOD	Mission Objective Document; Mission Operations Directive; Mission Operations Directorate
mod	Modification; Modified
mon	Monitor
mot	Motor
MOV	Main Oxidizer Valve
MPCA	Midpower Controller Assembly
MPL	Minimum Power Level
MPM	Manipulator Position Mechanism
MPS	Main Propulsion System (Subsystem) (SSID)
MPU	Magnetic Pickup Unit
MRL	Manipulator Retention Latch
MRT	Measurement Requirement Table
ms	Microswitch; Millisecond
MS	Mission Specialist
MSBLS	Microwave Scan Beam Landing System

MSFC	George C. Marshall Space Flight Center
msg	Message
MSID	Measurement Stimulation Identification
msn	Mission
MSU	Mass Storage Unit
mtr	Motor
mtrs	Motors
MTU	Master Timing Unit
mux	Multiplex; Multiplexer
mV	Millivolt
MVP	Master Verification Plan
MVS	Midvalue Select

N

n	Nautical
N/A	Not Applicable
N/W	Nose Wheel
N2	Nitrogen
N2H4	Hydrazine
NA	Not Applicable
NASA	National Aeronautics and Space Administration
NASCOM	NASA Communications (network)
nav	Navigation
NC	Nose Cone
NCR	Non Critical
neg	Negative
NG	Nose Gear
NH3	Ammonia
NL	Non-linear
NLG	Nose Landing Gear
NM	Nautical Mile
NMC	Non Mission Capable
no	Number
norm	Normal
nos	Numbers
Nov	November
NOV	Non Volatile
noz	Nozzle
NPSP	Net Positive Suction Pressure
NR	Not Required
NSD	NASA Standard Detonator
NSI	NASA Standard Initiator
NSP	Network Signal Processor
NSTS	National Space Transportation System
NTD	NASA Test Director
NVM	Non Volatile Memory
NW	Nose Wheel
NWS	Nose Wheel Steering

O

O	Open
O/B	Outboard
O/I	Outboard/Inboard
O/P	Output
O/Pt	Output
O/Put	Output
O/V	Over Voltage
O2	Oxygen
OAA	Orbiter Access Arm
OB	Outboard
OBSS	Orbiter Boom Sensor System
ODA	Orbiter Disconnect Assembly
ODS	Orbiter Docking System
OFI	Operational Flight Instrumentation
OI	Operational Instrumentation
OIS	Operational Intercommunication System
OIT	Orbiter Integrated Test
OIU	Orbiter Interface Unit
OK	Okay
OME	Orbiter Maneuvering Engine; Orbiter Main Engine
OMI	Operations and Maintenance Instruction
OMRS	Operations and Maintenance Requirements and Specification
OMRSD	Operations and Maintenance Requirements and Specification Document
OMS	Orbital Maneuvering System (Subsystem) (SSID)
onbd	Onboard
op	Open; Operation; Operational
Op Stat	Operational Status
Op Sup	Operations Supplement
OPB	Oxidizer Pre-Burner
OPCL	Orbit Pocket Check List
oper	Operating
OPF	Orbiter Processing Facility
OPOV	Oxidizer Preburner Oxidizer Valve
opr	Operator
OPR	Office of Primary Responsibility
ops	Operations
OPS	Oxygen Purge System; Operations Sequence
OPT	Operational Pressure Transducer
OR	Operational Right
orb	Orbiter
osc	Oscillator
OSL	Off Scale Low
OST	Operational Self Test
ot	Outlet
otbd	Outboard
OTC	Orbiter Test Conductor
OTP	Operational Test Procedure
OTV	Operational Television
out	Outlet
outbd	Outboard

OV	Orbiter Vehicle
ovbd	Overboard
OVCC	Closeout Crew Leader
ovld	Overload
ovrd	Override
ox	Oxidizer
oxdzr	Oxidizer
oxid	Oxidizer

P

P	Pressure; Pitch
P/L	Payload
P/S	Power Supply
P/Y	Pitch/Yaw
PA	Power Amplifier
PAC	Pressure Alpha Center
PAL	Pressure Alpha Lower
para	Paragraph
PASS	Primary Avionics Software System; Primary Avionics System Software
PAU	Pressure Alpha Upper
PAV	Pressure Actuated Valve
PAY	Payloads (SSID)
PB	Payload Bay; Push Button
PBD	Payload Bay Door
PBI	Push Button Indicator
PBP	Preburner Pump
Pc	Chamber Pressure
PCA	Pneumatic Control Assembly; Power Control Assembly
PCI	Peripheral Controller Interface
PCIN	Program Change Identification Notice
PCL	Programming Check List
PCM	Pulse-Code Modulation
PCMMU	Pulse-Code Modulation Master Unit
pcnt	Percent
PCP	Preplanned Contingency Procedure
PCS	Pressure Control System
pct	Percent
PCV	Pulse Control Valve
PDA	Payload Disconnect Assembly
PDI	Payload Data Interleaver
PDIP	Payload Data Interface Panel
PDL	Ponce de Leon
PDR	Processed-Data Recorder; Processed-Data Recording
PDRS	Payload Deployment and Retrieval System
PDU	Power Drive Unit; Power Distribution Unit
PF	Payload Forward
PFB	Pre-Flight BITE
pg	Purge
pge	Purge
pgm	Program
PGME	Propylene Glycol Monomethyl Ether

ph	Phase
pH	Hydrogen-ion concentration (alkalinity)
PHX	Payload Heat Exchanger
PI	Payload Interrogator
PIC	Pyrotechnic Initiator Controller
PL	Payload
plat	Platform
PLB	Payload Bay
PLBD	Payload Bay Door
PLC	Programmable Logic Controller
PLCN	Preliminary LCN
pld	Payload
PLS	Primary Landing Site
PLT	Pilot
PM	Pulse Modulation; Pulse-Modulated; Phase Modulation
PMC	Partially Mission Capable
pmp	Pump
PMU	Pulse Modulation Unit
pneu	Pneumatic
pnl	Panel
POCC	Payload Operations Control Center
POCS	Photo Optical Control System
POGO	Pogo Suppression System
pos	Position; Positive
posn	Position
POST	Power On Self Test
postlftf	Post lift-off
pot	Potable
PPCO2	Partial Pressure Carbon Dioxide
PPM	Parts Per Million
PPO2	Partial Pressure Oxygen
PPRV	Positive Pressure Relief Valve
pps	Passes Per Second
pr	Pressure; Primary
PR	Pressure Regulator; Problem Report
PRCB	Program Requirements Control Board
PRCBD	Program Requirements Control Board Directive
prebnr	Preburner
prechg	Precharge
prepress	Prepressure
press	Pressure
prevlv	Prevalve
prg	Purge
pri	Primary
prim	Primary
PRL	Priority Rate Limiting
PRLA	Payload Retention Latch Assembly
PRO	Planning Resident Order
PROM	Programmable Read-Only Memory
prop	Propellant
prox	Proximity
prs	Pressurization

PRSD	Power Reactant Supply and Distribution (SSID)
prss	Pressurization
PS	Power Supply; Payload Station; Power Separation
Ps	Static Pressure
PSEB	Point Sensor Electronics Box
psi	Pounds per Square Inch
psia	Pounds per Square Inch Absolute
psid	Pounds per Square Inch Differential
psig	Pounds per Square Inch Gauge
PSN	Purge Sequence Number
PSP	Payload Signal Processor
pstlftf	Post lift-off
pt	Point; Put
ptbl	Potable
PTCR	Payload Transfer and Checkout Room
PTO	Power Turn On
puls	Pulse
PUP	Principle User Processor
PV	Pre-Valve; Pneumatic Valve
PVD	Purge, Vent and Drain
PVT	Pressure, Volume and Temperature
pwr	Power
Pyro	Pyrotechnic

Q

QD	Quick Disconnect
QDMA	Quick Don Mask Assembly
QMVS	Quad Mid-Value Select
Qsol	Diffuse Solar Flux
qty	Quantity
quad	Quadrangle; Quadrant; Quadrature
qual	Qualification
quan	Quantity

R

R	Right; Rankin; Roll
R/H	Right-Hand
R/L	Redline
R/Y	Roll/Yaw
RA	Radar Altimeter; Right Aft
rad	Radiator
RAM	Random Access Memory
rcdr	Recorder
RCRS	Regenerable Carbon Dioxide Removal System
RCS	Reaction Control System (Subsystem) (SSID)
RCV	Receive-Only
rcvr	Receiver
rcvy	Recovery
RDM	Research Double Module
rdtr	Radiator

RDU	Remote Decoder Unit
rdy	Ready
reac	Reactant
recirc	Recirculation
recirn	Recirculation
recrc	Recirculation
redun	Redundancy
ref	Reference
REF	References (SSID)
reg	Regulator
rel	Release
rep	Representative
repress	Repressurization
req	Required; Requirement
reqd	Required
reqmt	Requirement
req't	Requirement
ret	Retract
retnn	Retention
retr	Retract
rev	Revolution; Revision
RF	Radio Frequency; Right Forward
R-F-L	Ready For Latch
RGA	Rate Gyro Assembly
rgltr	Regulator
RH	Right-Hand
R-h	Right-Hand
RHC	Rotation Hand Controller; Rotational Hand Controller
RI	Rockwell International
RIB	Right Inboard
RJD	Reaction Jet Driver
RJDA	Reaction Jet Driver Aft
RJDF	Reaction Jet Driver Forward
rk	Rock
RLDS	Remote Leak Detector System
rlf	Relief
rlse	Release
RM	Redundancy Management
RMG	Right Main Gear
RMS	Remote Manipulator System (Subsystem)
rndz	Rendezvous
rng	Range
ROB	Right Outboard
ROCC	Range Operations Control Center
ROEU	Remotely Operated Electrical Umbilical
ROM	Read-Only Memory
ROMS	Right OMS Pod
rot	Rotational
RPC	Remote Power Controller
RPG	Radar Product Generator
rpm	Revolutions Per Minute
RPS	Record and Playback System

RPTA	Rudder Pedal Transducer Assembly
RPU	Receiver Processing Unit
RSD	Range Safety Display
RSLS	Redundant Set Launch Sequencer (SSID)
rslvr	Resolver
RSO	Range Safety Officer; Range Safety Office
RSOR	Range Safety Operations Requirement
RSR	Range Safety Representative
RSRM	Reusable Solid Rocket Motor
RSS	Range Safety System; Root Sum Square; Rotating Service Structure
rsvr	Reservoir
rt	Right
RTA	Recovery Temperature Algorithm
RTD	Resistance Temperature Detector; Resistance Temperature Device
RTLS	Return to Launch Site
rtn	Return
RTP	Real-Time Processor
rtr	Retract
rud	Rudder
RV	Relief Valve
RVDT	Rotary Variable Differential Transducer
RX	Resolver

S

s	Second(s)
S	Star
S&A	Safe and Arm (device)
S/F	Shut Off
S/Off	Shut Off
S/W	Status Word
SAFE	KSC Flight Crew & Pad Personnel Safety (SSID)
SB	Speed Brake
S-Band	Short-band (1.55 - 5.2 GHz)
SBC	Single Board Computer
S-Bd	Short-band (1.55 - 5.2 GHz)
S-BND	Short-band (1.55 - 5.2 GHz)
SBTC	Speed Brake Thrust Controller
sc	Secondary
SC	Signal Conditioner
sccm	Standard Cubic Centimeters per Minute
scfm	Standard Cubic Feet per Minute
scim	Standard Cubic Inches per Minute
SCO	Surveillance Control Officer
SCSI	Small Computer System Interface
SCU	Sequence Control Unit
SD	Smoke Detection
sec	Second(s); Secondary
SEC	Software Error Counter
SEES	Shuttle Emergency Egress System
sel	Select
sen	Sensor

SEOS	STS Operations & Systems Analysis
sep	Separation
sepn	Separation
seq	Sequence
SEQ	Space Shuttle Vehicle Functional Sequence (SSID)
serv	Service
servo	Servomechanism
SEU	Single Event Upset
sev	Severance
SEV	Status, Error, and Validity
SF	Signaling Frequency
sft	Software
SH	Spacehab (SSID)
shdn	Shutdown
shld	Shield; Shoulder
sht	Sheet; Shutdown
shtdn	Shutdown
Si	Incoming Signal
sig	Signal
SII	SRM Ignition Initiators
sit	Situation
SL	Spacelab (SSID)
SLWT	Super Light Weight Tank
SM	System(s) Management
SMRD	Spin Motor Run Detector
Snr	Sensor
snsr	Sensor
SODB	Shuttle Operational Data Book
sol	Solenoid
SOP	Subsystem Operating Program
SOV	Shut-Off Valve
sp	Speed
SPA	Steering Position Sensor Assembly
SPARC	Single Point Acquisition and Radar Control
Spbk	Speed Brake
spd	Speed
Spdbk	Speed Brake
SPDS	Stabilized Payload Deployment System
SPE	Shuttle Project Engineer
spec	Specification
SPI	Surface Position Indicator
sply	Supply
SPRT	Standard Platinum Resistance Thermometer
SPT	Steering Position Transducer
SR&QA	Safety, Reliability, and Quality Assurance
SRB	Solid Rocket Booster
SRGA	SRB Rate Gyro Assembly
SRM	Solid Rocket Motor (SSID)
SRO	Superintendent of Range Operations
Ss	Selected Signal
SS	Sound Suppression
SSER	Space to Space EVA Radio

SSI	Shuttle Standard Initiator
SSID	Subsystem Identification (identifier)
SSME	Space Shuttle Main Engine (SSID)
SSMEC	Space Shuttle Main Engine Controller
SSMM	Solid State Mass Memory
SSOR	Space to Space Orbiter Radio
SSP	Space Shuttle Program; Standard Switch Panel
SSR	Solid State Recorder
SST	Signal Strength Telemetry
SSV	Space Shuttle Vehicle
st	Status
ST	Star Tracker
sta	Station
stat	Status
stbd	Starboard
stby	Standby
STDN	Spaceflight Tracking and Data Network
STEN	Start Enable (SSME)
stng	String
str	Strut
strg	String
struct	Structure
STS	Space Transportation System
STT	Spacehab Transfer Tunnel
Subs	Subsequent Missions
sum	Summary
sup	Supplement; Supply
suppr	Suppression
supr	Suppresser
supt	Support
surf	Surface
svc	Service
SVS	Space Vision System
sw	Switch
SW	Space Wing; Status Word
sync	Synchronize
sys	System

T

t	Time
T	Temperature
T/O	Takeover
T/R	Transmit/Receive
TAC	Tactical Air Command; TACAN
TACAN	Tactical Air Controlled Navigation
TAGS	Text and Graphics System
TAL	Transatlantic Abort Landing
Tamb	Ambient Temperature
tau	FDIR Threshold Limit
TB	Talk Back
TB0	Time Base Zero
TBD	To Be Determined

TC	Throttle Control
Tce	Condenser Exit Temperature
TCID	Test Configuration Identifier Document
TCS	Thermal Control System
TD	Test Director
TDRS	Tracking and Data Relay Satellite
TEC	Thermo Electric Cooler
tech	Technical
TELCU	Thermal Electric Liquid Cooling Unit
telecon	Teleconference
temp	Temperature
temps	Temperatures
TFL	Telemetry Format Load
THC	Translational Hand Controller
therm	Thermal
thr	Thrust
thrm	Thermal
throt	Throttle
TIPS	Thermal Impulse Printer System
tk	Tank
tl	Tilt
tlm	Telemetry
TLP	Title Page (as used with an SSID)
tm	Telemetry
Tmin	Minimum Temperature Limit
TMP	Time Management Processor
TOC	Table of Contents (as used with an SSID)
tol	Tolerance
tot	Total
TP	Test Port
tpg	Topping
TPS	Thermal Protection System (Subsystem)
trans	Translational
transl	Translational
trk	Track
trkg	Tracking
trkr	Tracker
TSM	Tail Service Mast
tst	Test
TTEST	Special Test (SSID)
TV	Television
TVC	Thrust Vector Control (SSID)

U

U/L	Uplink
U/V	Under Voltage
U-Fails	Software Test Talkback (reads like "You Fails")
ug/m3	Micrograms/cubic meter
UDI	User Development Interface
uG	Micro Gravity
UHF	Ultrahigh Frequency (300 to 3000 MHz)

ull	Ullage
umb	Umbilical
uncert	Uncertainty
uncomp	Uncompensated
unl	Unlatched
unlckd	Unlocked
uplk	Uplink
upr	Upper
UPS	Uninterruptible Power Supply
URL	User Selectable Layer Composite Reflectivity; Uniform Resource Locator
UV	Ultraviolet

V

V	Volt(s); Valve
V/m	Volts per Meter
VAB	Vehicle Assembly Building
VAHIRR	Volume-Averaged, Height-Integrated Radar Reflectivity
val	Validation
VARR	Volume-Averaged Radar Reflectivity
VCR	Videocassette Recorder
Vdc	Volt(s) Direct Current
VDT	Vehicle Data Table
Vel	Velocity
vern	Vernier
vert	Vertical
VIP	Vertical Interval Processor
VJ	Vacuum Jacketed
Ver	Vernier
vlv	Valve
vlvs	Valves
VM	Virtual Memory
VME	Vertical Memory Expansion
Vmin	Minimum Volume
vol	Volume
VPU	Video Processing Unit
vs	Versus
VTR	Video Tape Recorder

W

W	Watt
W/B	Water Spray Boiler
W/WMS	Water and Waste Management System (Subsystem)
WAIV	Waiver/Deviations (SSID)
WCDDT	Wet Count Down Demonstration Test
WCL	Water Coolant Loop
wd	Word
WEA	Weather Rules (SSID)
WFCEU	Water Flow Control Electronics Unit
WG	Working Group
WLE	Wing Leading Edge

WOW	Weight On Wheels
WSB	Water Spray Boiler
WVS	Wireless Video System
WWMS	Water and Waste Management System (Subsystem)

X

X	X-Axis; Hexadecimal
xcvr	Transceiver
xdcr	Transducer
xducer	Transducer
xfd	Crossfeed
xfeed	Crossfeed
xfer	Transfer
xmit	Transmit
xover	Crossover
xovr	Crossover
xpndr	Transponder

Y

Y	Y-Axis; Yaw

Z

Z	Z-Axis

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APPENDIX B

CHANGE PROCEDURES

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CHANGE PROCEDURES

1.0 SHUTTLE LAUNCH COMMIT CRITERIA AND BACKGROUND DOCUMENT CHANGE CONTROL.

1.1 PURPOSE. This appendix defines the Space Shuttle Program (SSP) requirements, responsibilities and procedures for all Program/Projects with regard to changes to this document.

1.2 SCOPE. All changes to NSTS 16007, Shuttle Launch Commit Criteria and Background Document will be controlled in accordance with the procedures prescribed herein. Changes will reflect program decisions and will record new, changed and/or deleted requirements.

1.3 CHANGE POLICY.

1.3.1 Change Initiation. All proposed changes to NSTS 16007 shall be initiated either via a Launch Commit Criteria Change Notice (LCN) (reference Figure B-01) or a Waiver/Deviation (reference Figure B-03) in the Launch Commit Criteria Management System (LMS). All changes shall be sponsored by a Voting Member or Functional Representative.

1.3.2 Change Evaluation. All proposed changes via LCN to NSTS 16007 shall have a formal evaluation submitted in LMS prior to disposition. All formal evaluations shall be sponsored by a Space Shuttle Program Requirements Control Board (PRCB) member or the member's designated representative(s). For the purposes of this appendix, the PRCB member, or the designated representative(s) will be referred to as the Voting Member.

1.3.3 Change Disposition. All changes will be dispositioned by a PRCB directive. The Manager, Launch Integration, will be responsible for the approval of these changes (Ref. NSTS 07700, Volume IV).

1.3.4. Record Change Processing/Disposition. Review and disposition of record changes will be at the discretion of the LCC Manager and appropriate Voting Members. A change is defined as a "record" change when the following criteria are satisfied (Reference NSTS 07700, Volume IV):

1. The change is required to update or correct program documentation consistent with established program baselines or to define the design implementation for a previously authorized change.

2. The change does not constitute the originating authority for hardware or software design changes or modifications.

3. The change does not affect changes in program costs, schedule, weight or performance.

1.4 DOCUMENT MAINTENANCE AND PUBLICATION. All changes to this document will be implemented under the auspices of the Space Shuttle Management Integration and Planning Office. All changes that have been approved in accordance with the preceding paragraphs shall be provided to the Management Integration and Planning Office for incorporation in NSTS 16007. Responsibility for publication and document maintenance of NSTS 16007 is assigned to the Management Integration and Planning Office. Updates will be accomplished by using page changes or

complete document revision, as appropriate. A list of changes (Section 0, SSID LOC-XX), showing cumulative changes that have been made since change 000 of the current revision was issued, will be issued or updated with each subsequent change to the current revision. Complete revisions to the document will be published as necessary and denoted by a revision letter on the front cover.

LCNs that are initiated for the purpose of maintaining the document, at the discretion of the LCC Documentation System Analyst (Publisher), will not require LCC Working Group (LCCWG) review. These changes are generally "errata" changes and do not require concurrence from the Program/Projects.

1.5 WORKING GROUP. The LCC Working Group will review/coordinate LCNs prior to being dispositioned with the exception of those changes which the LCC Manager determines do not require LCCWG review and evaluation (such as record change LCNs, LCN revisions resulting from Daily PRCB (DPRCB) "approval with revision" direction). The Working Group is chaired by the Shuttle Launch Commit Criteria and Background Document Manager (LCC Manager) and is composed of the Voting Members, Functional Representatives and respective system engineering representatives.

The Voting Members represent the following:

Space Shuttle KSC Integration Office (LCC Manager)
Space Shuttle S&MA Office, JSC
Space Shuttle Flight Operations and Integration Office, JSC
Space Shuttle Orbiter Project Office, JSC
Mission Operations Directorate, JSC
Shuttle Processing Directorate, KSC
ISS & Spacecraft Processing Directorate, KSC
External Tank Project, MSFC
Space Shuttle Main Engine Project, MSFC
Reusable Solid Rocket Booster Project, MSFC
Space Program Operations Contractor

1.6 ROLES AND RESPONSIBILITIES.

1.6.1 LCC Voting Member. Each SSP Project is responsible for designating a Voting Member who will act as the focal point for LCC activity for their Functional Organization. The Voting Member is responsible for identifying Functional Representatives; reviewing the LCC Working Group LCN Log for required LCN activity; coordinating the review of LCNs; providing an official Vote for LCN evaluation; ensuring LCNs sponsored by their organization are technically accurate and conform to the LCC groundrules and guidelines; and providing technical support and presentation at the LCC Working Group and DPRCB, as required.

1.6.2 LCC Manager. The Manager, Space Shuttle KSC Integration, will appoint an LCC Manager who will act as the Office of Primary Responsibility (OPR) for the LCC document. The LCC Manager is responsible for ensuring that the LCC document is consistent with program guidelines; scheduling and chairing the LCC Working Group Telecon; acting as the focal point for identifying issues and impacts resulting from an LCN; maintaining the LCC Working Group LCN Log (Reference B.7.2); updating and maintaining the LCC Working Group Minutes and Notepad; and presenting LCNs to the DPRCB for disposition.

1.6.3 LCC Publisher. The LCC Publisher is designated by the Management Integration and Planning Office. The Publisher is responsible for the generation of the Program Requirements Control Board Directives (PRCBDs) resulting from LCNs approved or disapproved by the PRCB; providing maintenance and ensuring consistency and integrity of the Master LCC data base; maintaining the LCC document Table of Contents; periodically retiring expired effectivity SSIDs; and performing a final quality check prior to publication of a Change Package.

1.7 LCC LMS AUTHORIZATION. LMS provides security access control and allows only authorized users to add or modify data in the system. The following shows user access categories:

User	Can create preliminary LCNs, access, review and submit unreleased comments to LCNs for their Functional Organization.
Functional Representative	Has all User authority, as well as official LCN creation and official evaluation authority for their Functional Organization. Capabilities of the Functional Representative will be granted by the LCC Manager upon request from the appropriate Functional Organization Voting Member.
Voting Member	Has all Functional Representative authority and can also submit the official vote for their Functional Organization. Capabilities of the Voting Member will be granted by the LCC Manager upon written request from the appropriate PRCB member.

In addition to the user access categories, there are user privileges for the management, maintenance and dispositioning of LCC activity. These privileges are: Working Group Support, User Administration, Manager and Publisher.

1.8 LCN PROCESSING.

Reference Figure B-02 for the LCN Flow Process.

1.8.1 Change Processing Guidelines.

a. LCC changes shall be submitted in a timely manner to support the implementation of the requirements and the Flight Readiness Review (FRR). Changes shall be processed in the following order:

   1. Prior to FRR, LCC changes shall be submitted via an LCN (exception: mission unique configuration or anomaly driven LCC changes, reference following subparagraph). After FRR, changes shall be submitted via a Waiver/Deviation for one flight and an LCN shall be processed for subsequent flights if required.

   2. A mission unique configuration or anomaly which could violate an LCC requirement but which is acceptable for flight, may be processed for one flight as a Launch Commit Criteria Waiver/Deviation (shown in Figure B-03).

b. For LCNs, the originating Functional Organization initiates a change to the LCC by generating a Preliminary LCN (PLCN) in LMS. The content and format shall conform to the LCC guidelines and groundrules as specified in GEN-01 and GUID-01 (Appendix C) of this document.

c. When releasing an LCN, the Functional Representative/Voting Member shall provide a title, a description of change, rationale for the change (e.g., controlling hardware or software change documentation), mission effectivity, mandatory/non-mandatory change category, proposed action due date, technical point of contact and mandatory review organizations. The rationale for identifying changes as mandatory or non-mandatory is as follows:

1. Mandatory - those changes required for safety of flight, hardware and/or software configuration compatibility and problem resolution (OMRS Waiver, Interim Problem Report), or to meet Primary Mission Objectives. Mandatory changes shall have a specific flight effectivity and will have first priority for resources.

2. Non-Mandatory - those changes that do not meet the criteria for mandatory changes. For resource allocation purposes only, non-mandatory changes may be broken down into two subcategories:

Value Added - those non-mandatory changes for which an identifiable benefit can be quantified in terms of cost, schedule, risk reduction, launch probability, or mission success. These changes will have second priority for resources. Mission effectivities of Value Added changes not approved prior to FRR will be automatically rolled to the next flight unless otherwise directed by the DPRCB chair.

Optional - those non-mandatory changes which do not have quantifiable value added characteristics. Changes to correct editorial errors, or change documentation, shall be considered optional changes. These changes have last priority for resources. Mission effectivities of Optional changes not approved prior to FRR will be automatically rolled to the next flight unless otherwise directed by the DPRCB chair.

d. Each LCN, basic or subsequent revision, that is reviewed by the LCCWG will be given a review period of two weeks, unless coordinated with the LCC Manager.

e. The LCC Manager will specify the Scheduled Review Date and/or Vote Due Date (as required) for each LCN.

f. Each organization shall review the LCC Working Group LCN Log for changes which may affect its area of responsibility.

g. When an LCN is released for review, the entire SSID(s) shall be reviewed for technical content and format.

h. All LCN evaluations will be submitted via LMS and released (by the Functional Representative/Voting Member) prior to the scheduled review date. The Voting Member will indicate their organization's vote via LMS by the Vote Due Date. For a non-concurrence or concur with comments, comments, supporting rationale and recommended changes (if applicable) will be included.

i. LCN revisions will only be made after presentation at the LCC Working Group, by special direction of the LCC Manager (with consensus of the LCC Working Group) or as directed by the DPRCB.

j. Only the sponsoring organization of a released LCN is permitted to withdraw the LCN.

k. All LCN comments/issues will be addressed by the LCC Working Group. Unresolved comments/issues will be forwarded to the DPRCB for disposition. If the Chair of the DPRCB deems that additional changes are necessary, the LCN will be revised and, if deemed necessary by the LCC Manager, reviewed and voted on by the LCC Working Group.

1.9 WAIVERS/DEVIATIONS. The LMS shall be utilized for generation of the preliminary Waiver/Deviation. A Functional Representative or Voting Member is authorized to release the Waiver/Deviation for review. Upon release, LMS automatically assigns a tracking number to the Waiver/Deviation. The LCC Deviation can be reviewed at the LCC Working Group and approved at any time prior to the L-2 Day Review at the DPRCB. The releasing Voting Member or Functional Representative will be responsible for contacting the LCC Manager to schedule the Deviation to the LCC Working Group and the Daily PRCB, coordinating the Deviation with the KSC Shuttle Project Engineer (SPE) and presentation of the Deviation to the DPRCB, FRR and L-2 as required. The Manager, Launch Integration, will be the only approval signature required on the Deviation prior to L-2.

After the FRR, all new mandatory mission specific changes to the LCC are considered Deviations and shall be submitted as a Launch Commit Criteria Deviation. Subsequent to the FRR and prior to the L-2 Day Review, all Deviations will be reviewed at the next scheduled LCC Working Group (time permitting) and submitted to the DPRCB for approval. The individual Voting Member or Functional Representative will be responsible for contacting the LCC Manager to schedule the Deviation to the LCC Working Group and the DPRCB, coordinating the Deviation with the KSC SPE and the presentation of the Deviation to the DPRCB and L-2 as required. The Manager, Launch Integration, will be the only approval signature required on the Deviation prior to L-2.

After the L-2 Day Review, the KSC SPE will be responsible for coordinating the Waiver/Deviation and obtaining the following signatures (as a minimum):

- Launch Director
- Space Shuttle S&MA Manager
- Space Shuttle KSC Integration Manager
- MMT representatives of all affected elements and their prime contractors
- Launch Integration Manager

Post launch/scrub, the original approved Waiver/Deviation shall be provided to the Management Integration and Planning Office. The Management Integration and Planning Office will prepare a PRCBD documenting the approval of the Waiver/Deviation and directing update of Appendix J of this document. The LCC Manager will coordinate update of LMS to reflect the Waiver/Deviation disposition and in the case of an approved Waiver/Deviation shall process an LCN in response to the PRCBD action to update Appendix J of this document.

MM/DD/YYYY **LAUNCH COMMIT CRITERIA & BACKGROUND DOCUMENT** Created:
HH:MM:AM CDT MM/DD/YYYY

NSTS 16007

LCC CHANGE NOTICE

LCN: RELEASED

SUBSYSTEM:

TITLE:

SSIDs AFFECTED:

SSID	REV	CHG NO	MISSION

DESCRIPTION OF CHANGE:

RATIONALE FOR CHANGE:

LCN SPONSOR:
TELEPHONE:

TECHNICAL CONTACT:
TELEPHONE:

Figure B-01 LCN Cover Page Layout

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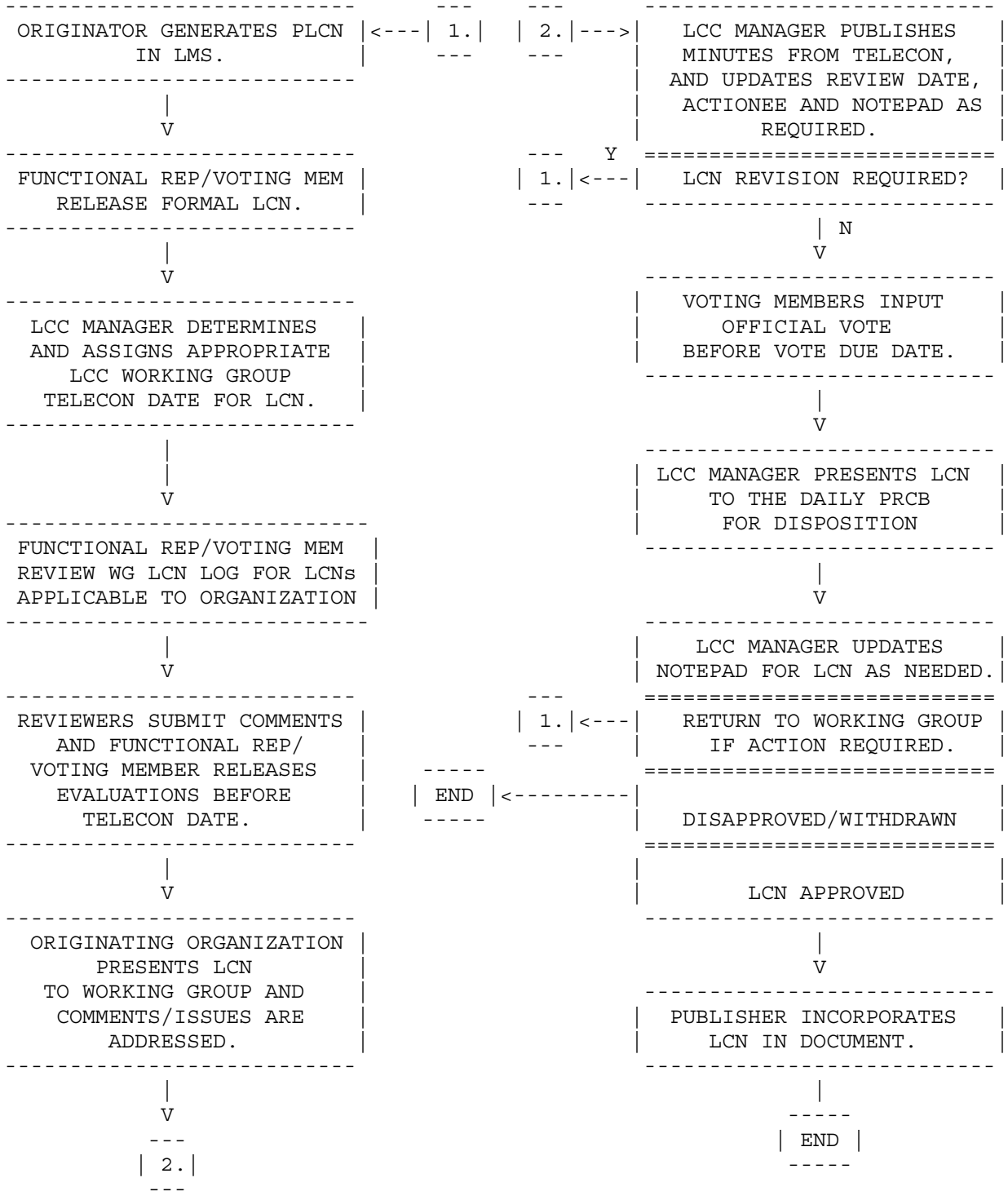

Figure B-02 LCN Flow Process

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SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/DEVIATION

TRACKING NUMBER:	**PCIN**:	**MISSION**:
ORIGINATOR:	**DATE**:	**PAGE** OF

SSID/PAGE:
DESCRIPTION:
REQUIREMENT:
WAIVER/DEVIATION:
JUSTIFICATION:
WORKAROUND:

APPROVALS:

Launch Director	Date	Manager, Launch Integration	Date
NASA Project Manager	Date	Manager, Space Shuttle KSC Integration	Date
Contractor Manager	Date	Manager, Space Shuttle Projects MSFC	Date
	Date	Manager, Space Shuttle SR&QA	Date

Figure B-03

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APPENDIX C

GUIDELINES AND DEFINITIONS

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APPENDIX C: GUIDELINES AND DEFINITIONS

SSID No.	Description/Violation Call	Page
GUID-01	LCC Redline Development Guidelines	C-01.1
GUID-FG01	Formatted SSID Layout	C-FG01.1

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1.0 LCC DEVELOPMENT GUIDELINES

1.1 LCC REDLINE DEVELOPMENT GUIDELINES

The Launch Commit Criteria (LCC) for the flight and ground systems are described in terms of redline measurement limits or measurement discrete values. The following items shall be considered in the development of redlines:

A. Minimize single measurements by identifying alternate means of monitoring the health of a system.

B. Minimize the number of redlines necessary to monitor the health of the system.

C. Redlines are developed for normal countdown procedures and nominal launch configuration. Nominal launch configurations can be mission specific.

D. If two or more subsystem failures are required to cause a single LCC parameter to violate its redline, the violation is assumed to be due to instrumentation failure. This will only be considered as a redline if instrumentation failure is unacceptable.

E. Data sources other than telemetry/hardwire to ground or displayed data may be used for necessary redline monitors. Some data types that fall into this category are Pulse Code Modulation (PCM) synchronization, relative signal strength for communication systems and visual monitors.

F. Caution and Warning (C&W), System Management (SM) and the Vehicle displays provide backup for certain redline monitors; they may validate values when limits are approached and can also be used in place of failed PCM measurements. However, these methods will only be used if no other means are available.

G. Redlines shall only be developed for verifiable functions.

H. Instrumentation Error Guidelines:

1. Instrumentation Error. Generally, redlines must be narrowed by the amount of the instrumentation error or Root Sum Square (RSS) with other independent uncertainties.

2. If a redline exceeds the end limit of the measurement and it is impossible to determine if the limit is exceeded, special effort shall be made to define alternate parameter(s). As a last resort, a readable value that is two data bits within the measurement range shall be chosen as a redline limit.

3. If the operating level is close to a redline and the redline is not a well defined value, the redline shall be made wider by the amount of the instrumentation error.

1.2 LCN PREPARATION GUIDELINES

A. GENERAL

The Launch Commit Criteria & Background Document (LCC&BD) includes the rationale for redlines, preplanned contingency procedures (if available), probable causes and consequences of violating the redline and other supporting information.

B. FORMAT AND INSTRUCTIONS

All information needed to properly evaluate MEASUREMENT REQUIREMENT TABLE, TIME PERIOD and REQUIREMENTS entries and to perform PREPLANNED CONTINGENCY PROCEDURES, shall be included within those sections without recourse to parenthetical references to NOTES, REDLINE DERIVATION, CONSEQUENCES OF EXCEEDING REDLINE, CAUSES OF EXCEEDING REDLINE or MEASUREMENT INFORMATION TABLE entries. The EMERG COND. entry (if other than "None") is required to parenthetically reference the CONSEQUENCES OF EXCEEDING REDLINE entry upon which it is based.

Acronyms used in an SSID that are defined within Appendix A may be, but are not required to be, spelled out at first usage. However if multiple definitions of that acronym exist in Appendix A then the acronym must be spelled out upon first use. If multiple definitions of the same acronym are required to be used in the same SSID then use of the acronym will not be allowed. In those cases where an acronym is used within an SSID but the acronym is not defined in Appendix A then the acronym will be noted by the LCCWG and implemented via a routine Appendix A update LCN that must be approved prior to L-1 week for the next mission.

Instructions for preparing a formatted Subsystem Identifier (SSID) follow this paragraph. The subparagraph number corresponds to the numbers in GUID-FG01. Subparagraph 4 through 10 constitutes the MEASUREMENT REQUIREMENT TABLE (MRT). The MRT is not to be confused with the MEASUREMENT INFORMATION TABLE (MIT), which is described in subparagraphs 20 through 20n. Unformatted SSIDs (such as GEN-01, ETR-01, WEA-01, etc.) are exempt from the following formatting and content requirements. Unformatted SSIDs that provide requirements which could constrain launch should provide the same level of rationale for the requirements as provided in formatted SSIDs. This rationale may be contained in each SSID or, for sections such as the MEL or MIL, contained in a single SSID which supports the other SSIDs within that section.

1. SSID

The SSID is the Subsystem Identification Number. This number is a unique identifier assigned to a specific LCC requirement. It consists of a specific alphanumeric code with two to four characters designating the subsystem, a hyphen and two to four additional characters. Since all sections have fewer than 100 SSIDs, only two numbers will be used (lead zeros are required for SSID numbers below 10). (Ex.: MPS-29, ET-05, SSME-12, GUID-FG01) If it is desirable to insert a new requirement in the LCC&BD at a point other than at the end of a section and a suitable deleted SSID number is not available, that requirement may be assigned the SSID of the

preceding SSID with a letter appended. (Example: MPS-29a, ET-05a, SSME-12a.) Any page included in the LCC&BD must be assigned an SSID. For mission unique changes, the effectivity can be included after the SSID (Example: MEL-13(103) for STS-103).

2. LCC VIOLATION CALL

   This entry contains the call used by the console operator to announce the violation of that LCC. The call shall be brief, unique and descriptive. (Example: External Tank Nose Cone Purge Temperature Anomaly.)

3. EMERG COND.

   This entry indicates the potential hazard to the flight Crew and/or Pad Personnel caused by violation of that LCC. The two emergency conditions that apply are Yellow and Critical. Reference SSID SAFE-01 for detailed definitions of these conditions. For either of these conditions, place a parenthetical number (e.g., (2)) in the EMERG COND column next to the condition and explain the condition under the referenced item number in the CONSEQUENCES OF EXCEEDING REDLINE section. If neither of these emergency conditions apply for a specific LCC, enter the word “None”.

4. MEAS. NO.

   This entry contains the complete Measurement Stimulation Identification (MSID) number(s) from the current Master Measurement List (MML) and Checkout Control and Monitor Subsystem (CCMS) Data Bank. Payload measurement numbers may not be included in these sources. If a measurement number is not applicable, an identifier of ten or fewer characters or “N/A” (or “NA”) must be added. If no particular grouping is dictated by the content of the LCC, list them in alphanumeric order.

5. MEASUREMENT DESCRIPTION

   The official measurement title/description from the current MML and CCMS Data Bank must be used. If no formal measurement description exists, provide a title.

6. CAT.

   This entry is used to indicate the measurement voting logic (if any) or to reference specific TIME PERIODS, REQUIREMENTS or PREPLANNED CONTINGENCY PROCEDURES.

   a. If two or more measurements (or items) are combined into a voting logic that requires fewer than all the measurements (or items), that voting logic may be entered here. (Example: 1 of 2, 2 of 3, 2 of 4, etc.) This type measurement voting logic is implemented in the following manner: So long as the specified number of parameters is within the redlines, the condition is acceptable even if the other parameters are functional and outside the redline limits. If required to define more complex voting logic, the voting logic may be entered in the

REQUIREMENTS section.

b. For redline violations that are acceptable for confirmed instrumentation failure, a parenthetical number (e.g., (3)) may be placed in the CAT. Column if needed to clarify which REQUIREMENT and/or PREPLANNED CONTINGENCY PROCEDURE should be referenced for evaluation of the violation.

7. MINIMUM

The minimum acceptable value of a measurement is stated in the MINIMUM entry and must be explained in the REDLINE DERIVATION section.

a. A numerical limit includes instrumentation inaccuracy and other applicable allowances.

b. The desired state of a discrete measurement (i.e., logical "1" or "0") as identified in the MML and CCMS Data Bank or as represented to the console operator via the Launch Processing System (LPS).

c. If there is no applicable lower limit, place an "N/A" or "NA" in the MINIMUM column.

d. All negative values will be preceded by a minus (-) sign, otherwise the value will be considered positive.

e. If further restriction or explanation of the minimum list is required, place a number in parenthesis (e.g., (2)) beside or below the minimum limit value and describe the restriction or explanation in the REQUIREMENTS section.

f. If the minimum limit is not a number or cannot otherwise be fully described by an entry in the minimum column, place a number in parenthesis (e.g., (1)) in the MINIMUM column and describe the requirement in the REQUIREMENTS section.

8. MAXIMUM

The maximum acceptable value of the measurement is stated in the MAXIMUM entry and must be explained in the REDLINE DERIVATION section.

a. A numerical limit includes instrumentation inaccuracy and other applicable allowances.

b. For event/discrete measurements, place an "N/A" or "NA" in the MAXIMUM column.

c. If there is no applicable upper limit, place an "N/A" or "NA" in the MAXIMUM column.

d. All negative values will be preceded by a minus (-) sign, otherwise the value will be considered positive.

e. If further restriction or explanation of the maximum limit is required, place a number in parenthesis (e.g., (2)) beside or below the maximum limit value and describe the restriction or explanation in the REQUIREMENTS section.

f. If the maximum limit is not a number or cannot otherwise be fully described by an entry in the maximum column, place a number in parenthesis (e.g., (1)) in the MAXIMUM column and describe the requirement in the REQUIREMENTS section.

9. UNITS

The engineering units (or appropriate abbreviation) for each measurement is entered here. Units will be as contained in the MML and CCMS. For event/discrete measurements enter EVENT in this column.

10. CODE

This entry designates one of three categories of measurements as follows:

a. CI - Continuous Interlock indicates that the measurement on that line must be continuously monitored and must remain within the range bounded by the minimum and maximum limits (or, for events, at the desired state) during the period specified in the TIME PERIOD section.

b. DI - Discrete Interlock indicates that the measurement on that line must be within the range bounded by the minimum and maximum limits (or, for events, at the desired state) during a snapshot (one-time check) at the time specified in the TIME PERIOD section.

c. BU - Backup indicates that the measurement on that line is a backup to other measurements contained in that LCC. These measurements are used to determine primary measurement failure and verify system criteria. Backup measurements require some engineering judgment or special procedure to determine if the associated system is within acceptable limits. Criteria for the use of backup measurements shall be explained in the REQUIREMENTS section and implementing procedures (if any) shall be described in the PREPLANNED CONTINGENCY PROCEDURES section.

11. TIME PERIOD

The time or period for which the LCC redlines apply and are required to be monitored. It is acceptable to have approximate times represented if an exact time is not available or to facilitate implementation.

a. For measurements with continuous interlock requirements, the start time and the stop time is specified here. If applicable, it is preferable to identify the start and stop times as a countdown milestone with the associated clock time given in

parenthesis. If a time is enclosed in parenthesis that follows a milestone name, it must be the time of the milestone.

b. For measurements with discrete interlock requirements, the acceptable time for the check is specified here.

c. Multiple time periods shall be reflected as separate items with a parenthetical reference to their applicable requirements.

12. REQUIREMENTS

This section is used to define the MEASUREMENT REQUIREMENT TABLE requirements (from CAT., MINIMUM, MAXIMUM and CODE entries). It is used to specify the circumstances, if any, for which redline limit violations are acceptable.

a. The REQUIREMENTS section will only be used to document specific requirements relative to entries contained in the MEASUREMENT REQUIREMENT TABLE or the TIME PERIOD section.

b. If a requirement allows continuing the countdown for confirmed instrumentation failure, a reference to the preplanned contingency procedure that confirms instrumentation failure will be noted here.

c. Include specific monitoring instructions in this section.

d. State specific mission applicability in this section. For mission dependent items, reference Appendix H (Minimum Equipment List) as applicable.

e. Requirements which accept reduced functional redundancy or fault tolerance, based on the criteria of GEN-01 paragraph 1.4.A, shall reference a preplanned contingency procedure if the acceptability is dependent on confirmation that the loss of function is isolated and has not affected the remaining functional redundancy or fault tolerance of the system.

f. To explicitly reflect the clearing of, or continued existence of an LCC violation, the statements "LCC violation cleared, continue countdown" or "LCC violation confirmed, No Go for launch" may be used. No other terminology will be used for this purpose.

13. FIGURE/TABLE

Figures or tables contained in the LCC&BD which support this SSID are referenced in this section. Space Shuttle Systems Handbook drawings, Integrated Systems Schematics and other drawings not contained in the LCC will not be referenced here.

14. PREPLANNED CONTINGENCY PROCEDURE

Procedure to verify that a function, or functional fault tolerance, is still acceptable. With the exception of emergency safing procedures, Warnings and Cautions, Preplanned Contingency Procedures

shall be written with the intent of providing explicit Go (as a minimum) and if appropriate, No Go guidance (depending on the nature and possible outcome of the procedure).

a. All Preplanned Contingency Procedures shall result in one of two possible conditions:

   1. Procedures/conditions that verify a function or functional fault tolerance IS acceptable for launch shall conclude with the statement "LCC violation cleared, continue countdown".

   2. Procedures/conditions that verify a function or functional fault tolerance IS NOT acceptable for launch shall conclude with the statement "LCC violation confirmed, No Go for launch".

   Multi-paragraph Preplanned Contingency Procedures need only to contain the above statements where logical conclusions are reached. No other terminology will be used to reflect the clearing of, or the continued existence of an LCC violation.

b. Where expanded procedures/flow diagrams exist, they shall be included in the LCC as a figure and referenced from this section. Conclusions reached by such procedures/flow diagrams shall be reflected either within the procedure/flow diagram or solely within the referencing preplanned contingency procedure, by use of one of the statements specified in subparagraph (a) above.

c. When a supporting sequence exists in an Operations and Maintenance Instruction (OMI), that document shall be referenced (e.g., S0007.500) and the Go/No Go criteria shall be outlined. Conclusions reached by such OMI sequences shall be reflected within the referencing preplanned contingency procedure by use of one of the statements specified in subparagraph (a) above.

d. Procedures for confirming instrumentation failure shall be included in this section, as applicable.

e. Procedures that verify acceptable loss of function to ensure remaining redundancy of the system shall be included in this section.

f. Warnings (personnel injury or death risk) or Cautions (equipment damage risk) deemed necessary for a preplanned contingency procedure shall be included within the appropriate procedure statement and preceded with "WARNING - " or "CAUTION - ". Warnings or Cautions which are applicable to multiple procedures may be entered as a separate preplanned contingency procedure entry and parenthetically referenced, as appropriate.

g. When a Preplanned Contingency Procedure specifically references MDM failure as an acceptable condition, the specific type of MDM (Operational Instrumentation, Payload, Flight Critical) will be referenced in a Note or in the Redline Derivation section.

15. NOTES

Useful information which provides clarification or explanation is contained in this section. The NOTES section will not contain requirements, constraints or information required to evaluate requirements or perform preplanned contingency procedures. In addition, background information regarding LCC development which is not considered part of the REDLINE DERIVATION should be included in the NOTES section.

16. REDLINE DERIVATION

As a minimum, the REDLINE DERIVATION section should contain the following subparagraphs, each of which will be titled as indicated and will address the titled topic as directed below. Additional sequential subparagraphs may be included in addition to those indicated below and will be titled appropriately based on the subparagraph content. If a subparagraph is not applicable then it shall be marked with an "N/A" following the title.

Subparagraph a)

Titled "SSID Intent Summary", this statement will be written similar to an executive summary in level of detail. It will address the overall purpose of the SSID by summarizing what the SSID is protecting, how it is being protected by the monitoring requirements within the SSID, and what foreseeable consequences could occur if this protection were not maintained. This subparagraph will also include a high level discussion of fault tolerance of the system/function.

Subparagraph b)

Titled "Voting Logic", this statement will provide details on the rationale for accepting, without confirmation of instrumentation failure and without further consideration, redline violations of a subset of the total suite of parameters monitored in the SSID and the minimum required redundancy for this system/function. This Voting Logic is usually reflected in the CAT column and/or the REQUIREMENTS Section.

Subparagraph c)

Titled "Minimum and/or Maximum Redline Development", this statement details the origins of, and rationale for, the redline(s) documented under the Measurement Requirement Table (MRT) MINIMUM and/or MAXIMUM columns and will include redline adjustments for instrumentation error and, where applicable, known bias effects. Additionally, references to supporting engineering documentation may be included. If either a Minimum or Maximum redline does not exist (marked "N/A") for a monitored function (with the exception of redlines which specify a required logical state, such as ON or OFF) then the rationale for the missing redline must be addressed in this section unless the absence is considered self explanatory by the LCC Working Group (LCCWG) due to the nature of the measurement.

Subparagraph d)

Titled "Time Period" (or "Time Effectivity"), TIME PERIOD entries should, whenever possible, be consistent with GEN-01 subparagraphs 1.4.D.(1) through 1.4.D.(5). This statement will explain why the monitoring time frame and technique are appropriate to the protection provided by the monitored system/function. Exceptions to the above GEN-01 subparagraphs may require supporting rationale as to why the GEN-01 guidelines for monitoring times and techniques are not followed.

Subparagraph e)

Titled "Requirements", for REQUIREMENT entries that contain redline limits or acceptance criteria not already called out within the Measurement Requirement Table (MRT) MINIMUM and/or MAXIMUM columns, this statement details the origins of, and rationale for, the redline(s) or acceptance criteria. This rationale will include redline adjustments for instrumentation error and, where applicable, known bias effects. Additionally, references to supporting engineering documentation may be included. For REQUIREMENT entries that either allow redline violations that can be confirmed to be the result of instrumentation failure, or prohibit acceptance of instrumentation failure, even when the instrumentation failure does not violate any other redlines, this statement will provide details on the rationale for accepting, or prohibiting, the confirmed occurrence of instrumentation failure.

Subparagraph f)

Titled "Preplanned Contingency Procedures", this statement will summarize the technical rationale supporting steps taken to ensure that the redline violation that drove performance of the PREPLANNED CONTINGENCY PROCEDURE is acceptable for launch. The statement will include justification of the acceptability of any alternate measurements used and, if alternate redlines are used; provide rationale for the alternate redlines. PREPLANNED CONTINGENCY PROCEDURES that perform emergency safing steps are exempt from rationalization other than a brief explanation of the need for performance of the safing steps.

17. CRITICALITY

This entry designates the Functional Criticality, as defined in the Failure Mode Effects Analysis (FMEA) (NSTS 22206) and Critical Items List (CIL) (NSTS 08399), of the subsystem, without failures, being monitored by the SSID.

18. CONSEQUENCES OF EXCEEDING REDLINE

This section describes the potential results of exceeding the minimum and maximum redlines (e.g., loss of cabin pressure). References to associated Integrated Hazard Reports will be appended to applicable consequences. Where no associated Integrated Hazard Reports exist for a given consequence, but an associated Element

Hazard Report does exist, then the associated Element Hazard Report will be appended to the applicable consequence.

19. CAUSES OF EXCEEDING REDLINE

This section explains the possible causes for exceeding the minimum and maximum redlines (e.g., malfunction of the relief valve).

20. MEASUREMENT INFORMATION TABLE (MIT) INSTRUCTIONS

Instructions for preparing the MIT follow this paragraph. The subparagraph number corresponds to the numbers within the MIT in Figure C-01.

For discrete measurements, no MIT entry is required. Exception: If the discrete can cause a C&W alarm or SM Alert during the LCC timeframe and the annunciation is not otherwise identified in the SSID, a MIT entry should be included.

Values contained in the table apply to the LCC timeframe, only. Alarm information pertinent to other portions of the mission may be listed in the NOTES section of the relevant SSID. If a table entry is not applicable for a measurement, that entry shall be left blank.

The following is a description of each of the fields present in the MIT and the instructions for preparing the information to be contained in each field.

20a. UNITS

The engineering units associated with the listed measurement(s). The units listed in the table apply to all measurements listed below or until another UNITS entry is encountered.

20b. MSID

The MSIDs for applicable measurements referenced in the Measurement Requirement Table are contained in this column.

20c. BIT VALUE

The engineering value associated with a single PCM count change for each analog measurement as specified in the CCMS data bank (ground measurements), MML (Orbiter measurements) or CP406R0008/CP406R0021, Block II/Block II-AHM (Advanced Health Management) controller software (SSME measurements ending in 'D' or 'B') is contained in this column. If the engineering value is derived from a non-linear equation, the BIT VALUE will be denoted as “NL” or “NonLinear”.

20d. PCM RANGE LOW

The engineering value of the lower end of the measurement range as specified in the CCMS data bank (ground measurements), MML (Orbiter measurements) or

CP406R0008/CP406R0021, Block II/Block II-AHM (Advanced Health Management) controller software (SSME measurements ending in 'D' or 'B') is contained in this column.

20e. PCM RANGE HIGH

The engineering value of the higher end of the measurement range as specified in the CCMS data bank (ground measurements), MML (Orbiter measurements) or CP406R0008/CP406R0021, Block II/Block II-AHM (Advanced Health Management) controller software (SSME measurements ending in 'D' or 'B') is contained in this column.

20f. HARDWARE C&W MIN.

If a measurement has a lower limit monitored by the onboard Hardware Caution and Warning System, the limit is contained in this column (in engineering units).

20g. HARDWARE C&W MAX.

If a measurement has an upper limit monitored by the onboard Hardware Caution and Warning System, the limit is contained in this column (in engineering units).

20h. BACKUP C&W MIN.

If a measurement has a lower limit monitored by the Backup Caution and Warning System (made up of Primary Avionics Software System (PASS) and/or Backup Flight Software (BFS) functions), the limit is contained in this column (in engineering units).

20i. BACKUP C&W MAX.

If a measurement has an upper limit monitored by the Backup Caution and Warning System (made up of PASS and/or BFS functions), the limit is contained in this column (in engineering units).

20j. BFS SM MIN.

If a measurement has a lower limit monitored for an SM Alert by the onboard BFS software, the limit is contained in this column (in engineering units).

20k. BFS SM MAX.

If a measurement has an upper limit monitored for an SM Alert by the onboard BFS software, the limit is contained in this column (in engineering units).

20l. METER/DISPLAY RANGE - MSID

The MSID for a measurement that has an associated meter or Multifunction Electronic Display Subsystem (MEDS) display.

20m. METER/DISPLAY RANGE - LOW

If a measurement can be read on an onboard meter or display, the lower end of the scale is contained in this portion of the MIT (in engineering units).

20n. METER/DISPLAY RANGE - HIGH

If a measurement can be read on an onboard meter or display, the upper end of the scale is contained in this portion of the MIT (in engineering units).

21. SPACE SHUTTLE SYSTEMS HANDBOOK

This section contains the Space Shuttle Systems Handbook drawing number, the drawing page number and the zone where measurements included in the SSID are located. Additional lines may be added, if necessary.

22. INTEGRATED SYSTEMS SCHEMATIC

This section contains the Integrated Systems Schematic drawing number, the drawing page number and the zone where measurements included in this SSID are located. Additional lines may be added, if necessary.

23. ELEMENT

The Program/Project responsible for the requirements in this SSID is contained in this section.

24. SUBSYSTEM

The subsystem, as defined by the responsible Program/Project to which this SSID applies, is contained in this section. Generally, this section will contain the SSID prefix.

25. SUPPORTING DATA

A table, figure or flow diagram associated with an SSID and bearing the SSID number, must be designated “SUPPORTING DATA:” (this term must be at the top left of the page). If the table, figure or flow diagram is a standalone SSID, the term “SUPPORTING DATA:” is not required.

1.3 LCC WAIVER/DEVIATION PREPARATION

The instructions for preparing a LCC Waiver/Deviation follow this paragraph. The Waiver/Deviation is shown in Figure B-03.

A. TRACKING NUMBER

A unique Waiver/Deviation number, which is assigned by the LCC Management System (LMS) when the Waiver/Deviation is released, is indicated as LD-XXX or LW-XXX, where D-denotes a Deviation and W-

denotes a Waiver.

B. PCIN

A Program Change Identification Number (PCIN) can be obtained from the Space Shuttle Management Integration Office.

C. MISSION

Identifies applicable Space Transportation System (STS) number and Orbiter (e.g., STS-92/OV-103).

D. SSID/PAGE

Denotes the SSID (e.g., DPS-17) and the page number of the applicable requirement. Page number is optional.

E. ORIGINATOR

Individual originating the Waiver/Deviation.

F. DATE

The date the Waiver/Deviation is released.

G. DESCRIPTION

The LCC Violation Call for the applicable SSID.

H. PAGE

Denotes the page number of the Waiver/Deviation (e.g., 1 of 2). This is an automatic function accomplished by LMS.

I. REQUIREMENT

State the requirement within the SSID that is being deviated/waived.

J. WAIVER/DEVIATION

Describes the new or modified LCC requirement(s).

K. JUSTIFICATION

Supporting rationale for the Waiver/Deviation. State why the requirement is being changed.

L. WORKAROUND

Describe any steps or procedures not described in the SSID that will be used if the new requirement is violated or additional steps which are required to return the system within the LCC parameters, or the new Waiver/Deviation parameters.

M. SIGNATURE

Obtain appropriate signatures. If a signature is not required, place a NR in this block, if not applicable, place a "N/A" or "NA" in this block (Ref. SSID: CHG-01 paragraph 1.9 for minimum required signature list). Multi-Element Waiver/Deviations resulting in additional signature requirements than those listed in paragraph 1.9 of CHG-01 will have additional signatures (with corresponding Titles) recorded in blank signature blocks.

1.4 DEFINITIONS

A. Abort

To terminate an operation or procedure before its completion.

B. Confirmed

The term used to define the high confidence level associated with a measurement, indication or condition when additional information is available which corroborates that measurement, indication or condition.

C. Deviation

Authorization, granted before the fact, to depart from a particular LCC requirement for Launch Countdown.

D. Ground Support Equipment

Non-flight hardware that is routinely required for the handling, servicing, inspection, testing, maintenance, alignment, adjustment, checkout, repair, or overhaul of flight hardware.

E. Highly Desirable

A Space Shuttle Vehicle function, payload function, or operational support function that supports and enhances the accomplishment of the mission.

F. Hold

An interruption of the countdown for any reason. Holds may be preplanned or occur for a system out of specification, unfavorable weather, problem investigation, repair of hardware, or correction of conditions unsatisfactory for launch or flight.

G. Hold-point

A Hold-point is designated based on Vehicle conditions that can be maintained for a period of time during the launch countdown without adverse effects. In the event that an interruption is required at other than a Hold-point, it will be necessary to Recycle to a Hold-point.

H. Instrumentation

The means, by which data is acquired, transmitted and monitored in order to remotely evaluate performance of Space Shuttle Vehicle, payload or operational support equipment.

I. Intact Abort

An ascent abort that results in the safe landing of personnel, payload and Orbiter on a runway.

J. Launch Countdown

A sequence of events (after the Vehicle has been certified launch ready) that results in Vehicle launch.

K. LCC Violation

The term used to define the condition which exists when the criteria identified in the SSID has not been met. An LCC violation, by definition, is a constraint to launch (No Go condition) that exists from the time of the initial violation and may only be cleared by meeting Go condition criteria contained in PREPLANNED CONTINGENCY PROCEDURE(s)(ref. App. C, paragraph 1.2.B.14) or by an MMT approved Waiver (ref. GEN-01 paragraph 1.6.C and App. B, paragraph 1.9). Reference IMPL-01 paragraph 1.1 for exceptions to this definition.

L. Lift-off

The event determined by Reusable Solid Rocket Motor (RSRM) Ignition and is the point in time when plus time commences.

M. Measurement

A specific data channel of instrumentation monitoring a single function.

N. One-fault Tolerant

The condition of a system being fully capable of performing its critical functions after sustaining a single failure.

O. Operational Support Element

A part of any system or activity that is involved in the countdown, launch, flight or landing operations, other than those elements that are a part of the Space Shuttle Vehicle itself (e.g., support equipment/facilities, communications, utilities and tracking).

P. Recycle

The countdown is interrupted and cycled back to a designated Hold-point. A Recycle is usually executed to get to a designated Hold-point or get to the beginning of a sequence that is necessary to bring hardware back on-line or into a ready condition.

Q. Safety Critical Item

The term used to describe items, events, or damage that could result in any of the following situations if countdown proceeds:

1. Injury to personnel/public
2. Loss of Vehicle
3. An on pad or ascent abort
4. An unsafe condition for pad abort

Note: This definition is unique to the LCC. Other definitions for Safety Critical Requirement are found in National Space Transportation System (NSTS) 07700, Volume XI, Appendix B and for Safety Critical are found in NSTS 5300.4(1D-2) Appendix A.

R. Two-fault Tolerant

The condition of a system being fully capable of performing its critical functions after sustaining two failures.

S. Waiver

Acceptance of an LCC Violation, which is authorized after the violation of the requirement.

T. Zero-Fault Tolerant

The condition of a system being fully capable of performing its critical functions but is unable to sustain failures.

NSTS 16007 LAUNCH COMMIT CRITERIA AND BACKGROUND SSID: (1)

LCC VIOLATION CALL: (2) | EMERG COND: (3)

MEAS. NO. (4)	MEASUREMENT DESCRIPTION (5)	CAT. (6)	MINIMUM (7)	MAXIMUM (8)	UNITS (9)	CODE (10)

TIME PERIOD: (11)

REQUIREMENTS: (12) FIGURES/TABLES: (13)

PREPLANNED CONTINGENCY PROCEDURE: (14)

NOTES: (15)

REDLINE DERIVATION: (16) CRITICALITY: (17)

CONSEQUENCES OF EXCEEDING REDLINE: (18)

CAUSES OF EXCEEDING REDLINE: (19)

MEASUREMENT INFORMATION TABLE: (20)

MSID	BIT VALUE	PCM RANGE LOW	PCM RANGE HIGH	HW C&W MIN	HW C&W MAX	BACKUP C&W MIN	BACKUP C&W MAX	BFS SM MIN	BFS SM MAX
(20a/b)	(20c)	(20d)	(20e)	(20f)	(20g)	(20h)	(20i)	(20j)	(20k)

METER/DISPLAY RANGE - MSID: (20l) LOW: (20m) HIGH: (20n)

SPACE SHUTTLE SYSTEMS HANDBOOK: DWG NO (21) SHEET ZONE
INTEGRATED SYSTEMS SCHEMATIC: DWG NO (22) SHEET ZONE

ELEMENT: (23) SUBSYSTEM: (24)

MISSION: STS-XXX REVISION X
AUTH: XXXXXXXXX CHANGE NO. XXX

ABCD-XX.X

Figure C-01 Formatted SSID Layout

NSTS 16007 LAUNCH COMMIT CRITERIA AND BACKGROUND SSID: (1)

SUPPORTING DATA: (25)

MISSION: STS-XXX REVISION X
AUTH: XXXXXXXXX CHANGE NO. XXX
ABCD-XX.X

Figure C-01 Formatted SSID Layout (Continued)

APPENDIX D

REFERENCES

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APPENDIX D

REFERENCES

Document Number	Document Title
NSTS 07700 Vol IV	Configuration Management Requirements
NSTS 07700 Vol X	Flight and Ground System Specification
NSTS 07700 Vol XI	System Integrity Assurance Program Plan
NSTS 07700 Vol XIV	System Payload Accommodations
NSTS 07700-10-MVP-01	Shuttle Master Verification Plan
NSTS 08171	Operations and Maintenance Requirements and Specifications Document
NSTS 08209	Shuttle Systems Design Criteria
NSTS 08303	NSTS Program Ice Debris Inspection Criteria
NSTS 08329	DOLILU II Definition and Requirements Document
NSTS 08399	Space Shuttle Program Critical Items List (CIL)
NSTS 08934	Shuttle Operational Data Book
NSTS 12820	Space Shuttle Operational Flight Rules
NSTS 17462	Flight Requirements Document
NSTS 22206	Requirements for Preparation and Approval of Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL)
NSTS 5300.4	Safety, Reliability, Maintainability and Quality Provisions for the Space Shuttle Program
JSC 11174	Space Shuttle Systems Handbook
EWR 127-1	Eastern and Western Range 127-1
DOD 3200.11	DOD Directive - Major Range and Test Facility Base
OMI-S0007	Shuttle Countdown (LPS) - PAD OMI
KLO-82-0071	Ground Launch Sequencer Requirements Document
MK Letter Dated 11/23/87	Subject: Documentation of Mission Operations Directorate Preflight Minimum Line Replacement Unit (LRU) and Mandatory Instrumentation Requirements

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APPENDIX E

FAULT SUMMARY MESSAGE AND CAUTION AND WARNING LISTINGS

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APPENDIX E: FAULT SUMMARY MESSAGE AND CAUTION AND WARNING LISTINGS

SSID No.	Description/Violation Call	Page
FSUM-01	Introduction	Ea-01.1
FSUM-02	APU/HYD Fault Summary Messages	Ea-02.1
FSUM-03	MPS Fault Summary Messages	Ea-03.1
FSUM-04	RCS/OMS Fault Summary Messages	Ea-04.1
FSUM-05	PRSD/FC Fault Summary Messages	Ea-05.1
FSUM-06	ECLSS Fault Summary Messages	Ea-06.1
FSUM-07	EPDC Fault Summary Messages	Ea-07.1
FSUM-08	Avionics Fault Summary Messages	Ea-08.1
CW-01	Table E-01: Caution and Warnings Listed by Caution and Warning Light	Eb-01.1
CW-02	Table E-02: Caution and Warnings Listed by Channel	Eb-02.1

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APPENDIX E

FAULT SUMMARY MESSAGES AND CAUTION AND WARNING LISTINGS

INTRODUCTION

FAULT SUMMARY MESSAGES:

This portion of the appendix contains all GPC Fault Summary Messages which are active during the time the LCC is in effect. Messages are grouped by Orbiter system as follows:

Auxiliary Power Units/Hydraulics (APU/HYD)
Main Propulsion System (MPS)
Reaction Control System/Orbiter Maneuvering System (RCS/OMS)
Power Reactant Storage & Distribution/Fuel Cells (PRSD/FC)
Environmental Control & Life Support System (ECLSS)
Electrical Power Distribution & Control (EPDC)
Avionics

The purpose of the Fault Summary Message portion of this appendix is to assist operators in cross referencing Fault Summary Messages with the associated system SSIDs (sections 10-44). The Fault Summary entries in this appendix are not requirements and shall not be used to generate automated Holds. Any Holds required solely by the occurrence of a Fault Summary Message should be addressed in the associated system SSIDs.

Message text is listed as it will appear on the Orbiter displays. For each message there is a description of the measurements which drive it and reference to the SSID which contains the measurements. In some instances the SSID will specify an alternate measurement or there may be no applicable SSID, in which case explanatory notes are provided.

Since Primary Avionics Software System (PASS) Systems Management (SM) software is not active pre-launch, most non-avionics message drivers originate in the BFS SM software. Most avionics messages are generated by PASS System Level or GNC software and many have BFS drivers as well.

CAUTION AND WARNING LISTINGS:

This portion of the appendix contains Caution and Warning indications which could be encountered during the LCC time frame. The purpose of the Caution and Warning indication tables in this appendix is to assist operators in cross referencing Caution and Warning indications with the associated system SSIDs (sections 10-44). The Caution and Warning entries contained in this appendix are not requirements and shall not be used to generate automated Holds. Any Holds required solely by the occurrence of a Caution and Warning message should be addressed in the associated system SSIDs.

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APU/HYD FAULT SUMMARY MESSAGE:

MESSAGE TEXT	MESSAGE DRIVERS	SSID REF
SM2 APU 1(2,3)	LUBE OIL OUT PRESS (3)	APU-11
	LUBE OIL OUT TEMP (3)	APU-08, 09
	DRN LINE PRESS (3)	APU-16
	FUEL TK QTY (3)	NONE. SEE (A)
SM2 APU SPD HI 1(2,3)	TURBINE SPEED (3)	APU-06
SM2 APU SPD LO 1(2,3)	TURBINE SPEED (3)	APU-06
SM2 APU TEMP 1(2,3)	TURBINE EXH TEMPS (6)	NONE
	LUBE OIL RTN TEMP (3)	APU-08, 09
SM2 FU TK VLV APU	ISO VLV TEMP (6)	APU-21
SM2 HYD ACUM P 1(2,3)	GN2 ACCUM PRESS (3)	HYD-07
SM2 HYD PRESS 1(2,3)	HYD SYS SPLY PRESS B (3)	HYD-02
SM2 HYD QTY 1(2,3)	RSVR FLUID VOL (3)	HYD-01
SM2 HYD RSVR T 1(2,3)	RSVR FLUID TEMP (3)	NONE. SEE (B)
SM0 THRM APU	GG BED TEMP (3)	APU-04
	INJ TUBE TEMP (3)	APU-04, 22
	PMP H20 LN TEMPS (6)	NONE. SEE (C)
	FUEL LINE TEMP (3)	APU-05
	FUEL VLV TEMP (3)	APU-05
SM2 W/B QTY 1(2,3)	CMPTD QTY (3)	NONE. SEE (D)
SM0 BRAKE P 1/3(2/3)	LOB BRAKE PRESS (2)	GNC-79
	LIB BRAKE PRESS (2)	GNC-79
	RIB BRAKE PRESS (2)	GNC-79
	ROB BRAKE PRESS (2)	GNC-79

(A) Tank pressures monitored for leakage (APU-01).

(B) Fluid temp monitored at SSME hydraulic actuators for lower limit. Upper limit N/A prelaunch (SSME-15, 23).

(C) Line is dry prelaunch. Sensor should read ambient.

(D) GN2 pressures and temps monitored for leakage (HYD-04).

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MPS FAULT SUMMARY MESSAGE

MESSAGE TEXT	MESSAGE DRIVERS	SSID REF
ME SHDN SW C(L,R)	FLAG FROM GNC SW RM (3)	NONE. SEE (A)
MPS DATA C(L,R)	FLAG FROM SSME SOP (3)	RSLS-01
MPS ELEC C(L,R)	FLAG FROM SSME SOP (3)	RSLS-01
MPS H2 OUT P C(L,R)	MPS H2 OUTLET PRESS (3)	NONE. SEE (C)
MPS HYD C(L,R)	FLAG FROM SSME SOP (3)	RSLS-01
MPS HE P C(L,R)	MPS HE SPLY PRESS (3)	MPS-01
	MPS HE REG A,B PRESS (6)	MPS-03
MPS LH2/O2 MANF	LH2 MANF PRESS	NONE. SEE (B)
	LO2 MANF PRESS	NONE. SEE (B)
MPS LH2/O2 ULL	ET LH2 ULL PRESS (3)	ET-05
	ET LO2 ULL PRESS (3)	ET-06
MPS O2 OUT T C(L,R)	MPS O2 OUTLET TEMPS (3)	NONE. SEE (C)
MPS PNEU P TK	MPS PNEU HE TK PRESS	MPS-01
MPS PNEU P REG	MPS PNEU HE REG PRESS	MPS-03
MPS PNEU P ACUM	MPS PNEU HE ACCUM PRESS	MPS-03

(A) Crew must perform backup procedure for manual engine shutdown.

(B) Prelaunch system pressure protected by OMRSD and SSIDs ET-05 & ET-06.

(C) MPS H2 Outlet pressures and MPS O2 Outlet temperatures are backup measurements to verify SSME operation in the event of loss of SSME data.

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RCS/OMS FAULT SUMMARY MESSAGES

MESSAGE TEXT	MESSAGE DRIVERS	SSID REF
F RCS HE P	FWD HE OX TK PRESS	RCS-01
	FWD HE FU TK PRESS	RCS-01
L RCS HE P	LT HE OX TK PRESS	RCS-01
	LT HE FU TK PRESS	RCS-01
R RCS HE P	RT HE OX TK PRESS	RCS-01
	RT HE FU TK PRESS	RCS-01
F RCS TK P	FWD OX TK ULL PRESS	RCS-02
	FWD FU TK ULL PRESS	RCS-02
L RCS TK P	LT OX TK ULL PRESS	RCS-02
	LT FU TK ULL PRESS	RCS-02
R RCS TK P	RT OX TK ULL PRESS	RCS-02
	RT FU TK ULL PRESS	RCS-02
F RCS LEAK	LEAKAGE ALERT FROM BFS	NONE. SEE (A)
L RCS LEAK	LEAKAGE ALERT FROM BFS	NONE. SEE (A)
R RCS LEAK	LEAKAGE ALERT FROM BFS	NONE. SEE (A)
F RCS F(L,R,U,D) JET	JET LEAKING (14) FROM RCS RM	RCS-06 SEE (B)
L RCS D(L,U,A) JET	JET LEAKING (12) FROM RCS RM	RCS-06 SEE (B)
R RCS D(R,U,A) JET	JET LEAKING (12) FROM RCS RM	RCS-06 SEE (B)
L OMS QTY	LT FU OR OX LOW LEVEL (2)	OMS-18 SEE (C)
R OMS QTY	RT RU OR OX LOW LEVEL (2)	OMS-18 SEE (C)
L OMS TEMP	LT FU INJ TEMP	OMS-12
R OMS TEMP	RT FU INJ TEMP	OMS-12
L OMS TK P	LT HE TK PRESS	OMS-01
	LT PNEU SPLY PRESS	OMS-08
	LT REG OUT PRESS	OMS-09
	LT OX TK ULLAGE PRESS	OMS-05
	LT FU TK ULLAGE PRESS	OMS-05
R OMS TK P	RT HE TK PRESS	OMS-01
	RT PNEU SPLY PRESS	OMS-08
	RT REG OUT PRESS	OMS-09
	RT OX TK ULLAGE PRESS	OMS-05
	LT FU TK ULLAGE PRESS	OMS-05

(A) Tank pressures monitored for leakage (RCS-02). BFS LEAKAGE ALERT can be caused by transducer failure.

(B) Injector temp redlines (RCS-06) will be exceeded before RM generates leak alarm.

(C) SSID specifies aft probe gauge reading as opposed to low level events.

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PRSD/FC FAULT SUMMARY MESSAGES

MESSAGE TEXT	MESSAGE DRIVERS	SSID REF
SM2 CRYO H2 MANF	H2 MANIFOLD PRESS 1/2	NONE. SEE (D)
SM2 CRYO H2 PRES	H2 TK HTR CNTL PRESS (4)	PRSD-06
SM2 CRYO O2 HTR	O2 TK HTR TEMPS (10)	NONE. SEE (A)
SM2 CRYO O2 MANF	O2 MANIFOLD PRESS 1/2	NONE. SEE (D)
SM2 CRYO O2 PRES	O2 TK HTR CNTL PRSS (4)	PRSD-01
SM1 DC VOLT FC 1(2,3)	FC VOLTAGE (3)	FCP-01
SM1 FC AMPS 1(2,3)	FC CURRENT (3)	FCP-01 SEE (B)
SM1 FC COOL P 1(2,3)	FC CLNT PRESS (3)	FCP-02
SM1 FC DELTA V 1(2,3)	FC DELTA VOLTS(9)	FCP-03
SM1 FC EXIT T 1(2,3)	FC CNDSR EX TEMP (3)	FCP-02
SM1 FC PH 1(2,3)	FC H2O CONDITION (3)	FCP-05 SEE (C)
SM1 FC PUMP 1(2,3)	FC PUMP STATUS (3)	FCP-04
SM1 FC REAC 1(2,3)	FC O2 OR H2 REAC VLV CLSD (6)	PRSD-03
SM1 FC STACK T 1(2,3)	FC CLNT OUT TEMP (3)	FCP-02

(A) A failed on heater will cause affected tank pressure to exceed GSE supply pressure (PRSD-01), but may not cause violation of O2 TK HTR CNTL PRESS.

(B) SM limits may be exceeded without violating LCC redlines (based on performance curve).

(C) The common PH sensor is not annunciated in SM.

(D) H2 TK HTR CNTL PRESS (PRSD-06) and O2 TK HTR CNTL PRESS (PRSD-01) measurements are monitored Prelaunch for insight into manifold pressures.

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ECLSS FAULT SUMMARY MESSAGES

MESSAGE TEXT	MESSAGE DRIVERS	SSID REF
SM2 AV BAY FAN	AV BAY DELTA PRESS (3)	ECL-10
SM2 AV BAY TEMP	AV BAY OUT AIR TEMP (3)	ECL-10
SM1 CABIN O2	O2 FLOW RATE (2)	NONE. SEE (A)
SM1 CABIN PRESS	CABIN PRESS	ECL-05
SM1 CABIN PPO2	PPO2 A & B (2)	ECL-06
SM1 CABIN N2	N2 FLOW RATE (2)	NONE. SEE (A)
SM1 CABIN FAN	CABIN FAN DELTA PRESS	ECL-07
SM1 CABIN IMU	IMU FAN SPD NORM (3)	ECL-11
SM1 CABN DP/DT BU	PRESS RATE OF CHANGE	ECL-04
SM2 EVAP OUT T 1(2)	EVAP OUT TEMP (2)	ECL-43
SM2 FREON FLOW 1(2)	INTERCHANGR FLOW RATE (2)	ECL-40
SM2 H2O PUMP P 1(2)	PUMP OUT PRESS (2)	ECL-08
SM1 SMOKE ALRM	CONCENTRATION (9)	ECL-30

(A) Pressure control system not active prelaunch.

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EPDC FAULT SUMMARY MESSAGES:

MESSAGE TEXT	MESSAGE DRIVERS	SSID REF
SM1 AC OVLD 1(2,3)	EVENT FROM AC SENSOR (3)	EPDC-04 SEE (A)
SM1 AC VOLTS 1(2,3)	AC BUS VOLTAGES (9)	EPDC-03
SM1 CNTL/ESS V	CNTL BUS VOLTAGES (9)	NONE. SEE (B)
	ESS BUS VOLTAGES (3)	NONE. SEE (B)
SM1 MAIN BUS V A(B,C)	MAIN BUS VOLTAGES (3)	EPDC-01

(A) SSID specifies bus currents as opposed to sensor event.

(B) SSIDs EPDC-02 and EPDC-06 protect against loss of control/essential bus power sources (RPCs, switches) as opposed to voltage redlines.

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AVIONICS FAULT SUMMARY MESSAGES:

MESSAGE TEXT	PASS	BFS	SSID REF
BCE STRG 1(2,3,4) A	X	X	DPS-03
BCE STRG 1(2,3,4) B	X	X	DPS-03
BCE STRG 1(2,3,4) C	X	X	DPS-03
BCE STRG 1(2,3,4) D	X	X	DPS-03
BCE STRG 1(2,3,4) PASS		X	BFS-06
BCE STRG 1(2,3,4) ADTA	X	X	DPS-15
BCE STRG 1(2,3) MTU	X	X	DPS-16, BFS-03
BCE STRG 1(2,3) TAC	X	X	DPS-17
BCE STRG 1(2,3) GPS	X	X	DPS-28
BCE STRG 1(2,3) MLS	X		NONE. (SEE A)
BCE STRG 1(2,3) IMU	X	X	DPS-12, 13
BCE STRG 1(3) NSP	X	X	DPS-14
BODY FLAP CYCL	X		NONE. (SEE B)
BODY FLAP FAIL	X		NONE. (SEE B)
BODY FLAP HOLD	X		NONE. (SEE B)
CRT BITE 1(2,3,4)	X	X	DPS-01a, BFS-10a
DISPLAY SW L(R)	X		NONE. (SEE C)
DK XMTR 1(2,3,4)		X	BFS-05
ET SEP-MAN	X		NONE. (SEE D)
FCS CHAN 1(2,3,4)	X	X	GNC-09
GPC BITE	X	X	DPS-05, BFS-04
GPC CONF	X		NONE. (SEE E)
GPC PWR		X	BFS-05
GPC 1(2,3,4)	X		DPS-02
IMU BITE/T 1(2,3)	X		GNC-56, 57, 58, 59, 60
I/O ERROR CRT 1(2,3,4)	X	X	DPS-01a, BFS-10a
I/O ERROR D/L	X		LPS-18
I/O ERROR FA 1(2,3,4)	X	X	DPS-03, BFS-06
I/O ERROR FF 1(2,3,4)	X	X	DPS-03, BFS-06
I/O ERROR MMU 1(2)	X		DPS-06a
I/O ERROR PCM		X	INS-01, BFS-15
I/O ERROR PL 1(2)	X	X	DPS-03, BFS-09
I/O ERROR LF1 (LA1)	X		DPS-22, LPS-17
MDM OUTPUT FA 1(2,3,4)	X		DPS-20
MDM OUTPUT FF 1(2,3,4)	X		DPS-20
MDM OUTPUT PL 1(2)	X		DPS-20
ME SHDN SW C (L,R)	X		SSME-36
OFF/BUSY MMU 1(2)	X		DPS-07
RHC L (R)	X		GNC-01
RM DLMA IMU	X	X	NONE. (SEE F)
RM DLMA PRL	X		NONE. (SEE G)
RM FAIL IMU	X		GNC-66
RM FAIL RGA	X		GNC-12
RM FAIL ACC	X		GNC-13
RM FAIL XFER		X	BFS-11. (SEE H)
SUMWORD ICC 1(2,3,4)	X		DPS-21
TFL FAIL		X	NONE. (SEE J)
TIME MTU	X		DPS-10, INS-01, 03
TIME TONE	X		NONE. (SEE I)

AVIONICS FAULT SUMMARY MESSAGES: (Concluded)

(A) MSBLSs powered off; message expected.

(B) Body Flap redlines (GNC-30 or GNC-31) will be violated before RM generates these messages.

(C) RM selects default position for ADI, HSI, RA, and Air Data sel switches.

(D) Crew must perform manual ET separation.

(E) This message can only be generated by a procedure error and will preclude transition to OPS 101.

(F) IMU FAIL criteria (GNC-66) will be violated before this message is generated.

(G) Hydraulic system redlines (HYD-03) will be violated before this message is generated.

(H) This message indicates the PASS/BFS data transfer has failed.

(I) No constraint to launch.

(J) This message indicates a TFL autoload has failed during a PCM power switchover. No constraint to launch.

C&W Light	CH	MSID	Nomenclature	LCC Reference	Notes
AC OVERLOAD (H)	063	V76X1506E	AC BUS 1 OVERLOAD	EPDC-04	EPDC-04 uses following nine MSIDs: V76C154(0,1,2)A V76C164(0,1,2)A V76C174(0,1,2)A
	073	V76X1606E	AC BUS 2 OVERLOAD		
	083	V76X1706E	AC BUS 3 OVERLOAD		
AC VOLTAGE (H)	033	V76X1505E	INVERTER BUS NO 1 O/V-U/V	EPDC-03	BFS monitors AC BUS 1-3 PHASE A/B/C VOLTAGES using V76V150(0,1,2)A, V76V160(0,1,2)A, V76V170(0,1,2)A. EPDC-03 uses same nine MSIDs
	043	V76X1605E	INVERTER BUS NO 2 O/V-U/V		
	053	V76X1705E	INVERTER BUS NO 3 O/V-U/V		
AIR DATA (P)	091	V72X4580X	NAVIGATION SENSOR FAILURE	GNC-73, 74, 75	The PASS RM software monitors for ADTA dilemmas. A dilemma is declared if there are no ADTAs available for RM or if the pressures between two selected ADTAs miscompare on 3 consecutive cycles. A miscompare occurs when the difference between the pressures from two ADTAs exceeds a calculated limit.
APU OVERSPEED (H)	068	V46X0165E	APU 1 TURBINE OVERSPEED	APU-06	BFS monitors APU TURBINE SPEEDS using V46R0(1,2,3)35A. APU-06 uses same 3 MSIDs
	078	V46X0265E	APU 2 TURBINE OVERSPEED		
	088	V46X0365E	APU 3 TURBINE OVERSPEED		
APU TEMP (H)	008	V46T0142A	APU 1 TURBINE EXHAUST TEMP NO 1	-	There is no backup C&W defined for these parameters. Hardware C&W is inhibited prelaunch.
	018	V46T0242A	APU 2 TURBINE EXHAUST TEMP NO 1		
	028	V46T0342A	APU 3 TURBINE EXHAUST TEMP NO 1		
	038	V46T0150A	APU 1 GEARBOX LUBE OIL RETURN TEMP	APU-08	BFS can generate a C&W Alarm for APU TURBINE EXHAUST TEMP 2 parameters V46T0(1,2,3)40A but current limits are set off-scale.
	048	V46T0250A	APU 2 GEARBOX LUBE OIL RETURN TEMP		
	058	V46T0350A	APU 3 GEARBOX LUBE OIL RETURN TEMP		
APU UNDERSPEED (H)	098	V46X0166E	APU 1 TURBINE UNDERSPEED	APU-06	BFS monitors APU TURBINE SPEEDS using V46R0(1,2,3)35A. APU-06 uses same 3 MSIDs
	108	V46X0266E	APU 2 TURBINE UNDERSPEED		
	118	V46X0366E	APU 3 TURBINE UNDERSPEED		
AV BAY/ CABIN AIR (H)	074	V61P2556A	CABIN FAN DELTA PRESS	ECL-07	
	084	V61T2645A	AVNS BAY 1 OUTLET AIR TEMP	ECL-10	
	094	V61T2650A	AVNS BAY 2 OUTLET AIR TEMP		
	104	V61T2661A	AVNS BAY 3 OUTLET AIR TEMP		
	114	V61T2635A	CABIN HX OUT-AIR TEMP	ECL-07	There is no BFS C&W defined for this parameter.

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P - C&W light is illuminated by PASS, only. No BFS interface.
B - C&W light is illuminated by BFS, only. No PASS interface.
PB - C&W light is illuminated by PASS S/W pre-engage, BFS S/W post-engage.
HPB - C&W light is illuminated by either Hardware or PASS inputs pre-engage, Hardware or BFS inputs post-engage.

Table E-01 Caution and Warnings Listed by Caution and Warning Light

C&W Light	CH	MSID	Nomenclature	LCC Reference	Notes
AVIONICS BAY SMOKE DETECTION (H)	H/W	V62X0620E	SMOKE DETECTOR-A AV BAY-1	ECL-33	Hardwire to C&W box drives a Class 1 alarm with PNL L1 lights, Master alarm, and siren.
		V62X0621E	SMOKE DETECTOR-B AV BAY-1		
		V62X0610E	SMOKE DETECTOR-A AV BAY-2		
		V62X0611E	SMOKE DETECTOR-B AV BAY-2		
		V62X0630E	SMOKE DETECTOR-A AV BAY-3		
		V62X0631E	SMOKE DETECTOR-B AV BAY-3		
	B/U	V62Q0618A	SMOKE DETECTOR CONCN A-AV BAY 1	ECL-33	Class 2 alarm with BU C&W light.
		V62Q0619A	SMOKE DETECTOR CONCN B-AV BAY 1		
		V62Q0608A	SMOKE DETECTOR CONCN A-AV BAY 2		
		V62Q0609A	SMOKE DETECTOR CONCN B-AV BAY 2		
		V62Q0628A	SMOKE DETECTOR CONCN A-AV BAY 3		
		V62Q0629A	SMOKE DETECTOR CONCN B-AV BAY 3		
BACKUP C/W ALARM	PASS/BFS illumination of this light will be accompanied by a Fault Summary Message on corresponding CRT. BFS will illuminate this light for all C&W conditions marked by (H) (except Payload Warning), (B), (PB) and (HPB). BFS may illuminate this light for other conditions not included on this list. PASS will illuminate this light for all conditions marked by (P), (PB), (HPB) and for the GPC Light.				
CABIN ATM (H)	004	V61P2405A	CABIN PRESS	ECL-04 & 05	
	014	V61R2105A	SYS 1 O2 FLOWRATE	ECL-04, 05, 06	
	024	V61R2205A	SYS 2 O2 FLOWRATE		
	034	V61P2511A	O2 PARTIAL PRESSURE - A	ECL-06	
	044	V61P2513A	O2 PARTIAL PRESSURE - B		
	054	V61R2553A	SYS 1 N2 FLOWRATE	ECL-02 & 03	
	064	V61R2554A	SYS 2 N2 FLOWRATE		
CABIN dP/dT (H)	H/W	V61R2401A	CABIN PRESS RATE OF CHANGE IND	ECL-04	Hardwire to C&W box for upper limit (pressure loss) drives a Class 1 alarm with Master Alarm and klaxon.
	B/U	V61P2405A	CABIN PRESS	ECL-04	Samples used to calculate dP/dT and drives a Class 3 SM alert (no BU C&W light).

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PB - C&W light is illuminated by PASS S/W pre-engage, BFS S/W post-engage.
HPB - C&W light is illuminated by either Hardware or PASS inputs pre-engage, Hardware or BFS inputs post-engage.

Table E-01 Caution and Warnings Listed by Caution and Warning Light

C&W Light	CH	MSID	Nomenclature	LCC Reference	Notes
CREW CABIN SMOKE DETECTION (H)	H/W	V62X0596E	SMOKE DET-RTN AIR TO CAB HX	ECL-31	Hardwire to C&W box drives a Class 1 alarm with PNL L1 lights, Master alarm, and siren.
		V62X0606E	SMOKE DETECTOR-LEFT FLIGHT DECK		
		V62X0607E	SMOKE DETECTOR-RIGHT FLIGHT DECK		
	B/U	V62Q0595A	SMOKE DETR CONCN RTN AIR-CAB HX	ECL-31	Class 2 alarm with BU C&W light.
		V62Q0590A	SMOKE DET CONCN LEFT-FLIGHT DECK		
		V62Q0591A	SMOKE DET CONCN RIGHT-FLIGHT DECK		
FCS CHANNEL (PB)	111	V72X4550X	FLIGHT CONTROL CHANNEL FAILURE	GNC-38	The software monitors for an FCS channel fail signal. This signal is set whenever secondary Δ pressure exceeds $\pm$2025 psig for 120 $\pm$ 20ms or if the filtered driver current is 4 milliamps (at greater than 5 hz) for 120 $\pm$ 20ms.
FCS SATURATION (PB)	101	V72X4555X	FLIGHT CONTROL SYSTEM SATURATE	GNC-22, 23, 24	The software monitors elevon position and delta pressure feedbacks. For BFS, biases and scale factors are applied to convert position and pressure feedback data into engineering units. These compensated values are then used to determine C&W conditions. For elevon position, the limits are -15 to +12 deg. For delta pressures, the upper limit is 80% (2400 psia). BFS C&W for these functions is limited to OPS 3 & 6.
FREON LOOP (H)	106	V63R1100A	FCL 1 INTERCHANGER FLOWRATE	ECL-40	
	116	V63R1300A	FCL 2 INTERCHANGER FLOWRATE		
	107	V63T1207A	FCL 1 EVAP OUT TEMP	ECL-43	
	117	V63T1407A	FCL 2 EVAP OUT TEMP		
FUEL CELL PUMP (H)	092	V45X0143E	FUEL CELL NO 1 COOLANT PUMP STATUS	FCP-04	
	102	V45X0243E	FUEL CELL NO 2 COOLANT PUMP STATUS		
	112	V45X0343E	FUEL CELL NO 3 COOLANT PUMP STATUS		

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P - C&W light is illuminated by PASS, only. No BFS interface.
B - C&W light is illuminated by BFS, only. No PASS interface.
PB - C&W light is illuminated by PASS S/W pre-engage, BFS S/W post-engage.
HPB - C&W light is illuminated by either Hardware or PASS inputs pre-engage, Hardware or BFS inputs post-engage.

Table E-01 Caution and Warnings Listed by Caution and Warning Light

C&W Light	CH	MSID	Nomenclature	LCC Reference	Notes
FUEL CELL REAC (H)	002	V45X1150E	PRSD FCP 1 O2 REAC VLV - OPEN	PRSD-03	
	012	V45X2150E	PRSD FCP 1 H2 REAC VLV - OPEN		
	022	V45X1155E	PRSD FCP 2 O2 REAC VLV - OPEN		
	032	V45X2155E	PRSD FCP 2 H2 REAC VLV - OPEN		
	042	V45X1160E	PRSD FCP 3 O2 REAC VLV - OPEN		
	052	V45X2160E	PRSD FCP 3 H2 REAC VLV - OPEN		
FUEL CELL STACK TEMP (H)	062	V45T0120A	FUEL CELL NO 1 STACK COOL OUT TEMP	FCP-02	
	072	V45T0220A	FUEL CELL NO 2 STACK COOL OUT TEMP		
	082	V45T0320A	FUEL CELL NO 3 STACK COOL OUT TEMP		
FWD RCS (HPB)	006	V42P1115C	RCS FWD OX TANK ULLAGE PRESS	RCS-02	
	016	V42P1116C	RCS FWD FU TANK ULLAGE PRESS		
	026	V72X6035X	FWD RCS LEAK DET (DPS)	RCS-02	The software will calculate the difference between FU and OX quantities using a PVT algorithm. In BFS, a difference of > 9.5% will cause a C&W alarm to be generated while engaged or tracking PASS. The PASS limit is 12.6% and is I-Loaded to 9.5% for every flight.
GPC	005	V72X7011E	GPC 1 FAIL INDICATOR	DPS-02 RSLS-01	All 5 GPC FAIL discretes are OR'd together to illuminate the 'GPC' matrix light. After T-20 Min, PASS GPC Fail Indicators are indirectly monitored via SSID RSLS-01.
	015	V72X7012E	GPC 2 FAIL INDICATOR		
	025	V72X7013E	GPC 3 FAIL INDICATOR		
	035	V72X7014E	GPC 4 FAIL INDICATOR		
	045	V72X7015E	GPC 5 FAIL INDICATOR	BFS-04 & 08	GPC-5 (BFS) Fail Indicator indirectly monitored via listed SSIDs.
H2 PRESS (H)	050	V45P2110A	PRSD H2 TK 1 HTR CONTROL PRESS	PRSD-06	
	060	V45P2210A	PRSD H2 TK 2 HTR CONTROL PRESS		
	070	V45P2310A	PRSD H2 TK 3 HTR CONT PRESS (MBK)		
	080	V45P2410A	PRSD H2 TK 4(&5) HTR CONT PRESS		
	090	V45P2510A	PRSD H2 TK 5 HTR CONT PRESS		090 not applicable for OV-102

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P - C&W light is illuminated by PASS, only. No BFS interface.
B - C&W light is illuminated by BFS, only. No PASS interface.
PB - C&W light is illuminated by PASS S/W pre-engage, BFS S/W post-engage.
HPB - C&W light is illuminated by either Hardware or PASS inputs pre-engage, Hardware or BFS inputs post-engage.

Table E-01 Caution and Warnings Listed by Caution and Warning Light

C&W Light	CH	MSID	Nomenclature	LCC Reference	Notes
H2O LOOP (H)	105	V61P2600A	H2O LOOP 1 PUMP OUTLET PRESS	ECL-09	
	115	V61P2700A	H2O LOOP 2 PUMP OUTLET PRESS		
HYD PRESS (H)	099	V58P0114C	HYDR SYS 1 SUPPLY PRESS A	HYD-02	C&W not applicable from APU start @ T-5 min 00 sec until T-4 min 05 sec to allow for pump stabilization. C&W not applicable from T-3 min 55 sec until T-3 min 03 sec due to potential for exceeding redlines during aerosurface and SSME gimbal profile. BFS monitors the "B" parameters for HYD SYS SUPPLY PRESS using V58P01(2,3)15A.
	109	V58P0214C	HYDR SYS 2 SUPPLY PRESS A		
	119	V58P0314C	HYDR SYS 3 SUPPLY PRESS A		
IMU (P)	103	V72X4560X	IMU FAILURE	GNC-60	The PASS software monitors for IMU attitude and velocity miscompares. Miscompares are set whenever the square of the attitude or delta velocity error exceeds the square of the associated fault detection limit. If a miscompare exists for 3 consecutive cycles (48 seconds), a C&W alarm is generated. Fault detection limits vary with different phases of flight. GNC-60 uses V90X2(6,7,8)01X MSIDs
LEFT OMS (HPB)	007	V43P4221C	OMS-L POD OXDZR TANK ULLAGE PRESS	OMS-05	
	017	V43P4321C	OMS-L POD FUEL TANK ULLAGE PRESS		
	027	V72X4547X	OMS-L ENG ABNORMAL (DPS)	OMS-14	The software will detect low chamber pressure (PC) conditions for the LOMS.
LEFT RCS (HPB)	036	V42P2115C	RCS L AFT OX TANK ULLAGE PRESS	RCS-02	
	046	V42P2116C	RCS L AFT FU TANK ULLAGE PRESS		
	056	V72X6036X	LEFT RCS LEAK DET (DPS)	RCS-02	The software will calculate the difference between FU and OX quantities using a PVT algorithm. In BFS, a difference of > 9.5% will cause a C&W alarm to be generated while engaged or tracking PASS. The PASS limit is 12.6% and is I-Loaded to 9.5% for every flight.

H - C&W light is illuminated by Hardware, only. No GPC interface.
P - C&W light is illuminated by PASS, only. No BFS interface.
B - C&W light is illuminated by BFS, only. No PASS interface.
PB - C&W light is illuminated by PASS S/W pre-engage, BFS S/W post-engage.
HPB - C&W light is illuminated by either Hardware or PASS inputs pre-engage, Hardware or BFS inputs post-engage.

Table E-01 Caution and Warnings Listed by Caution and Warning Light

C&W Light	CH	MSID	Nomenclature	LCC Reference	Notes
LEFT RHC (P)	100	V72X4575X	LEFT RHC FAILURE	GNC-01	The PASS RM software monitors for disagreements on RHC inputs. If the difference between two of the three pairs of RHC input signals exceeds an I-loaded limit, the common input is deemed failed. If the difference between the two remaining signals exceeds the I-loaded value for 3 consecutive cycles, a dilemma is declared and a C&W alarm is generated.
MAIN BUS UNDERVOLT (H)	003	V76V0101A	MAIN BUS A UNDERVOLT	EPDC-01	BFS monitors MAIN BUS A/B/C VOLTAGES using V76V0(1,2,3)00A. EPDC-01 uses same three MSIDs
	013	V76V0201A	MAIN BUS B UNDERVOLT		
	023	V76V0301A	MAIN BUS C UNDERVOLT		
MPS (H)	009	V41P1150C	MPS E1 HE SUPPLY BOTTLE PRESS	MPS-01	C&W low limit of 1150 is applicable to mainstage. There is no C&W high limit. LCC and EMON limits are much tighter.
	019	V41P1250C	MPS E2 HE SUPPLY BOTTLE PRESS		
	029	V41P1350C	MPS E3 HE SUPPLY BOTTLE PRESS		
	039	V41P1154A	MPS E1 REG A HE OUTLET PRESS	MPS-03	There is no software C&W defined for these parameters. BFS has SM Alerts defined for REG A & B parameters with limits of 679-810 psia. C&W limits are applicable to mainstage. LCC and EMON limits are tighter.
	049	V41P1254A	MPS E2 REG A HE OUTLET PRESS		
	059	V41P1354A	MPS E3 REG A HE OUTLET PRESS		
	069	V41P1533C	MPS LO2 17IN FEED MANF DISC PRESS	-	These C&W limits were intended for in-flight usage post MECO. There are no C&W low limits. If C&W alarm occurred with no other data supporting a pressure spike, recommend continue count.
	079	V41P1433C	MPS LH2 17IN FEED MANF DISC PRESS		
O2 HTR TEMP (H)	001	V45T1107A	PRSD O2 TK 1 HTR ASSY 1 TEMP	PRSD-01 & 04	BFS monitors PRSD O2 TK 5 HTR ASSY 2 TEMP using V45T1509A. PRSD-04 is tank heater current PRSD-01 is tank heater control pressure.
	011	V45T1109A	PRSD O2 TK 1 HTR ASSY 2 TEMP		
	021	V45T1207A	PRSD O2 TK 2 HTR ASSY 1 TEMP		
	031	V45T1209A	PRSD O2 TK 2 HTR ASSY 2 TEMP		
	041	V45T1307A	PRSD O2 TK 3 HTR ASSY 1 TEMP (MBK)		
	051	V45T1309A	PRSD O2 TK 3 HTR ASSY 2 TEMP (MBK)		
	061	V45T1407A	PRSD O2 TK 4 HTR ASSY 1 TEMP (MBK)		
	071	V45T1409A	PRSD O2 TK 4 HTR ASSY 2 TEMP (MBK)		
	081	V45T1507A	PRSD O2 TK 5 HTR ASSY 1 TEMP (MBK)		

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P - C&W light is illuminated by PASS, only. No BFS interface.
B - C&W light is illuminated by BFS, only. No PASS interface.
PB - C&W light is illuminated by PASS S/W pre-engage, BFS S/W post-engage.
HPB - C&W light is illuminated by either Hardware or PASS inputs pre-engage, Hardware or BFS inputs post-engage.

Table E-01 Caution and Warnings Listed by Caution and Warning Light

C&W Light	CH	MSID	Nomenclature	LCC Reference	Notes
O2 PRESS (H)	000	V45P1110A	PRSD O2 TK 1 HTR CONTROL PRESS	PRSD-01	
	010	V45P1210A	PRSD O2 TK 2 HTR CONTROL PRESS		
	020	V45P1310A	PRSD O2 TK 3 HTR CONT PRESS (MBK)		
	030	V45P1410A	PRSD O2 TK 4(&5) HTR CONT PRESS		
	040	V45P1510A	PRSD O2 TK 5 HTR CONT PRESS		040 not applicable for OV-102
OMS KIT	077	V43P6221C	OMS KIT OXID TK ULL	-	There is no backup C&W defined for these parameters. Hardware C&W for these parameters is inhibited prelaunch.
	087	V43P6321C	OMS KIT FUEL TK ULL		
OMS TVC (PB)	067	V72X4546X	OMS-TVC FAIL (DPS)	GNC-44	The software will detect off-nominal performance of the pitch and yaw gimbal actuators of the two OMS engines. An OMS actuator is deemed failed if there is > 2 degree difference between the commanded and actual position of the actuator for 3.84 seconds. BFS C&W for these functions is limited to engage, only.
PAYLOAD CAUTION (B)	097	V72X0001Y	GPC-PAYLOAD CAUTION	-	BFS will detect off-nominal payload conditions based on the support interface defined for the specific mission.
PAYLOAD WARNING (H)	055	P01X5025E	PL DIR-TO-CWE HARDWIRE C&W INPUT 1	-	Hardware monitoring of the Payload is reconfigured flight-by-flight.
	065	P01X5026E	PL DIR-TO-CWE HARDWIRE C&W INPUT 2		
	075	P01X5027E	PL DIR-TO-CWE HARDWIRE C&W INPUT 3		
	085	P01X5028E	PL DIR-TO-CWE HARDWIRE C&W INPUT 4		
	095	P01X5029E	PL DIR-TO-CWE HARDWIRE C&W INPUT 5		
PRIMARY C/W				INS-06	This C&W light is used exclusively to indicate failure in the primary C&W system. It will be illuminated for loss of C&W power supply, loss of C&W timing or failure of the C&W self-test parameter to pass limit check. This C&W light has no GPC interface.

H - C&W light is illuminated by Hardware, only. No GPC interface.
P - C&W light is illuminated by PASS, only. No BFS interface.
B - C&W light is illuminated by BFS, only. No PASS interface.
PB - C&W light is illuminated by PASS S/W pre-engage, BFS S/W post-engage.
HPB - C&W light is illuminated by either Hardware or PASS inputs pre-engage, Hardware or BFS inputs post-engage.

Table E-01 Caution and Warnings Listed by Caution and Warning Light

C&W Light	CH	MSID	Nomenclature	LCC Reference	Notes
RCS JET (PB)	096	V72X4545X	RCS FAIL	GNC-45 & RCS-08	The software will detect fail-on and fail-off conditions for each RCS JET. A fail–on condition exists if an RCS jet is commanded off and its chamber pressure remains above 36 psi after 400 ms. A fail–off exists if an RCS jet is commanded on and its chamber pressure remains below 36 psi after 240ms. BFS C&W for RCS jets is limited to engage, only.
RGA/ACCEL (P)	093	V72X4590X	GYRO/ACCELEROMETER FAILURE	GNC-11, 12, 13	PASS monitoring of RGA/AA failures is terminated after detection of the first failure. As a result, no dilemma conditions will be detected and no C&W alarms will be generated.
RIGHT OMS (HPB)	037	V43P5221C	OMS-R POD OXDZR TANK ULLAGE PRESS	OMS-05	
	047	V43P5321C	OMS-R POD FU TANK ULLAGE PRESS		
	057	V72X4548X	OMS-R ENG ABNORMAL (DPS)	OMS-14	The software will detect low chamber pressure (PC) conditions for the ROMS.
RIGHT RCS (HPB)	066	V42P3115C	RCS R AFT OX TANK ULLAGE PRESS	RCS-02	
	076	V42P3116C	RCS R AFT FU TANK ULLAGE PRESS		
	086	V72X6037X	RIGHT RCS LEAK DET (DPS)	RCS-02	The software will calculate the difference between FU and OX quantities using a PVT algorithm. In BFS, a difference of > 9.5% will cause a C&W alarm to be generated while engaged or tracking PASS. The PASS limit is 12.6% and is I-Loaded to 9.5% for every flight.
RIGHT/AFT RHC (P)	110	V72X4570X	RIGHT RHC FAILURE	GNC-01	The PASS RM software monitors for disagreements on RHC inputs. If the difference between two of the three pairs of RHC input signals exceeds an I-loaded limit, the common input is deemed failed. If the difference between the two remaining signals exceeds the I-loaded value for 3 consecutive cycles, a dilemma is declared and a C&W alarm is generated.
SPARE	089				
SPARE	113				

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B - C&W light is illuminated by BFS, only. No PASS interface.
PB - C&W light is illuminated by PASS S/W pre-engage, BFS S/W post-engage.
HPB - C&W light is illuminated by either Hardware or PASS inputs pre-engage, Hardware or BFS inputs post-engage.

Table E-01 Caution and Warnings Listed by Caution and Warning Light

CH	MSID	Nomenclature	LCC Reference	C & W Light
000	V45P1110A	PRSD O2 TK 1 HTR CONTROL PRESS	PRSD-01	O2 PRESS (H)
001	V45T1107A	PRSD O2 TK 1 HTR ASSY 1 TEMP	PRSD-01, 04	O2 HTR TEMP (H)
002	V45X1150E	PRSD FCP 1 O2 REAC VLV - OPEN	PRSD-03	FUEL CELL REAC (H)
003	V76V0101A	MAIN BUS A UNDERVOLT	EPDC-01	MAIN BUS UNDERVOLT (H)
004	V61P2405A	CABIN PRESS	ECL-04, 05	CABIN ATM (H)
005	V72X7011E	GPC 1 FAIL INDICATOR	DPS-02, RSLS-01	GPC
006	V42P1115C	RCS FWD OX TANK ULLAGE PRESS	RCS-02	FWD RCS (HPB)
007	V43P4221C	OMS-L POD OXDZR TANK ULLAGE PRESS	OMS-05	LEFT OMS (HPB)
008	V46T0142A	APU 1 TURBINE EXHAUST TEMP NO 1	-	APU TEMP (H)
009	V41P1150C	MPS E1 HE SUPPLY BOTTLE PRESS	MPS-01	MPS (H)
010	V45P1210A	PRSD O2 TK 2 HTR CONTROL PRESS	PRSD-01	O2 PRESS (H)
011	V45T1109A	PRSD O2 TK 1 HTR ASSY 2 TEMP	PRSD-01, 04	O2 HTR TEMP (H)
012	V45X2150E	PRSD FCP 1 H2 REAC VLV - OPEN	PRSD-03	FUEL CELL REAC (H)
013	V76V0201A	MAIN BUS B UNDERVOLT	EPDC-01	MAIN BUS UNDERVOLT (H)
014	V61R2105A	SYS 1 O2 FLOWRATE	ECL-04, 05, 06	CABIN ATM (H)
015	V72X7012E	GPC 2 FAIL INDICATOR	DPS-02, RSLS-01	GPC
016	V42P1116C	RCS FWD FU TANK ULLAGE PRESS	RCS-02	FWD RCS (HPB)
017	V43P4321C	OMS-L POD FUEL TANK ULLAGE PRESS	OMS-05	LEFT OMS (HPB)
018	V46T0242A	APU 2 TURBINE EXHAUST TEMP NO 1	-	APU TEMP (H)
019	V41P1250C	MPS E2 HE SUPPLY BOTTLE PRESS	MPS-01	MPS (H)
020	V45P1310A	PRSD O2 TK 3 HTR CONT PRESS (MBK)	PRSD-01	O2 PRESS (H)
021	V45T1207A	PRSD O2 TK 2 HTR ASSY 1 TEMP	PRSD-01, 04	O2 HTR TEMP (H)
022	V45X1155E	PRSD FCP 2 O2 REAC VLV - OPEN	PRSD-03	FUEL CELL REAC (H)
023	V76V0301A	MAIN BUS C UNDERVOLT	EPDC-01	MAIN BUS UNDERVOLT (H)
024	V61R2205A	SYS 2 O2 FLOWRATE	ECL-04, 05, 06	CABIN ATM (H)
025	V72X7013E	GPC 3 FAIL INDICATOR	DPS-02, RSLS-01	GPC
026	V72X6035X	FWD RCS LEAK DET (DPS)	RCS-02	FWD RCS (HPB)
027	V72X4547X	OMS-L ENG ABNORMAL (DPS)	OMS-14	LEFT OMS (HPB)
028	V46T0342A	APU 3 TURBINE EXHAUST TEMP NO 1	-	APU TEMP (H)
029	V41P1350C	MPS E3 HE SUPPLY BOTTLE PRESS	MPS-01	MPS (H)
030	V45P1410A	PRSD O2 TK 4(&5) HTR CONT PRESS	PRSD-01	O2 PRESS (H)
031	V45T1209A	PRSD O2 TK 2 HTR ASSY 2 TEMP	PRSD-01, 04	O2 HTR TEMP (H)
032	V45X2155E	PRSD FCP 2 H2 REAC VLV - OPEN	PRSD-03	FUEL CELL REAC (H)
033	V76X1505E	INVERTER BUS NO 1 O/V-U/V	EPDC-03	AC VOLTAGE (H)
034	V61P2511A	O2 PARTIAL PRESSURE - A	ECL-06	CABIN ATM (H)
035	V72X7014E	GPC 4 FAIL INDICATOR	DPS-02, RSLS-01	GPC
036	V42P2115C	RCS L AFT OX TANK ULLAGE PRESS	RCS-02	LEFT RCS (HPB)
037	V43P5221C	OMS-R POD OXDZR TANK ULLAGE PRESS	OMS-05	RIGHT OMS (HPB)
038	V46T0150A	APU 1 GEARBOX LUBE OIL RETURN TEMP	APU-08	APU TEMP (H)
039	V41P1154A	MPS E1 REG A HE OUTLET PRESS	MPS-03	MPS (H)
040	V45P1510A	PRSD O2 TK 5 HTR CONT PRESS	PRSD-01	O2 PRESS (H)
041	V45T1307A	PRSD O2 TK 3 HTR ASSY 1 TEMP (MBK)	PRSD-01, 04	O2 HTR TEMP (H)
042	V45X1160E	PRSD FCP 3 O2 REAC VLV - OPEN	PRSD-03	FUEL CELL REAC (H)
043	V76X1605E	INVERTER BUS NO 2 O/V-U/V	EPDC-03	AC VOLTAGE (H)
044	V61P2513A	O2 PARTIAL PRESSURE - B	ECL-06	CABIN ATM (H)
045	V72X7015E	GPC 5 FAIL INDICATOR	BFS-04, 08	GPC
046	V42P2116C	RCS L AFT FU TANK ULLAGE PRESS	RCS-02	LEFT RCS (HPB)

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B - C&W light is illuminated by BFS, only. No PASS interface.
PB - C&W light is illuminated by PASS S/W pre-engage, BFS S/W post-engage.
HPB - C&W light is illuminated by either Hardware or PASS inputs pre-engage, Hardware or BFS inputs post-engage.

Figure E-02 Caution and Warnings Listed by Channel

CH	MSID	Nomenclature	LCC Reference	C & W Light
047	V43P5321C	OMS-R POD FU TANK ULLAGE PRESS	OMS-05	RIGHT OMS (HPB)
048	V46T0250A	APU 2 GEARBOX LUBE OIL RETURN TEMP	APU-08	APU TEMP (H)
049	V41P1254A	MPS E2 REG A HE OUTLET PRESS	MPS-03	MPS (H)
050	V45P2110A	PRSD H2 TK 1 HTR CONTROL PRESS	PRSD-06	H2 PRESS (H)
051	V45T1309A	PRSD O2 TK 3 HTR ASSY 2 TEMP (MBK)	PRSD-01, 04	O2 HTR TEMP (H)
052	V45X2160E	PRSD FCP 3 H2 REAC VLV - OPEN	PRSD-03	FUEL CELL REAC (H)
053	V76X1705E	INVERTER BUS NO 3 O/V-U/V	EPDC-03	AC VOLTAGE (H)
054	V61R2553A	SYS 1 N2 FLOWRATE	ECL-02, 03	CABIN ATM (H)
055	P01X5025E	PL DIR-TO-CWE HARDWIRE C&W INPUT 1	-	PAYLOAD WARNING (H)
056	V72X6036X	LEFT RCS LEAK DET (DPS)	RCS-02	LEFT RCS (HPB)
057	V72X4548X	OMS-R ENG ABNORMAL (DPS)	OMS-14	RIGHT OMS (HPB)
058	V46T0350A	APU 3 GEARBOX LUBE OIL RETURN TEMP	APU-08	APU TEMP (H)
059	V41P1354A	MPS E3 REG A HE OUTLET PRESS	MPS-03	MPS (H)
060	V45P2210A	PRSD H2 TK 2 HTR CONTROL PRESS	PRSD-06	H2 PRESS (H)
061	V45T1407A	PRSD O2 TK 4 HTR ASSY 1 TEMP (MBK)	PRSD-01, 04	O2 HTR TEMP (H)
062	V45T0120A	FUEL CELL NO 1 STACK COOL OUT TEMP	FCP-02	FUEL CELL STACK TEMP (H)
063	V76X1506E	AC BUS 1 OVERLOAD	EPDC-04	AC OVERLOAD (H)
064	V61R2554A	SYS 2 N2 FLOWRATE	ECL-02, 03	CABIN ATM (H)
065	P01X5026E	PL DIR-TO-CWE HARDWIRE C&W INPUT 2	-	PAYLOAD WARNING (H)
066	V42P3115C	RCS R AFT OX TANK ULLAGE PRESS	RCS-02	RIGHT RCS (HPB)
067	V72X4546X	OMS-TVC FAIL (DPS)	GNC-44	OMS TVC (PB)
068	V46X0165E	APU 1 TURBINE OVERSPEED	APU-06	APU OVERSPEED (H)
069	V41P1533C	MPS LO2 17IN FEED MANF DISC PRESS	-	MPS (H)
070	V45P2310A	PRSD H2 TK 3 HTR CONT PRESS (MBK)	PRSD-06	H2 PRESS (H)
071	V45T1409A	PRSD O2 TK 4 HTR ASSY 2 TEMP (MBK)	PRSD-01, 04	O2 HTR TEMP (H)
072	V45T0220A	FUEL CELL NO 2 STACK COOL OUT TEMP	FCP-02	FUEL CELL STACK TEMP (H)
073	V76X1606E	AC BUS 2 OVERLOAD	EPDC-04	AC OVERLOAD (H)
074	V61P2556A	CABIN FAN DELTA PRESS	ECL-07	AV BAY/CABIN AIR (H)
075	P01X5027E	PL DIR-TO-CWE HARDWIRE C&W INPUT 3	-	PAYLOAD WARNING (H)
076	V42P3116C	RCS R AFT FU TANK ULLAGE PRESS	RCS-02	RIGHT RCS (HPB)
077	V43P6221C	OMS KIT OXID TK ULL	-	OMS KIT
078	V46X0265E	APU 2 TURBINE OVERSPEED	APU-06	APU OVERSPEED (H)
079	V41P1433C	MPS LH2 17IN FEED MANF DISC PRESS	-	MPS (H)
080	V45P2410A	PRSD H2 TK 4(&5) HTR CONT PRESS	PRSD-06	H2 PRESS (H)
081	V45T1507A	PRSD O2 TK 5 HTR ASSY 1 TEMP (MBK)	PRSD-01, 04	O2 HTR TEMP (H)
082	V45T0320A	FUEL CELL NO 3 STACK COOL OUT TEMP	FCP-02	FUEL CELL STACK TEMP (H)
083	V76X1706E	AC BUS 3 OVERLOAD	EPDC-04	AC OVERLOAD (H)
084	V61T2645A	AVNS BAY 1 OUTLET AIR TEMP	ECL-10	AV BAY/CABIN AIR (H)
085	P01X5028E	PL DIR-TO-CWE HARDWIRE C&W INPUT 4	-	PAYLOAD WARNING (H)
086	V72X6037X	RIGHT RCS LEAK DET (DPS)	RCS-02	RIGHT RCS (HPB)
087	V43P6321C	OMS KIT FUEL TK ULL	-	OMS KIT
088	V46X0365E	APU 3 TURBINE OVERSPEED	APU-06	APU OVERSPEED (H)
089				SPARE
090	V45P2510A	PRSD H2 TK 5 HTR CONT PRESS	PRSD-06	H2 PRESS (H)
091	V72X4580X	NAVIGATION SENSOR FAILURE	GNC-73, 74, 75	AIR DATA (P)
092	V45X0143E	FUEL CELL NO 1 COOLANT PUMP STATUS	FCP-04	FUEL CELL PUMP (H)
093	V72X4590X	GYRO/ACCELEROMETER FAILURE	GNC-11, 12, 13	RGA/ACCEL (P)

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HPB - C&W light is illuminated by either Hardware or PASS inputs pre-engage, Hardware or BFS inputs post-engage.

Figure E-02 Caution and Warnings Listed by Channel

CH	MSID	Nomenclature	LCC Reference	C & W Light
094	V61T2650A	AVNS BAY 2 OUTLET AIR TEMP	ECL-10	AV BAY/CABIN AIR (H)
095	P01X5029E	PL DIR-TO-CWE HARDWIRE C&W INPUT 5	-	PAYLOAD WARNING (H)
096	V72X4545X	RCS FAIL	GNC-45, RCS-08	RCS JET (PB)
097	V72X0001Y	GPC-PAYLOAD CAUTION	-	PAYLOAD CAUTION (B)
098	V46X0166E	APU 1 TURBINE UNDERSPEED	APU-06	APU UNDERSPEED (H)
099	V58P0114C	HYDR SYS 1 SUPPLY PRESS A	HYD-02	HYD PRESS (H)
100	V72X4575X	LEFT RHC FAILURE	GNC-01	LEFT RHC (P)
101	V72X4555X	FLIGHT CONTROL SYSTEM SATURATE	GNC-22, 23,24	FCS SATURATION (PB)
102	V45X0243E	FUEL CELL NO 2 COOLANT PUMP STATUS	FCP-04	FUEL CELL PUMP (H)
103	V72X4560X	IMU FAILURE	GNC-60	IMU (P)
104	V61T2661A	AVNS BAY 3 OUTLET AIR TEMP	ECL-10	AV BAY/CABIN AIR (H)
105	V61P2600A	H2O LOOP 1 PUMP OUTLET PRESS	ECL-09	H2O LOOP (H)
106	V63R1100A	FCL 1 INTERCHANGER FLOWRATE	ECL-40	FREON LOOP (H)
107	V63T1207A	FCL 1 EVAP OUT TEMP	ECL-43	FREON LOOP (H)
108	V46X0266E	APU 2 TURBINE UNDERSPEED	APU-06	APU UNDERSPEED (H)
109	V58P0214C	HYDR SYS 2 SUPPLY PRESS A	HYD-02	HYD PRESS (H)
110	V72X4570X	RIGHT RHC FAILURE	GNC-01	RIGHT/AFT RHC (P)
111	V72X4550X	FLIGHT CONTROL CHANNEL FAILURE	GNC-38	FCS CHANNEL (PB)
112	V45X0343E	FUEL CELL NO 3 COOLANT PUMP STATUS	FCP-04	FUEL CELL PUMP (H)
113				SPARE
114	V61T2635A	CABIN HX OUT-AIR TEMP	ECL-07	AV BAY/CABIN AIR (H)
115	V61P2700A	H2O LOOP 2 PUMP OUTLET PRESS	ECL-09	H2O LOOP (H)
116	V63R1300A	FCL 2 INTERCHANGER FLOWRATE	ECL-40	FREON LOOP (H)
117	V63T1407A	FCL 2 EVAP OUT TEMP	ECL-43	FREON LOOP (H)
118	V46X0366E	APU 3 TURBINE UNDERSPEED	APU-06	APU UNDERSPEED (H)
119	V58P0314C	HYDR SYS 3 SUPPLY PRESS A	HYD-02	HYD PRESS (H)

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PB - C&W light is illuminated by PASS S/W pre-engage, BFS S/W post-engage.
HPB - C&W light is illuminated by either Hardware or PASS inputs pre-engage, Hardware or BFS inputs post-engage.

Figure E-02 Caution and Warnings Listed by Channel

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APPENDIX F

ICE LAUNCH COMMIT CRITERIA

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APPENDIX F: ICE LAUNCH COMMIT CRITERIA

SSID No.	Description/Violation Call	Page
ICE-01	Pre-Launch Debris and ET TPS Damage/Defects	F-01.1
ICE-02	Wind Factors and Thermal Model Parameters (REQUIREMENT DELETED)	F-02.1
ICE-03	Nomograph Charts (REQUIREMENT DELETED)	F-03.1
ICE-04	Cryogenic Propellant Visual Leakage Anomaly	F-04.1
ICE-FG01	Figure F-01 Ice Area Limits On External Tank (REQUIREMENT DELETED)	F-FG01.1
ICE-FG02	Figure F-02 Minimum ET Nose Cone Compartment Temperature Without Precipitation (REQUIREMENT DELETED)	F-FG02.1
ICE-FG03	Figure F-03 Minimum ET Nose Cone Compartment Temperature With Precipitation (REQUIREMENT DELETED)	F-FG03.1
ICE-FG04	Figure F-04 Ice Inspection Criteria (REQUIREMENT DELETED)	F-FG04.1

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LCC VIOLATION CALL: Pre-Launch Debris and ET TPS Damage/Defects | EMERG COND: None

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
N/A	Observed Debris/Potential Debris		N/A	(2)	N/A	CI
N/A	Observed ET TPS Defects/Damage		N/A	(3)	N/A	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (approximately T-6 hours) to Go for RSLS Start (T-31 seconds).

REQUIREMENTS: FIGURES/TABLES:

(2) Observed debris or potential debris conditions on the Space Shuttle Vehicle (SSV) and Launch Pad Facility that do not meet the applicable acceptance criteria contained in NSTS 08303 is unacceptable, LCC violation confirmed, No Go for launch.

(3) Observed ET Thermal Protection System (TPS) defect/damage conditions that either have not been previously documented on the flight tank and subsequently accepted for flight, or do not meet the applicable acceptance criteria contained in NSTS 08303 are unacceptable, LCC violation confirmed, No Go for launch.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(4) Ice on or around the SSV is a form of debris or potential debris.

REDLINE DERIVATION: CRITICALITY: 1S

(5) a. SSID Intent Summary - This SSID prevents launch if debris, potential debris or ET TPS defects/damage are detected during the prelaunch LCC time frame unless the debris or ET TPS defect/damage condition meets predefined limitations approved by the Program and documented in NSTS 08303. ET TPS defect/damage conditions that have been previously documented and approved for flight are acceptable.

b. Voting Logic - N/A

c. Maximum Redline Derivation - See Requirements subparagraph below.

d. Time Period - Due to the dynamics of cryo loading, terminal count final tank pressurization and SSV/Launch Pad configuration changes during terminal count, these conditions must be continually monitored from T-6 hrs and counting and must terminate at T-31 seconds and counting in order to allow Ice/Final Inspection Team assessment of ET Nose Cone for possible ice formation following Gaseous Oxygen Vent Hood retract.

e. Requirements - Any debris or ET TPS defect/damage condition that does not meet the acceptance criteria contained within NSTS 08303 represents a threat to the Vehicle and Crew that either has not been assessed or the Program has not accepted the associated risk for flight.

f. Preplanned Contingency Procedures - N/A

CONSEQUENCES OF EXCEEDING REDLINE:

(6) a. Debris impact damage to the SSV elements during liftoff or ascent that could result in unacceptable damage to the SSV.
b. ET TPS pre-launch defects/damage could have unacceptable aerodynamic, thermal or structural effects on the ET and could produce debris (see subparagraph (a) above).

CAUSES OF EXCEEDING REDLINE:

(7) Unexpected ET TPS defects due to cryogenic loading induced stresses or damage due to environmental damage (hail, wildlife activity, etc).
(8) Severe environmental conditions that promote ice formation growth in excess of that which has been determined to be acceptable for flight.
(9) The presence of unexpected debris or potential debris on the SSV/Launch Pad Facility which exceeds the NSTS 08303 acceptance criteria for that type of debris or for which no acceptance criteria exists in NSTS 08303.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO	SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO	SHEET	ZONE

ELEMENT: Launch and Landing SUBSYSTEM: ICE/FIT

Wind Factors and Thermal Model Parameters

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Nomograph Charts

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LCC VIOLATION CALL: Cryogenic Propellant Visual Leakage Anomaly | EMERG COND: Yellow (6)

MEAS. NO.	MEASUREMENT DESCRIPTION	CAT.	MINIMUM	MAXIMUM	UNITS	CODE
	Monitored Locations/Components					
N/A	LH2 ET/ORB Umbilical		N/A	(2)	N/A	CI
N/A	LH2 ET 17 Inch Feedline		N/A	(2)	N/A	CI
N/A	LH2 ET Recirc Line		N/A	(2)	N/A	CI
N/A	LH2 ET Aft Dome Manhole Covers		N/A	(2)	N/A	CI
N/A	LH2 ET Ground Umbilical		N/A	(2)	N/A	CI
N/A	LH2 T-0 Umbilical		N/A	(2)	N/A	CI
N/A	LO2 ET/ORB Umbilical		N/A	(2)	N/A	CI
N/A	LO2 ET 17 Inch Feedline		N/A	(2)	N/A	CI
N/A	LO2 T-0 Umbilical		N/A	(2)	N/A	CI

TIME PERIOD:

(1) From Start of ET Cryo Tanking (approximately T-6 hours) to Go for RSLS Start (T-31 seconds)

REQUIREMENTS: FIGURES/TABLES:

(2) The locations/components listed above shall be monitored periodically by Ice/Final Inspection Team personnel (as allowed by team resources), via OTV coverage and directly, during the T-3 hour Hold for evidence of cryogenic propellant leakage. Indications consistent with the characteristics of liquid (cryogenic) air produced by thermal shorts will not constrain launch if no other evidence supports the presence of cryogenic propellant leakage at that location. If cryogenic propellant leakage is observed, LCC violation confirmed, No Go for Launch.

Unplanned and/or unrecoverable loss of monitoring will not constrain launch provided last observation of unmonitorable location/component was nominal.

PREPLANNED CONTINGENCY PROCEDURE:

NOTES:

(3) Evaluation of visual observations for the determination of the presence of cryogenic propellant leakage requires both training and extensive experience in nominal and off nominal indications. The Ice/Final Inspection Team personnel are uniquely qualified and trained in this respect.

(4) The following locations/components are also monitored per the listed HAZ SSIDs:

- LH2 ET/ORB Umbilical - HAZ-12
- LH2 ET Ground Umbilical - HAZ-09
- LH2 T-0 Umbilical - HAZ-10, HAZ-11

REDLINE DERIVATION: CRITICALITY: 1S

(5) Ice/Final Inspection Team ability to identify cryogenic propellant leakage is based on both 1) training using historical OTV recordings of cryogenic propellant operations, including recordings of both suspected and verified cryogenic leakage, and 2) test stand footage of cryogenic Hydrogen leakage.

CONSEQUENCES OF EXCEEDING REDLINE:

(6) Unacceptable Hydrogen/Oxygen concentrations in the vicinity of leakage may result in increased risk of fire/explosion.

CAUSES OF EXCEEDING REDLINE:

(7) Cryogenic propellant leakage.

SPACE SHUTTLE SYSTEMS HANDBOOK:	DWG NO		SHEET	ZONE
INTEGRATED SYSTEMS SCHEMATIC:	DWG NO		SHEET	ZONE

ELEMENT: Launch and Landing SUBSYSTEM: ICE/FIT

Figure F-01 Ice Area Limits On External Tank

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Figure F-02 Minimum ET Nose Cone Compartment Temperature Without Precipitation

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Figure F-03 Minimum ET Nose Cone Compartment Temperature With Precipitation

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Figure F-04 Ice Inspection Criteria

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APPENDIX G

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APPENDIX G: RESERVED

SSID No.	Description/Violation Call	Page

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APPENDIX H

MINIMUM EQUIPMENT LIST

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APPENDIX H: MINIMUM EQUIPMENT LIST

SSID No.	Description/Violation Call	Page
MEL-01	LCC Minimum Equipment List Assumptions and Guidelines	H-01.1
MEL-02	Equipment Exceptions - All Missions	H-02.1
MEL-03	Equipment Exceptions - Mission Specific	H-03.1
MEL-04	GNC Minimum Equipment List	H-04.1
MEL-05	OMS/RCS Minimum Equipment List	H-05.1
MEL-06	SSME/MPS Minimum Equipment List	H-06.1
MEL-07	EPDC Minimum Equipment List	H-07.1
MEL-08	Life Support Systems Minimum Equipment List	H-08.1
MEL-09	APU/HYD, Airframe and PDRS Systems Minimum Equipment List	H-09.1
MEL-10	DPS Minimum Equipment List	H-10.1
MEL-11	INCO Minimum Equipment List	H-11.1
MEL-12	Crew Worn Equipment Minimum Equipment List	H-12.1
MEL-13(124)	Minimum Equipment List STS-124 Mission Specific Exceptions	H-13(124).1
MEL-13(125)	Minimum Equipment List STS-125 Mission Specific Exceptions	H-13(125).1
MEL-13(126)	Minimum Equipment List STS-126 Mission Specific Exceptions	H-13(126).1
MEL-13(400)	Minimum Equipment List STS-400 Mission Specific Exceptions	H-13(400).1

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LCC Minimum Equipment List Assumptions and Guidelines

Assumptions

A. A majority of system components are not monitorable during the period the LCC applies. Their performance or status is covered by OMRSD requirements which, at this time, do not accept any failure condition except by explicit waiver. Some of these items (e.g., OMS, RCS helium secondary regulators) are only checked every five flights. Regardless of the minimum set of LRUs finally agreed to, the OMRSD and inflight checkout requirements will remain as is (i.e., any deviation from normal operating limits must be reported and, if accepted, waived) and any change from a full LRU set must be formally waived based on the conditions at that time.

B. Redundancy Management software in the PASS for OPS 1 (ascent) and OPS 6 (RTLS), and in the BFS for all OPS modes is the limiting element in use of the available flight control system LRU redundancy.

C. Night landing and secure flights will impose more restrictive requirements on certain LRUs (MLS, HUD, Ku-Band, COMSEC, TAGS) making the minimum equipment list mission dependent.

D. The SSMEs and their associated MPS systems are designed to allow the occurrence of one failure during ascent without causing an engine shutdown and the resulting mission abort. The one exception to this criteria is the failure of an SSME as an LRU which would cause an abort. This design criteria will be maintained.

E. For the purposes of this listing, any LRU included is considered in its functional sense. It includes all electrical and/or mechanical peripheral equipment necessary to carry out its functions. Where redundancy (e.g., power supplies, input/output ports) is designed in, it is required except where explicitly excluded.

F. Onboard crew control and display functions (e.g., switches, meters, CRT) are required except as noted.

G. The worst case failure mode of the LRU and its attendant effects will be assumed unless demonstrated otherwise.

Guidelines

A. Failures that reduce the capability of a system to fail safe are unacceptable.

B. Failures that would result in a launch day deorbit will not be acceptable.

C. Failures which would result in a minimum duration flight or next PLS entry case will not be acceptable.

D. Failures which would result in a mandatory EVA to establish an acceptable entry configuration will not be acceptable.

E. Failures which would require a mandatory crew action not part of the normal procedures during a critical period to effect a safe ascent or entry will not be acceptable.

F. System capability will be retained to sustain a second failure, other than in the system causing the abort, and successfully perform all phases of the recognized abort cases (RTLS, TAL, AOA, ATO).

G. Where the program has mandated a fail ops/fail safe requirement, LRU failures which would violate it will not be acceptable.

H. IFM (inflight maintenance) cannot be relied on for restoration of required capability.

I. Loss of significant system monitoring capability impacting inflight or postflight troubleshooting or trend analysis is unacceptable.

J. Loss of Emergency system (e.g., fire/smoke) functional capability is unacceptable.

K. Proximity and rendezvous operations may result in higher redundancy requirements than normal operations; where the primary mission involves such operations, the capability must be maintained. For example, aft station control/monitor devices (RHC, THC, AFD1, IDP/CRT4, aft keyboard) are considered mission success only, and their criticality is a function of the flight manifest.

L. Failures impacting primary mission objectives will not be acceptable. However, simple IFM procedures can be used for restoration of mission success related capabilities, so long as an unplanned EVA is not involved.

M. The TDRS era and phasing out of the STDN will result in more restrictive requirements in the communications area. For example, we can provide

Guidelines (Concluded)

satisfactory communications without the S-band power amplifiers with the STDN but not with the TDRS; Ku-band is required for payload operations but not Orbiter operations with TDRS, etc.

N. Failed components that result in a substantial increase in the system management workload (e.g., comm failures prohibiting ground control) are not acceptable.

O. Vernier RCS will be addressed on a case by case basis based on the propellant consumption penalty, compromised attitude control and payload operations impact to the particular flight.

P. Certain heater requirements and the associated instrumentation are a function of flight duration and attitude plan and must be addressed on a case by case basis.

Q. While it is theoretically possible to accept leakage based on mission duration, liquid leaks in excess of specification are not acceptable; gas or vapor leaks other than hydrogen may be acceptable but only on a case by case review basis and assuming that a total loss of the particular leaking fluid will not require a contingency or emergency deorbit.

R. Failures of two or more like LRUs must be clearly understood before committing to launch, even if those failures would be acceptable individually as outlined in the table.

S. A list of required mission dependent equipment will be presented at the Flight Operations Review (FOR) and summarized for the SSP Director at the appropriate time.

NOTES: The "GDLINE REF" designations in the tabular data to follow, relates to specific paragraphs on pages H-06 and H-07.

Where applicable, LCC page number references have been replaced with subsystem identifiers (SSIDs); i.e., GNC-XX.

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EQUIPMENT EXCEPTIONS - ALL MISSIONS

LRU/FUNCTION	REQ'T	SSID	MEL REF	NOTES
GNC				
IMU RPC	5 of 6	None	MEL-04	
MLS	2* of 3	None	MEL-04	*3 of 3 required if one RA failed.
STAR TRKR DOOR MTRS	3 of 4	AFM-02	MEL-04	
FWD THC +/-Y CNTCTS	2 of 3	GNC-02	MEL-04	
L SBTC	0 of 3		MEL-04	
L,R OMS TVC (P/Y)	4* of 4	GNC-43	MEL-04	*Can launch if TVC OK on last flight of this pod.
FWD,AFT DAP SEL A(B)	2 of 3*	None	MEL-04	*Each switch.
FWD,AFT ROT ROLL DISC	2 of 2*	None	MEL-04	*Either switch.
FWD,AFT ROT ROLL PULSE	2 of 2*	None	MEL-04	*Either switch.
FWD,AFT ROT PITCH DISC	2 of 2*	None	MEL-04	*Either switch.
FWD,AFT ROT PITCH PULSE	2 of 2*	None	MEL-04	*Either switch.
FWD,AFT ROT YAW DISC	2 of 2*	None	MEL-04	*Either switch.
FWD,AFT ROT YAW PULSE	2 of 2*	None	MEL-04	*Either switch.
FWD,AFT DAP CNTL AUTO	2 of 3*	None	MEL-04	*Each switch.
FWD,AFT DAP CNTL INRTL	2 of 3*	None	MEL-04	*Each switch.
FWD,AFT DAP CNTL FREE	1 of 3	None	MEL-09	*Each switch.
FWD,AFT RCS JETS VERN	2 of 2*	None	MEL-04	*Each switch.
L,R BDYFLP AUTO/MAN	5 of 6	None	MEL-04	
L,R PITCH AUTO MODE	5 of 6	None	MEL-04	
L,R PITCH CSS MODE	3 of 3*	None	MEL-04	*Either switch.
L,R R/Y AUTO MODE	5 of 6	None	MEL-04	
L,R R/Y CSS MODE	3 of 3*	None	MEL-04	*Either switch.
L,R SPDBK/THROT AUTO/MAN	3 of 3*	None	MEL-04	*Either switch.
SENSE SWITCH -Z	0 of 3	None	MEL-04	Default is -Z.
ENTRY MODE LO GAIN	2 of 4	None	MEL-04	
ENTRY MODE NO Y JET	2 of 4	None	MEL-04	
L,R RHC PITCH TRIM +/-	4 of 4*	None	MEL-04	*Either switch.
L,R RHC ROLL TRIM +/-	4 of 4*	None	MEL-04	*Either switch.
L,R PITCH TRIM +/-	4 of 4*	None	MEL-04	*Either switch.
L,R ROLL TRIM +/-	4 of 4*	None	MEL-04	*Either switch.
L,R YAW TRIM +/-	4 of 4*	None	MEL-04	*Either switch.
L,R,A DISPLAY SW	0 of 1	None	MEL-04	
FCS CHANNEL OVERRIDE	0 of 3	None	MEL-04	

EQUIPMENT EXCEPTIONS - ALL MISSIONS

LRU/FUNCTION	REQ'T	SSID	MEL REF	NOTES
EPDC				
FUEL CELL PURGE	2 of 3	FCP-01	MEL-07	
AV BAY SMOKE DET	1 of 2/ BAY	ECL-32	MEL-07	Emergency system.
CABIN SMOKE DET	2 of 3	ECL-31	MEL-07	Emergency system.
LIFE SUPPORT				
CRYO 02,H2 CNTLRS (WITH CNTL PRESS XDCR)	1 of 2/ Tk Pair	PRSD-01 PRSD-06	MEL-08	
CRYO 02 HTR STRINGS	1 of 2/ Tank & 4 mini- mum	PRSD-01	MEL-08	
02 HTR TRIP SNSR	1 of 2/ req htr string	PRSD-04	MEL-08	
CRYO H2 HTR	1 of 2/ Tank	PRSD-06	MEL-08	
02,H2 MANF VALVES	* of 2	PRSD-02	MEL-08	*2 of 2 valves required for two tank set case. *1 of 2 valves required for cryo leak isolation.
H20 LOOP 1 PUMPS	1 of 2	ECL-08 ECL-09	MEL-08	Two operational H2O loops required.
AV BAY FANS	5 of 6	ECL-10	MEL-08	
IMU FANS	2 of 3	ECL-11	MEL-08	
HUMIDITY SEPS	1 of 2	None	MEL-08	
O2/N2 CNTL VLVS	1 of 2	None	MEL-08	
O2 XOVER VLV	2 of 2	None	MEL-08	
FES CNTLRS	2 of 3	None	MEL-08	
FES ACCUM	1 of 2	ECL-45	MEL-08	
TPG DUCT HTRS	2 of 3	ECL-46	MEL-08	
HI LD DUCT HTRS	2 of 3	ECL-47	MEL-08	
FES H20 FEEDLINE HTR SETS	1 of 2/ FDLN	ECL-48	MEL-08	
FREON PUMPS	3 of 4	ECL-40 ECL-41	MEL-08	
NH3 BOILER CNTLR	1 of 2/ SYS	None	MEL-08	
RAD FLOW CNTLR	1 of 2/ ASSY	None	MEL-08	
WATER TANKS B,C,D*	2 of 3 or 3 of 3**	ECL-20	MEL-08	*No External Leaks. **57 deg launch.

EQUIPMENT EXCEPTIONS - ALL MISSIONS

LRU/FUNCTION	REQ'T	SSID	MEL REF	NOTES
MMACS				
APU FUEL TANK HTRS	0 of 2/ TANK	None	MEL-09	
GG BED HTRS	1 of 2/ SYS	APU-04	MEL-09	
OIL LINE HTRS	1 of 2/ SYS	APU-09	MEL-09	
GG INJ TK/LN HTRS	1 of 2/ SYS	APU-19	MEL-09	
WSB VENT HTRS	1 of 2/ SYS	None	MEL-09	
MPS/TVC ISOL VLVS	2 of 3	None	MEL-09	
SSME ACCUMULATOR	0 of 3	None	MEL-09	
HYD HEATERS	0 of 11	None	MEL-09	
FREON/HYD HX CNTL VLV	0 of 1/ SYS	None	MEL-09	
ET UMB PLATE RETR ACTRS	2 of 3/ SYS	None	MEL-09	
VENT DOOR MOTORS	1 of 2/ DOOR	RSLS-01 AFM-30	MEL-09	
NLG NO WOW PROX SENSORS	0 of 2	None	MEL-09	
NOSE WHEEL STEERING	1 of 2	GNC-83	MEL-09	
AVIONICS CHANNELS		GNC-84		
PLBD PNL SWITCH & tb	0 of 1	None	MEL-09	
PRLA tb	0 of 5	None	MEL-09	
Pnl F6, F8 LDG tb	0 of 6	None	MEL-09	
DPS				
MTU ACCUM	2 of 3	DPS-10 DPS-16 BFS-03	MEL-10	GPCs must be on one of MTU accumulators.
INCO				
S-BND SW BEAM CNTL ASSY	1 of 2	None	MEL-11	
GCIL	1 of 2	CT-05	MEL-11	
COM SEC	0* of 2	None	MEL-11	*NASA Mission
OPS RCDRS	1 of 2	INS-02	MEL-11	IFM available
S-BND FM SYSTEM	0 of 2	None	MEL-11	
UHF (296.8, 259.7)	1 of 2	CT-05	MEL-11	Landing site voice.
MADS	0 of 1	None	MEL-11	

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EQUIPMENT EXCEPTIONS - MISSION SPECIFIC - STS-XXX

LRU/FUNCTION	REQ'T	SSID	MEL REF	NOTES
GNC				
RA	1* of 2	DPS-17 BFS-08	MEL-04	*2 of 2 for night landings.
AFT RHC XDCRS	0* of 3/ AXIS		MEL-04	*3 of 3 Rndz/Prox Ops.
AFT THC CNTCTS	0* of 3/ AXIS		MEL-04	*3 of 3 Rndz/Prox Ops.
AFT DDU	0* of 1	None	MEL-04	*1 of 1 Rndz/Prox Ops.
HUD	2 of 2*	None	MEL-04	*For night landings.
FWD,AFT DAP CONTL LVLH	0 of 4*	None	MEL-04	*4 of 6 Rndz/Prox Ops.
FWD,AFT ROTATION ALT	0 of 4*	None	MEL-04	*4 of 4 For A/L loads.
FWD,AFT TRANS X NORM	2 of 2*	None	MEL-04	*4 of 4 Rndz/Prox Ops.
FWD,AFT TRANS X PULSE	2 of 2*	None	MEL-04	*4 of 4 Rndz/Prox Ops.
FWD,AFT TRANS Y NORM	0 of 4*	None	MEL-04	*4 of 4 Rndz/Prox Ops.
FWD,AFT TRANS Y PULSE	0 of 4*	None	MEL-04	*4 of 4 Rndz/Prox Ops.
FWD,AFT TRANSL LO Z	0 of 4*	None	MEL-04	*4 of 4 Rndz/Prox Ops.
FWD,AFT TRANSL Z NORM	2 OF 2*	None	MEL-04	*4 of 4 Rndz/Prox Ops.
FWD,AFT TRANSL Z PULSE	2 OF 2*	None	MEL-04	*4 of 4 Rndz/Prox Ops.
FWD,AFT TRANSL Z HIGH	0 OF 4*	None	MEL-04	*4 of 4 Rndz/Prox Ops.
PROP				
AFT JET HTRS	24* of 24	RCS-06	MEL-05	*Mission dependent.
FWD JET HTRS	14* of 14	RCS-06	MEL-05	*Mission dependent.
AFT VERN JET HTRS	* of 4	RCS-07	MEL-05	*Mission dependent.
AFT VERN JETS	* of 4	RCS-07	MEL-05	*Mission dependent.
FWD VERN JET HTRS	* of 2	RCS-07	MEL-05	*Mission dependent.
FWD VERN JETS	* of 2	RCS-07	MEL-05	*Mission dependent.
VERN DRIVER	* of 1	GNC-46	MEL-05	*Mission dependent.
EPDC				
PL BAY FLOODLIGHTS	*	None	MEL-07	*Mission dependent.
CABIN LIGHTING	*	None	MEL-07	*Mission dependent.
ACA 4,5	*	None	MEL-07	*Mission dependent.
MMACS				
RADIATOR LTCH/PNL MTRS	* of 2/ LTCH and PNL	AFM-04 AFM-05	MEL-09	*Mission dependent. 2 of 2 for planned DPY, 1 of 2 if not planned.
PRLA MTRS	* of 2/ LATCH	PAY-01	MEL-09	*Mission dependent.
KU-BAND DEPLOY MTRS	* of 2	None	MEL-09	*Mission dependent.

EQUIPMENT EXCEPTIONS - MISSION SPECIFIC - STS-XXX

LRU/FUNCTION	REQ'T	SSID	MEL REF	NOTES
DPS				
AFT KYBD	* of 1	DPS-01a BFS-10a	MEL-10	*Mission dependent.
IDP4 (AFT)	* of 1	DPS-01a BFS-10a	MEL-10	*Mission dependent.
MDU AFD1	* of 1	DPS-01a BFS-10a	MEL-10	*1 of 1 Rndz/Prox Ops.
MDU CRT4	* of 1	DPS-01a BFS-10a	MEL-10	*Mission dependent.
INCO				
PL RCDR	0* of 1	None	MEL-11	*Mission dependent.
PI	* of 2	None	MEL-11	*Mission dependent.
PSP	* of 2	None	MEL-11	*Mission dependent.
PDI	* of 1	None	MEL-11	*Mission dependent.
TIPS	* of 1	None	MEL-11	*Mission dependent.
KU-BAND COMM/RADAR	* of 1	None	MEL-11	*Mission dependent.
CCTV SYSTEM				
A,B,C,D	4 of 4	None		
OTHERS	*	None	MEL-11	*Mission dependent.
MONITORS	1 of 2	None	MEL-11	

EQUIPMENT EXCEPTIONS - MISSION SPECIFIC - STS-XXX

LRU/FUNCTION	REQ'T	SSID	MEL REF	NOTES
PDRS				
SHOULDER BRACE RELEASE	*		MEL-09	*Mission dependent.
JETTISON SYS	2 of 2*		MEL-09	*If RMS deployed.
MPM MTRS	2* of 2		MEL-09	*Mission dependent.
MPM DPL/STOW CMD	SHLD*		MEL-09	*Mission dependent for safe configuration.
MRL MTRS	2* of 2		MEL-09	*Mission dependent.
THC AXIS CNTL	*		MEL-09	*Mission dependent.
RHC AXIS CNTL	*		MEL-09	*Mission dependent.
AUTO MODE	*		MEL-09	*Mission dependent.
OPR CMDED MODE	*		MEL-09	*Mission dependent.
MAN AUG MODE	*		MEL-09	*Mission dependent.
DIRECT MODE	*		MEL-09	*Mission dependent.
SINGLE MODE	*		MEL-09	*Mission dependent.
BACKUP MODE	*		MEL-09	*Mission dependent.
BRAKES	*		MEL-09	*Mission dependent.
AUTO BRAKES	*		MEL-09	*Mission dependent.
AUTO SAFING	*		MEL-09	*Mission dependent.
CAPTURE & RIGIDIZE	*		MEL-09	*Mission dependent.
DERIGIDIZE	*		MEL-09	*Mission dependent.
RELEASE	*		MEL-09	*Mission dependent.
BACKUP RELEASE	*		MEL-09	*Mission dependent.
HEATERS	*		MEL-09	*Mission dependent.

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GNC MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
GNC				
ALL FLIGHT CONTROL, SENSOR, NAVAID AND RELATED COMPONENTS, STRUCTURE, LINES, VALVES, FITTINGS, ACTUATORS, AND OTHER MECHANICAL AND ELECTRICAL DEVICES NECESSARY FOR FUNCTION OPERATION OF THE GUIDANCE, NAVIGATION AND CONTROL SYSTEMS ARE REQUIRED. ALL OF THE EQUIPMENTS SPECIFICALLY CONSIDERED ARE INCLUDED FOR COMPLETENESS. EXCEPTIONS TO LAUNCH COMMIT REQUIREMENTS ARE HIGHLIGHTED.				
ACCEL ASSY	4 of 4	GNC-09 GNC-13	f,g	
RGA	4 of 4	GNC-08 GNC-11 GNC-12	f,g	
IMU	3 of 3	DPS-12 DPS-13 GNC-56 GNC-58 GNC-59 GNC-60 GNC-61 GNC-62 GNC-63 GNC-64 GNC-65 GNC-66	c,f,g	
IMU RPC	5 of 6	GNC-57	g	Acceptable to launch with redundant input power lost to one IMU.
SRB RGA	2 of 2/ SRB	GNC-14 GNC-15 GNC-16	g	
TACAN	2* of 3	DPS-17 CT-01	c	*3 of 3 required if no high speed C-band for EOM. For OV-104, GPS 2 may be substituted for TACAN 2. Not applicable for OV-105.
GPS	2* of 3	CT-11 DPS-28	c	*3 of 3 required if no high Speed C-band for EOM. OV-105 only.
MSBLS	2* of 3	None	f	*3 of 3 required if one RA failed or if no high speed C-Band tracking scheduled for night EOM.

GNC MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
GNC (Continued)				
RA	1* of 2	DPS-17 CT-08	f,s	*2 of 2 required if one MSBLS failed. Used for independent altitude source at low altitudes.
ADTA	4 of 4	DPS-15 GNC-73 GNC-74 GNC-75	f,g	Default gains (no air data) may be difficult to fly; single ADTA data is not incorporated into GNC software per Flight Rules.
ADTA DPLY/STOW MTRS	4 of 4	AFM-15	f,g	Capability to deploy at least one probe must be two-fault tolerant.
STAR TRACKER	2 of 2	AFM-14	g	Alignment capability is fail safe with two Star Trackers until COAS is calibrated on orbit.
STAR TRKR DOOR MTRS	3 of 4			Capability to open and close at least one door must be one-fault tolerant.
ASA ELVN CHNL	4 of 4	GNC-38	c,f,g	
ASA RUD CHNL	4 of 4	GNC-38	c,f,g	
ASA SPBK CHNL	4 of 4	GNC-38	c,f,g	
ASA BF CHNL	3 of 3	GNC-29	c,f,g	
ASA POSN FDBK				
ELEVONS	4 of 4	GNC-22 GNC-25	f,g	3 of 4 required for instrumentation.
RUD/SPBK	4 of 4	GNC-26 GNC-28	g	3 of 4 required for instrumentation.
BODYFLAP	4 of 4	GNC-30 GNC-31	f,g	

GNC MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
GNC (Continued)				
ASA PRI DELTA P	4 of 4	GNC-27 GNC-23	g	Required for ascent load relief.
ASA SEC DELTA P	4 of 4	GNC-24	g	3 of 4 required for instrumentation.
L,R RHC XDCRS	3 of 3/ AXIS	GNC-01	f,g	
AFT RHC XDCRS	0* of 3/ AXIS	None	k,s	*Mission dependent (3 of 3 required for Rndz/Prox Ops).
FWD THC +/-X CNTCTS +/-Z CNTCTS +/-Y CNTCTS	3 of 3 3 of 3 2 of 3	GNC-02 GNC-02 GNC-02	f,g f,g f,g	Backup to auto -Z translation for ET Sep and OMS burns. Required to trim post OMS burn in-plane (X,Z) residuals.
AFT THC CNTCTS	0* of 3/ AXIS	None	k,s	*Mission dependent (3 of 3 required for Rndz/Prox Ops).
L(R) RPTA	3 of 3	GNC-03	g	
L SBTC	0 of 3	None		
R SBTC	3 of 3	GNC-04	f	Manual throttle required for system TAL aborts. MDM BITE TEST 4 required to verify limits (not on downlist).
R SBTC T/O	3 of 3	GNC-04	f	Same as for R SBTC.
ATVC CHNL	4 of 4	GNC-38	g	
ATVC SEC DELTA P	4 of 4	GNC-41	g	3 of 4 required for instrumentation.
SRB ACT CHNL	4 of 4	BTVC-11	g	

GNC MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
GNC (Continued)				
SRB SEC DELTA P	4 of 4	BTVC-12 BTVC-14	g	Full instrumentation is required since there is not time to verify an instrumentation failure and exercise workaround procedures.
L,R OMS TVC (P/Y)	4* of 4	GNC-44	f	*Will launch with one PRI or SEC actuator failed if "no-back" held on previous flight or is a new "no-back" and as long as single-fault tolerance for abort OMS dump capability is maintained.
L,R OMS POSN FDBK	4 of 4	GNC-43	f	Based on requirement to dump OMS for RTLS. Also used to maintain position during powered flight.
L,R DDU	1 of 1	GNC-85	g	All output power supplies (A-C) must be good.
AFT DDU	*0 of 1	None	k,l,s	*1 of 1 Rndz/Prox Ops.

GNC MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
GNC (Continued)				
L,R BDYFLAP UP (DN)	4 of 4*	None	f,g	*2 UP and 2 DN either switch. Maintains capability.
FWD,AFT DAP SEL A(B)	2 of 3*	None	l,n	*Each switch. Maintain one-fault tolerance.
FWD,AFT ROT ROLL DISC	2 of 2*	None	l,n	*Either switch. Maintain capability.
FWD,AFT ROT ROLL PULSE	2 of 2*	None	l,n	*Either switch. Maintain capability.
FWD,AFT ROT PITCH DISC	2 of 2*	None	l,n	*Either switch. Maintain capability.
FWD,AFT ROT PITCH PULSE	2 of 2	None	l,n	*Either switch. Maintain capability.
FWD,AFT ROT YAW DISC	2 of 2*	None	l,n	*Either switch. Maintain capability.
FWD,AFT ROT YAW PULSE	2 of 2*	None	l,n	*Either switch. Maintain capability.
FWD,AFT DAP CNTL AUTO	2 of 3*	None	l	*Each switch. Maintain one-fault tolerance.
FWD,AFT DAP CNTL INRTL	2 of 3*	None	l	*Each switch. Maintain capability. (Can downmode with RHC.)
FWD,AFT DAP CNTL LVLH	0 of 6*	None	l,s	*4 of 6 required on a mission dependent basis (Prox Ops).

GNC MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
GNC (Continued)				
FWD,AFT DAP CNTL FREE	2 of 3*	None		*Each switch. Maintain one-fault tolerance.
FWD,AFT RCS JETS PRI	2 of 2*	None	l	*Each switch. 0 of 4 required if 4 of 4 ALT pbi contacts available.
FWD,AFT ROTATION ALT	0 of 4*	None	l,s	*4 of 4 required on mission dependent basis (to maintain one-fault tolerance for payload load requirements).
FWD,AFT RCS JETS VERN	2 of 2*	None	l	*Each switch. Maintain one-fault tolerance.
FWD,AFT TRANS X NORM	2 of 2*	None	k,s	*Either switch. Maintain capability for backup to OMS. 4 of 4 required on mission dependent basis (to maintain one-fault tolerance for Rndz/Prox Ops).
FWD,AFT TRANS X PULSE	2 of 2*	None	k,s	*Either switch. 4 of 4 required on mission dependent basis (to maintain one-fault tolerance for Rndz/Prox Ops).
FWD,AFT TRANS Y NORM	0 of 4*	None	k,s	*4 of 4 required on mission dependent basis (to maintain one-fault tolerance for Rndz/Prox Ops).
FWD,AFT TRANS Y PULSE	0 of 4*	None	k,s	*4 of 4 required on mission dependent basis (to maintain one-fault tolerance for Rndz/Prox Ops).

GNC MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
GNC (Continued)				
FWD,AFT TRANSL LO Z	0 of 4*	None	k,s	*4 of 4 required on mission dependent basis (to maintain one-fault tolerance for Rndz/Prox Ops).
FWD,AFT TRANSL Z NORM	2 of 2*	None	k,s	*Either switch. 4 of 4 required on mission dependent basis.
FWD,AFT TRANSL Z PULSE	2 of 2*	None	k,s	*Either switch. 4 of 4 required on mission dependent basis (to maintain one-fault tolerance).
FWD,AFT TRANSL Z HIGH Z	0 of 4*	None	k,s	*4 of 4 required on mission dependent basis (to maintain one-fault tolerance for Rndz/Prox Ops).
L,R BDYFLP AUTO/MAN	5 of 6	None	g	Maintain two-fault tolerance. FR 8-60.
L,R PITCH AUTO MODE	5* of 6		g	*Maintain two-fault tolerance; however, failure mode must be low. FR 8-60.
L,R PITCH CSS MODE	0 of 6			Can mode to CSS with RHC.
L,R R/Y AUTO MODE	5* of 6		g	*Maintain two-fault tolerance; however, failure mode must be low. FR 8-60.
L,R R/Y CSS MODE	0 of 6			Can mode to CSS with RHC.
L,R SPDBK/THROT AUTO/MAN	3 of 3*	None	f	Either switch. Manual throttle required for some aborts, AUTO throttle then required for Auto MECO.

GNC MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
GNC (Concluded)				
SENSE SWITCH -X	0 of 3	None		Primary use is MMU rescue case.
SENSE SWITCH -Z	0 of 3	None		Default is -Z.
ENTRY MODE LO GAIN	2 of 4	None	f,g	Maintain capability for backup to body bending filter.
ENTRY MODE NO Y JET	2 of 4	None	f,g	Maintain capability for no yaw jet mode for dual RCS reg fail.
L,R RHC PITCH TRIM +/-	4 of 4*	None		*Either switch. Maintain rate trim capability.
L,R RHC ROLL TRIM +/-	4 of 4*	None		*Either switch. Maintain rate trim capability.
L,R RHC TRIM INHIBIT	2 of 2*	None	f,g	*Both switches. Maintain position trim capability.
L,R PITCH TRIM +/-	4 of 4*	None		*Either switch. Maintain position trim capability.
L,R ROLL TRIM +/-	4 of 4*	None		*Either switch. Maintain position trim capability.
L,R YAW TRIM +/-	4 of 4*	None		*Either switch. Maintain capability.
L,R ATT REF	2 of 2*	None	l,n	*Both sides. Maintain one-fault tolerance.
AFT ATT REF	0 of 2	None		Useful for taking COAS marks from aft station.
L,R,A DISPLAY SW	0 of 1	None		Default position is acceptable.
FCS CHANNEL OVERRIDE	0 of 3*	None		*Required to optimize for third failure. Switch position indication is feedback to GPC only. Functional requirement is for ON/OFF control of APA/ATVC RPCs.

OMS/RCS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
OMS				
ALL ORBITAL MANEUVERING SYSTEM (OMS) AND RELATED COMPONENTS, STRUCTURES, LINES, VALVES, FITTINGS, ACTUATORS, AND OTHER MECHANICAL AND ELECTRICAL DEVICES NECESSARY FOR FUNCTIONAL OPERATION OF THE OMS ARE REQUIRED. ALL OF THE EQUIPMENT SPECIFICALLY CONSIDERED ARE INCLUDED FOR COMPLETENESS. EXCEPTIONS TO LAUNCH COMMIT REQUIREMENTS ARE HIGHLIGHTED.				
HE TANKS	1 of 1/ POD	OMS-01	e,f,l,q	Loss of a helium tank prior to achieving maximum blowdown precludes the ability to successfully complete the planned mission and may result in an abort or early deorbit.
HE ISOL VLVS	2 of 2/ POD	OMS-02	f,q	Both valves required to provide redundancy. Loss of helium isolation valves (closed) is equivalent to the loss of a helium tank. Manual and GPC control of valves is required.
HE REGS	4 of 4/ POD	None	f,q	All regulators required to provide redundancy. Primary or secondary regulator failed closed results in loss of helium flow path and is equivalent to the loss of a helium tank.
VAP ISOL VLVS	2 of 2/ POD	OMS-03	f,q	Both valves required to provide redundancy. Both vapor isolation valves failed closed precludes helium flow to the oxidizer tank and is equivalent to helium tank failure until maximum blowdown achieved. Failed open vapor isolation valve allows propellant vapor mixing leading to helium system contamination. Contamination may result in component failures. Manual and GPC control valves is required.

OMS/RCS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
OMS (Continued)				
QUAD CHECK VLV	2 of 2/ POD	None	f,q	Prevents propellant contamination of helium system components. Contamination can result in failure of these components which is equivalent to helium tank failure. Failed closed check valve pair is equivalent to loss of helium tank.
BURST DISK	2 of 2/ POD	None	f,g	Burst disk provides redundancy for a failed open relief valve. Burst disk not in place combined with relief valve failure is the same as loss of the affected propellant tank.
RELIEF VLV	2 of 2/ POD	None	f,g	Protects propellant tank from overpressure for a failed open regulator. Failed open relief valve without burst disk in place is same as loss of propellant tank.
PROP TANKS	2 of 2/ POD	OMS-05	b,e,f,q	Loss of propellant tank results in either a launch day deorbit or a next PLS entry dependent on time of failure. Possible catastrophic failure.

OMS/RCS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
OMS (Continued)				
TANK ISOL VLVS	2 of 2/ TANK	OMS-06	b,e,f,q	Two valves per tank required to provide redundancy. Both tank isolation valves failed closed equivalent to loss of a propellant tank. Failed open tank isolation valve precludes proper propellant management. Manual and GPC control of valves is required.
N2 TANK	1 of 1/ ENGINE	OMS-08	e,f,l	Loss of a GN2 tank results in one start remaining for its associated OMS engine. Impact of this failure is dependent on time of failure and mission profile. May result in crew action not part of normal procedures during critical periods. Loss of GN2 tank during an abort is possible catastrophic failure due to incomplete abort dump.
ENG N2 P VLV	1 of 1/ ENGINE	OMS-10	e,f,l	Loss of engine press valve equivalent to loss of GN2 tank.
GN2 REG	1 of 1/ ENGINE	OMS-09	e,f,l	Loss of the GN2 regulator is equivalent to loss of an OMS engine.
GN2 ACCUM	1 of 1/ ENGINE	OMS-09	e,f,l	Loss of the GN2 accumulator due to leakage may be loss of OMS engine dependent on severity of leakage.

OMS/RCS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
OMS (Continued)				
GN2 RELIEF VLV	1 of 1/ ENGINE	None	e,f,l	Same as GN2 ACCUM.
ENGINE	1 of 1/ POD	None	e,f,l	For loss of an OMS engine, RCS Steep Deorbit must be redlined. Since propellant loading does not protect for this case, loss of an OMS engine can result in next PLS entry. Will result in crew action not part of normal procedures during critical periods. Loss of an OMS engine during an abort is possible catastrophic failure due to incomplete abort dump.
ENG CNTRL VLV	2 of 2/ ENGINE	None	e,f,l	Required for OMS engine operation. Loss of a control valve equivalent to loss of OMS engine.
BALL VLVS	4 of 4/ ENGINE	OMS-15	e,f,l	Required for OMS engine operation. Loss of a ball valve equivalent to loss of an OMS engine.
ENG PURGE VALVE	2 of 2/ ENGINE	OMS-11	e,f,l	Failed open purge valves result in loss of OMS engine. Impacts of a failed closed purge valve are dependent on mission profile.
ARM/PRESS SW	1 of 1/ ENGINE	None	e,f,l	Both contacts per switch required for OMS engine operation. Loss of an ARM/PRESS switch equivalent to loss of an engine.

OMS/RCS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
OMS (Concluded)				
OMS ENG VLV SW	1 of 1/ ENGINE	None	e,f,l	Both contacts per switch required for OMS engine operation. Loss of an OMS ENG VLV switch equivalent to loss of an engine.
OMS POD HTRS	2 of 2 SETS/POD	OMS-16	p	Manual control of heaters through switches is required.
OMS XFEED HTRS	1 of 2 SETS	OMS-17	p	Required to maintain crossfeed line thermal environment. Loss of both sets of crossfeed line heaters is equivalent to loss of the crossfeed line. Manual control of heaters through switches is required.
OMS XFEED VLVS	4 of 4/ POD	OMS-07	e,f,l	OMS crossfeed valves required to complete abort dumps for high propellant loads. Crossfeed valves may also be required to complete mission profile if interconnect operations are required. Manual and GPC control of valves is required.
XFEED LINE	1 Pair (OX, FU)	None	c,e,f,l	Loss of the crossfeed line requires a next PLS entry. Required for abort dumps for high propellant loads. Crossfeed line may also be required to complete mission if interconnect operations are required.

OMS/RCS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
ARCS				
ALL AFT REACTION CONTROL SYSTEM (ARCS) AND RELATED COMPONENTS, STRUCTURE, LINES, VALVES, FITTINGS, ACTUATORS, AND OTHER MECHANICAL AND ELECTRICAL DEVICES NECESSARY FOR FUNCTIONAL OPERATION OF THE ARCS ARE REQUIRED. CERTAIN EXCEPTIONS ARE INCLUDED IN THE LIST BELOW. ALL OF THE EQUIPMENT SPECIFICALLY CONSIDERED ARE INCLUDED FOR COMPLETENESS WHETHER OR NOT THEY WERE PROPOSED FOR EXCEPTION.				
HE TANKS	2 of 2/ POD	RCS-01	b,f,i,l, q	Loss of a helium tank precludes the ability to successfully complete the planned mission and will result in a next PLS entry.
HE ISOL VLVS	4 of 4/ POD	RCS-03	e,f,l	Both valves for each helium tank required to provide redundancy. Loss of helium isolation valves equivalent to the loss of a helium tank. Manual and GPC control of valves is required.
HE REGS	8 of 8/ POD	None	b,f	All regulators for each helium tank required to provide redundancy. Loss of helium regulators equivalent to the loss of a helium tank. Primary or secondary regulator failed closed results in loss of helium flow path.
QUAD CHECK VLV	4 of 4/ POD	None	b,f	Prevents propellant contamination of helium system components. Contamination can result in failure of these components which is equivalent to helium tank failure. Pair is equivalent to loss of helium tank.

OMS/RCS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
ARCS (Continued)				
BURST DISK	2 of 2/ POD	None	f,g	Burst disk provides redundancy for a failed open relief valve. Burst disk not in place combined with relief valve failure is the same as loss of the affected propellant tank.
RELIEF VLV	2 of 2/ POD	None	f,g	Protects propellant tank from overpressure for a failed open regulator. Failed open relief valve without burst disk in place is same as loss of propellant tank.
PROP TANKS	2 of 2/ POD	RCS-02	b,e,f,q	Loss of propellant tank results in either a launch day deorbit or a next PLS entry dependent on time of failure.
TANK ISOL VLVS	6 of 6/ POD	RCS-04	f,k,l	Tank isolation valves required to complete abort dumps for high propellant loads. Incomplete abort dump is possible catastrophic failure. Tank isolation may also be required to complete mission profile if interconnect operations are required. Manual and GPC control of valves is required.
MANF ISOL VLVS	10 of 10/ POD	RCS-05	f,g,k,l	Manifold isolation valves are required to isolate jet leaks. Inability to isolate a manifold in this case is loss of an RCS leg. Loss of an RCS leg results in a next PLS entry. Manual and GPC valve control is required.

OMS/RCS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
ARCS (Continued)				
RCS XFEED VLVS	4 of 4/ POD	RCS-10	f,k,l	RCS crossfeed valves required to complete abort dumps for high propellant loads. Incomplete abort dump is possible catastrophic failure. Crossfeed valves may also be required to complete mission profile if interconnect operations are required. Manual and GPC control of valves is required.
GROUP 7 JETS (Right +X)	2 of 2	RCS-06 RCS-08 GNC-45	f,g,k,l	+X is alternate method of deorbit and both jets are required. Also, jets are required for post-MECO abort dumps to meet RCS tank landing weight constraints. Instrumentation (Pc and INJ Temps) for redundancy management is required on 1 of 2 jets.
GROUP 8 JETS (Left +X)	2 of 2	RCS-06 RCS-08 GNC-45	f,g,k,l	+X is alternate method of deorbit and both jets are required. Also, jets are required for post-MECO abort dumps to meet RCS tank landing weight constraints. Instrumentation (Pc and INJ Temps) for redundancy management is required on 1 of 2 jets.

OMS/RCS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
ARCS (Continued)				
GROUP 9 JETS (Left Yaw)	4 of 4	RCS-06 RCS-08 GNC-45	f,g,k,l	All jets required to provide single-fault tolerance for RTLS ET SEP and to be Fail OP/Fail Safe for a nominal entry. Instrumentation (Pc and INJ Temps) for redundancy management is required on 3 of 4 jets.
GROUP 10 JETS (Right Yaw)	4 of 4	RCS-06 RCS-08 GNC-45	f,g,k,l	All jets required to provide single-fault tolerance for RTLS ET SEP and to be Fail OP/Fail Safe for a nominal entry. Instrumentation (Pc and INJ Temps) for redundancy management is required on 3 of 4 jets.
GROUP 11 JETS (Left Up)	3 of 3	RCS-06 RCS-08 GNC-45	f,g,k,l	All jets required to provide single-fault tolerance for RTLS ET SEP and to be Fail OP/Fail Safe for a nominal entry. Instrumentation (Pc and INJ Temps) for redundancy management is required on 2 of 3 jets.
GROUP 12 JETS (Right Up)	3 of 3	RCS-06 RCS-08 GNC-45	f,g,k,l	All jets required to provide single-fault tolerance for RTLS ET SEP and to be Fail OP/Fail Safe for a nominal entry. Instrumentation (Pc and INJ Temps) for redundancy management is required on 2 of 3 jets.

OMS/RCS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
ARCS (Continued)				
GROUP 13 JETS (Left Down)	3 of 3	RCS-06 RCS-08 GNC-45	f,g,k,l	All jets required to provide single-fault tolerance for RTLS ET SEP and to be Fail OP/Fail Safe for a nominal entry. Instrumentation (Pc and INJ Temps) for redundancy management is required on 2 of 3 jets.
GROUP 14 JETS (Right Down)	3 of 3	RCS-06 RCS-08 GNC-45	f,g,k,l	All jets required to provide single-fault tolerance for RTLS ET SEP and to be Fail OP/Fail Safe for a nominal entry. Instrumentation (Pc and INJ Temps) for redundancy management is required on 2 of 3 jets.
AFT VERN JETS	4* of 4	RCS-07	o,s	*Mission dependent.
AFT JET HTRS	24* of 24	RCS-06	k,l,p,s	*Mission dependent. Jet heaters required to prevent leaking jets. If a jet heater fails off, jet must be fired periodically to keep jet warm and prevent leakage. These firings may interfere with mission objectives (dependent on mission profile).
RJDA DRIVERS	4 of 4	GNC-48	f,g,k,l	Required for PRCS jet operation. Manual control of drivers through switches is required. 7 of 8 power supplies required.

OMS/RCS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
ARCS (Concluded)				
VERN DRIVER	1* of 1	GNC-46	o,s	*Mission dependent. Required for vernier jet operation. Manual control of driver through switches is required.
AFT VERN JET HTRS	4* of 4	RCS-07	o,s	*Mission dependent. Jet heaters required to prevent leaking jets. If jet heater fails off, verniers will not be available for mission objectives.

OMS/RCS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
FRCS				
ALL FORWARD REACTION CONTROL SYSTEM (FRCS) AND RELATED COMPONENTS, STRUCTURE, LINES, VALVES, FITTINGS, ACTUATORS, AND OTHER MECHANICAL AND ELECTRICAL DEVICES NECESSARY FOR FUNCTIONAL OPERATION OF THE FRCS ARE REQUIRED. ALL OF THE EQUIPMENT SPECIFICALLY CONSIDERED ARE INCLUDED FOR COMPLETENESS. EXCEPTIONS TO LAUNCH COMMIT REQUIREMENTS ARE HIGHLIGHTED.				
HE TANKS	2 of 2	RCS-01	f,k,l	Loss of a helium tank precludes the ability to successfully complete the planned mission and may result in a next PLS entry.
HE ISOL VLVS	4 of 4	RCS-03	f,k,l	Both valves for each helium tank required for redundancy. Loss of helium isol valves (closed) is equivalent to the loss of a helium tank. Manual and GPC control of valves is required.
HE REGS	8 of 8	None	f,k,l	All regulators for each helium tank required to provide redundancy. Loss of helium regulators (closed) is equivalent to the loss of a helium tank. Primary or secondary regulator failed closed results in loss of helium flow path.
QUAD CHECK VLV	4 of 4	None	f,k,l	Prevents propellant contamination of helium system components. Contamination can result in failure of these components which is equivalent to helium tank failure. Failed closed check valve pair is equivalent to loss of helium tank.

OMS/RCS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
FRCS (Continued)				
BURST DISK	2 of 2	None	f,k,l	Burst disk provides redundancy for a failed open relief valve. Burst disk not in place combined with relief valve failure is the same as loss of the affected propellant tank.
RELIEF VLV	2 of 2	None	f,k,l	Protects propellant tank from overpressure for a failed open regulator. Failed open relief valve without burst disk in place is same as loss of propellant tank.
PROP TANKS	2 of 2	RCS-02	c,f,k, l,q	Loss of propellant tank may result in either a launch day deorbit or a next PLS entry dependent on time of failure.
TANK ISOL VLVS	4 of 4	RCS-04	f,k,l	Manual and GPC control of valves is required.
MANF ISOL VLVS	10 of 10	RCS-05	k,l	Manifold isolation valves are required to isolate jet leaks. Inability to isolate a manifold in this case is loss of an RCS leg. Manual and GPC control of valves is required.
GROUP 1 JETS (-X)	3 of 3	RCS-06 RCS-08 GNC-45	k,l	All jets are required for missions with Low Z requirements. Instrumentation (Pc and INJ Temps) for redundancy management is required on 2 of 3 jets.

OMS/RCS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
FRCS (Continued)				
GROUP 2 JETS (Left Yaw)	2 of 2	RCS-06 RCS-08 GNC-45	f,k,l	All jets required to provide single-fault tolerance for RTLS ET SEP. Instrumentation (Pc and INJ Temps) for redundancy management is required on 1 of 2 jets.
GROUP 3 JETS (Right Yaw)	2 of 2	RCS-06 RCS-08 GNC-45	f,k,l	All jets required to provide single-fault tolerance for RTLS ET SEP. Instrumentation (Pc and INJ Temps) for redundancy management is required on 1 of 2 jets.
GROUP 4 JETS (Up Jets)	3 of 3	RCS-06 RCS-08 GNC-45	k,l	All jets required to provide redundancy for rendezvous. Instrumentation (Pc and INJ Temps) for redundancy management is required on 2 of 3 jets.
GROUPS 5 & 6 JETS (Down Jets)	4 of 4	RCS-06 RCS-08 GNC-45	f,k,l	All jets required to provide single-fault tolerance for RTLS ET SEP. Instrumentation (Pc and INJ Temps) for redundancy management is required on 3 of 4 jets.
FWD VERN JETS	2* of 2	RCS-07	o,s	*Mission dependent.

OMS/RCS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
FRCS (Concluded)				
FWD JET HTRS	14* of 14	RCS-06	k,l,p,s	*Mission dependent. Jet heaters required to prevent leaking jets. If a jet heater fails off, jet must be fired periodically to keep jet warm and prevent leakage. These firings may interfere with mission objectives (dependent on mission profile).
POD HEATERS	2 of 2 SETS/POD	None	p	Manual control of heaters through switches is required.
RJDF DRIVERS	4 of 4	GNC-48	f,l	Required for PRCS jet operation. Manual control of drivers through switches is required.
FWD VERN JET HTRS	2* of 2	RCS-07	o,s	*Mission dependent. Jet heater required to prevent leaking jets. If jet heater fails off, verniers will not be available for mission objectives.

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SSME/MPS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
MPS				
ALL MPS HARDWARE IS REQUIRED TO BE OPERATIONAL FOR LAUNCH (FULL REDUNDANCY). EXCEPT AS NOTED BELOW:				
SSME				
ALL SSME HARDWARE IS REQUIRED TO BE OPERATIONAL FOR LAUNCH (FULL REDUNDANCY).				

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ELECTRICAL POWER DISTRIBUTION AND CONTROL (EPDC) MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
EPDC				
ALL ELECTRICAL POWER GENERATION, DISTRIBUTION AND CONTROL (EPDC) COMPONENTS, STRUCTURE, LINES, VALVES, FITTINGS, ACTUATORS, AND OTHER MECHANICAL AND ELECTRICAL DEVICES NECESSARY FOR FUNCTIONAL OPERATION OF THE EPDC SYSTEMS ARE REQUIRED. ALL OF THE EQUIPMENT SPECIFICALLY CONSIDERED ARE INCLUDED FOR COMPLETENESS. EXCEPTIONS TO LAUNCH COMMIT REQUIREMENTS ARE HIGHLIGHTED.				
FUEL CELL	3 of 3	FCP-01 FCP-02 FCP-03 FCP-04 FCP-05 FCP-06	c,f	
FUEL CELL H20 RLF PATH	2 of 2	FCP-06	b	Primary (tank A relief path) and alternate (tank B relief path) systems required; primary and overboard dump systems have common failure point. Loss of overboard relief (e.g., heater failure) requires ullage maintenance in supply tanks B, C and D.
FUEL CELL PURGE	2 of 3	FCP-01	g	Successful reactant purging must be verified late in the countdown to assure adequate voltage through launch.
BUSSES - EXCEPT AS NOTED, THE REQUIREMENTS FOR ELECTRICAL SUB-BUSSES AND UTILITY OUTLETS WILL BE A FUNCTION OF THE EQUIPMENT POWERED BY THEM. IN ANY CASE, THE BUSS LOSS CAUSE AND EFFECT MUST BE UNDERSTOOD AND ACCEPTABLE. THEREFORE, INDIVIDUAL SUB-BUSSES WILL NOT BE LISTED HERE.				
MAIN DC BUSSES	3 of 3	EPDC-01	f	
AC BUSSES	9 of 9	EPDC-03 EPDC-04	a,b,f	Required for SSME redundancy.

ELECTRICAL POWER DISTRIBUTION AND CONTROL (EPDC) MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
EPDC (Continued)				
ESS BUSSES	3 of 3	EPDC-06	c	Require 2 of 3 power sources/buss.
SRB BUSSES	4 of 4	EPDC-05	g	SRB control redundancy; 2 of 2 power sources/buss required.
CNTL BUSSES	9 of 9	EPDC-02	b,c	PLBD operation redundancy. 2 of 3 power sources/buss required.
CWEA	A & B	None	e,n	Both systems required to alert crew to safe fuel cell for ESS BUSS 1BC or 2CA loss.
PYRO INITIATOR CONTROLLER (PICs)	All	EPDC-11 EPDC-12	g	Required for all Orbiter pyrotechnics and Range Safety Operations.
PL BAY FLOODLIGHTS	*	None	l,s	*Mission dependent.
CABIN LIGHTING	*	None	l,s	Crew call after cabin closeout. *Mission dependent.
ACA 1,2,3	3 of 3	None		Req'd for ABORT lights, ME Status lights, etc. Crew call after cabin closeout.
ACA 4,5	*	None	l,s	*Mission dependent.
FIRE DET/SUPR				
AV BAY SMOKE DET	1 of 2/ BAY	EPDC-32	b,c,j	Emergency system.
AV BAY FIRE BOT	3 of 3	EPDC-11	j	Emergency system.

ELECTRICAL POWER DISTRIBUTION AND CONTROL (EPDC) MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
EPDC (Concluded)				
CABIN SMOKE DET	*	EPDC-30,31	j	Emergency system. *Either the RTN AIR CAB or both the left and right FLT DECK sensors are required for flight for confirmed instrumentation failure.

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LIFE SUPPORT SYSTEMS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
CRYO (PRSD)				
ALL CRYOGENIC H2 AND 02 STORAGE AND CONTROL COMPONENTS, STRUCTURE, LINES, VALVES, FITTINGS, ACTUATORS, AND OTHER MECHANICAL AND ELECTRICAL DEVICES NECESSARY FOR FUNCTIONAL OPERATION OF THE CRYO H2 AND O2 SYSTEMS ARE REQUIRED. ALL OF THE EQUIPMENTS SPECIFICALLY CONSIDERED ARE INCLUDED FOR COMPLETENESS. EXCEPTIONS TO LAUNCH COMMIT REQUIREMENTS ARE HIGHLIGHTED.				
CRYO 02,H2 CNTLRS (WITH CNTL PRESS XDCR)	1 of 2/ Tank Pair	PRSD-01 PRSD-06	n,r	One auto control function is mandatory per tank pair (1&2, 3&4). Loss of auto control causes crew to manually operate heaters.
CRYO 02 HTR STRINGS	1 of 2/ Tank & 4 minimum	PRSD-01	f,l,r	Required for hole in cabin case to supply flow rate. For ascent aborts with only four heater strings, O2 flow into the cabin should be limited to 20 #/hr to prevent starving the fuel cells. For the worst case of only two tank sets with full O2 tanks (100% qty), four heater strings can provide about 34 lbm/hr O2 flow with no pressure decay. The fuel cells need about 16 lbm/hr O2 flow (22 kw) pre-MECO and 14 lbm/hr (19 kw) post-MECO. Some pressure decay is tolerable, but if O2 flow into the cabin is not limited, particularly for an AOA, O2 manifold pressure could drop too low to support the fuel cells before touchdown.

LIFE SUPPORT SYSTEMS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
CRYO (PRSD) (Concluded)				
02 HTR TRIP SNSR	1 of 2/ req htr string	PRSD-04	l	Sensor required to safely use heater. Tank lost if all trip sensors failed.
CRYO H2 HTR	1 of 2/ Tank	PRSD-06	f,l,r	Tank is lost if all heaters fail.
02,H2 MANF VALVES	* of 2	PRSD-07	e	*2 of 2 valves required for two tank set case. 1 of 2 valves required for cryo leak isolation.

LIFE SUPPORT SYSTEMS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
ARS				
ALL ATMOSPHERE REVITALIZATION SYSTEM (ARS) COMPONENTS, STRUCTURE, LINES, VALVES, FITTINGS, ACTUATORS, AND OTHER MECHANICAL AND ELECTRICAL DEVICES NECESSARY FOR FUNCTIONAL OPERATION OF THE ARS ARE REQUIRED. ALL OF THE EQUIPMENT SPECIFICALLY CONSIDERED ARE INCLUDED FOR COMPLETENESS. EXCEPTIONS TO LAUNCH COMMIT REQUIREMENTS ARE HIGHLIGHTED.				
H20 LOOP 1 PUMP	1 of 2	ECL-08 ECL-09	b	Two operational H2O loops required.
H20 LOOP 2 PUMP	1 of 1	ECL-08 ECL-09	b	Two operational H2O loops required.
AV BAY FANS		ECL-10	b	5 of 6 is required to
Standard Av Bay	5 of 6			insure generic failures are not allowed. If it could be assured that a generic failure mode is not at fault, 4 of 6 fans will meet all other guidelines provided that we must have at least one fan in each bay and have 3 fans on 3 different AC busses.
Modified Av Bay (Bay IIIA)	2 of 2			2 of 2 is required to insure continued cooling to Shuttle active avionics and Station payloads. One cabin fan is utilized to provide the required cooling.
(Bays I & II)	3 of 4			Av Bays I and II contain the standard Av Bay fans for cooling. 3 of 4 is required to insure generic failures are not allowed. If it could be assured that a generic failure mode is not at fault, 3 of 4 fans will meet all other guidelines provided that we must have at least one fan in each bay and have 2 fans on 2 different AC busses.

LIFE SUPPORT SYSTEMS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
ARS (Continued)				
CABIN FANS	2 of 2	ECL-07	b	Launch with one cabin fan down risks loss of crew and vehicle because the "Both Cabin Fans Lost" deorbit procedure is not fully certified.
IMU FANS	2 of 3	ECL-11	h	Launch with two IMU fans down risks loss of crew and vehicle because there are no specific response procedures to loss of all IMU fans other than an on-orbit IFM which would not be useful for an AOA or Rev 2 or 3 deorbit.
HUMIDITY SEPS	1 of 2	None	b	There should be no problem achieving the next PLS if the last Humidity Sep fails on-orbit.
PCS O2/N2 SPLY	2 of 2	PRSD-01 ECL-02 ECL-03	f	Protects for hole in cabin case. Launch with one system down risks non-CONUS landing if the second system fails on-orbit because the crew may run out of O2 in the cabin before reaching next PLS.
O2/N2 CNTL VLVS	1 of 2	None	f	Provides N2 path to cabin for press maintenance. Cabin integrity is backup for next failure.

LIFE SUPPORT SYSTEMS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
ARS (Concluded)				
CABIN VENT VLVS	2 of 2	ECL-01	f,g	Consists of a vent valve and series vent isolation valve; both valves must be closed. If one valve open, next worse failure (redundant valve fail open) means loss of crew and vehicle. Valve control circuit breakers are closed during launch and opened on-orbit.
CABIN RLF VLVS	2 of 2	None	f,g	Consists of two parallel valve packages with a pressure actuated valve and an inline isolation valve; status undetectable. With one valve failed closed, next worse failure coupled with cabin overpress may result in loss of crew and vehicle.
CABIN NEG P VLVS	2 of 2	None	f,g	Consists of 2 parallel valve packages containing a pressure activated valve and a cap; status not detectable. With one valve failed, next worse failure coupled with low pressure entry could result in loss of crew and vehicle during entry. Use of cabin vent valves cannot be depended on due to lack of knowledge of failure until too late.
O2 XOVER VLV	2 of 2	None	b,j	Provides O2 to the Emergency Breathing Stations.

LIFE SUPPORT SYSTEMS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
ATCS				
ALL ACTIVE THERMAL CONTROL SYSTEM (ATCS) AND RELATED COMPONENTS, STRUCTURE, LINES, VALVES, FITTINGS, ACTUATORS, AND OTHER MECHANICAL AND ELECTRICAL DEVICES NECESSARY FOR FUNCTIONAL OPERATION OF THE ATCS ARE REQUIRED. CERTAIN EXCEPTIONS ARE INCLUDED IN THE LIST BELOW. FOR COMPLETENESS, ALL OF THE EQUIPMENT SPECIFICALLY CONSIDERED ARE INCLUDED WHETHER OR NOT THEY WERE PROPOSED FOR EXCEPTION.				
FES CNTLRS	2 of 3	None	c	Next worse failure (loss of FES) requires a PLS.
FES CORES	2 of 2	None	c	
FES ACCUM	1 of 2	ECL-45	c	Next worse failure (loss of both feedlines/FES primary controllers) requires MDF.
TPG DUCT HTRS	2 of 3	ECL-46	r	A&B heaters must work in the A/B position for instrumentation failures.
HI LD DUCT HTRS	2 of 3	ECL-47	r	A&B heaters must work in the A/B position for instrumentation failures.
FES H20 FEEDLINE HTR SETS	1 of 2/ FDLN	ECL-49	r	
FREON PUMPS	3 of 4	ECL-40 ECL-41	r	Loss of 1 FCL requires PLS.
NH3 TANKS	2 of 2	ECL-42	f	Required for launch aborts or day one entries (loss of 1 FCL, emergency deorbits, contingency deorbits).
NH3 BOILER CNTLR	1 of 2/ SYS	None	f	Next worse failure is loss of NH3 BOILER.
RAD FLOW CNTL ASSY	2 of 2	None	c	

LIFE SUPPORT SYSTEMS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
ATCS (Concluded)				
RAD FLOW CNTLR	1 of 2/ ASSY	None	l	At least two controllers must be on different busses. Next worse failure results in loss of a RAD FLOW CNTL ASSY which is an MDF case.

LIFE SUPPORT SYSTEMS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
WWMS				
ALL WATER AND WASTE MANAGEMENT SYSTEM (WWMS) AND RELATED COMPONENTS, STRUCTURE, LINES, VALVES, FITTINGS, ACTUATORS, AND OTHER MECHANICAL AND ELECTRICAL DEVICES NECESSARY FOR FUNCTIONAL OPERATION OF THE WWMS ARE REQUIRED. CERTAIN EXCEPTIONS ARE INCLUDED IN THE LIST BELOW. FOR COMPLETENESS, ALL OF THE EQUIPMENT SPECIFICALLY CONSIDERED ARE INCLUDED WHETHER OR NOT THEY WERE PROPOSED FOR EXCEPTION.				
WATER TANK A	1 of 1	ECL-20	n	Must be depressed for ascent for proper Fuel Cell operation.
WATER TANKS B,C,D*	2 of 3 or 3 of 3**	ECL-20		*External Leaks not acceptable from any tank. **2 of 3 to insure Rev 3 with PLBD closed; 3 of 3 plus waste tank to insure Rev 7 with PLBD closed (57 deg launch).
WASTE TANK	1 of 1	ECL-21		Contingency Waste Containers (CWC) and bags are only for on-orbit contingency, not pre-planned use. Tank is also required for Rev 7 with PLBD closed.
WASTE MANAGEMENT	1 of 1	None	n	Contingency Waste Containers (CWC) and bags are only for on-orbit contingency, not pre-planned use.
DUMP NOZZLE HTRS	1 of 1/ NOZZLE	None	l	Waste dump through supply nozzle and use of CMC and bags are only for on-orbit contingency, not pre-planned use. Waste water used in FES is acceptable only as a last resort during a cooling emergency.

APU/HYD, AIRFRAME AND PDRS SYSTEMS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
APU/HYD/WSB				
ALL AUXILIARY POWER UNIT, HYDRAULIC AND WATER SPRAY BOILER (APU/HYD/WSB) AND RELATED COMPONENTS, STRUCTURE, LINES, VALVES, FITTINGS, ACTUATORS, AND OTHER MECHANICAL AND ELECTRICAL DEVICES NECESSARY FOR FUNCTIONAL OPERATION OF THE APU/HYD/WSB SYSTEMS ARE REQUIRED. CERTAIN EXCEPTIONS ARE INCLUDED IN THE LIST BELOW. ALL OF THE EQUIPMENT SPECIFICALLY CONSIDERED ARE INCLUDED FOR COMPLETENESS WHETHER OR NOT THEY WERE PROPOSED FOR EXCEPTION.				
APU CNTLRS	1 of 1/ SYS	None	e,c,g	
TANK VALVES	2 of 2/ SYS	APU-21 APU-23	f,c	Failure of second valve results in loss of APU which could cause abort.
GBX GN2 TANK	1 of 1/ SYS	APU-10	f	Tank insures pressure necessary for oil flow capability during A/E, or APU start in the event of a GBX repress.
GBX GN2 VALVE	1 of 1/ SYS	None	f	Same as GBX GN2 TANK.
FUEL TANK HTRS	0 of 2/ SYS	None		Thermal mass of tank/fluid prevents freezing for normal mission durations.
LINE/PMP HTRS	2 of 2/ SYS	APU-05 APU-14 APU-15	g,l	N2H4 will freeze on-orbit without heaters and detonate with failed on heaters. Freeze-thaw cycles could result in line rupture and leak.
GG BED HTRS	1 of 2/ SYS	APU-04	p	Required for normal start prelaunch APU.
OIL LINE HTRS	1 of 2/ SYS	APU-09	i	
GG INJ H2O TANK	1 of 1	APU-20	a,f	Covers AOA case that occurs after APU shutdown.

APU/HYD, AIRFRAME AND PDRS SYSTEMS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
APU/HYD/WSB (Continued)				
GG INJ H2O VALVES	3 of 3	None	a,f	Covers AOA case that occurs after APU shutdown.
GG INJ TK/LN HTRS	1 of 2	APU-19	a	

APU/HYD, AIRFRAME AND PDRS SYSTEMS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
APU/HYD/WSB (Continued)				
HYD PUMP	1 of 1/ SYS	HYD-02	c	SSME will not start without hydraulic pressure.
CIRC PUMP	1 of 1/ SYS	HYD-03		Required for accumulator repress on-orbit. Repress may be required for Hyd pump startup.
HYD PUMP DEPR VALVE	1 of 1/ SYS	HYD-09	g	Function required for APU start to support abort or normal entry.
HYD 1 LDG/NWS ISOL VALVE	1 of 1	HYD-08	g	Required for hydraulic GEAR DEPLOY and NWS. Also refered to as LDG EXTEND ISOL VALVE.
HYD BRAKE ISOL VLVS	1 of 1/ SYS	None	f	Capability to close any of the three sytems required to account for uncommanded brake pressure.
MPS/TVC ISOL VLVS	2 of 3	None	f	All TVC ISOL valves must be open to allow SSME control and at least two must be closable to protect APU fuel consumable margins during AOA.
HYD BOOTSTRAP ACCUM	1 of 1/ SYS	HYD-07	c,q	Required for on-orbit Hydraulic startup.
HYD RESERVOIR	1 of 1/ SYS	HYD-01 HYD-07	c	Required for makeup of minor leakage and thermal contraction. Also required for pump head pressure.
SSME ACCUMULATOR	0 of 3	None		

APU/HYD, AIRFRAME AND PDRS SYSTEMS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
APU/HYD/WSB (Continued)				
HYD HEATERS	0 of 11	None	p	Flight data indicate that heaters rarely, if ever, cycle.
LG EXTEND VLV 1	1 of 1	None	g	Failure of LG EXTEND and RETRACT valves in the right combination can prevent HYD LG deploy.
LG SHUTTLE VLV	3 of 3	AFM-11	f	Failure of this valve to cycle results in that particular landing gear failure to deploy, either hydraulically or pyrotechnically.
FREON/HYD HX CNTL VLV	0 of 1/ SYS	None		Flight data indicate heat source not usually required.
HYD ACCUM UNLOADER VLV	1 of 1/ SYS	None	c,l	Failure of valve could result in loss of Accumulator when APU off.
HYD ACCUM PRIORITY VLV	1 of 1/ SYS	None	c,l	Failure of valve could result in loss of Accumulator when APU off.
HYD PUMP RELIEF VLV	1 of 1/ SYS	None	f	Limits hydraulic pump output pressure in event of pump pressure control system failure.
ET UMB PLATE RETR ACTRS	2 of 3/ SYS	None	f,g	Retraction required for normal ET separation.

APU/HYD, AIRFRAME AND PDRS SYSTEMS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
APU/HYD/WSB (Concluded)				
WSB PRELOAD	1 of 1/ SYS	None	f	3.5 lb H20 preload will permit APU OPS through MECO even if all controllers for that system lost.
WSB CNTLRS	2 of 2/ SYS	HYD-10	f	Cannot monitor B controller unless it is ON.
WSB GN2 TANK	1 of 1/ SYS	HYD-04	f	If blowdown capability not viable.
WSB GN2 TANK VLVS	1 of 1/ SYS	None	f	Same as GN2 tank.
WSB GN2 REGULATOR	1 of 1/ SYS	None	f	Same as GN2 tank.
WSB RELIEF VALVES	1 of 1/ SYS	None	f	
WSB H20 TANK	1 of 1/ SYS	None	f	Same as loss of controllers.
WSB SPRAY VLVS	2 of 2/ SYS	None	f	APU gearbox oil or hydraulic fluid could overheat, causing limited life for abort or entry.
WSB VENT HTRS	1 of 2/	None	f	Required to insure WSB available for entry (thaw residual ice in vent). Failure of both heaters and ice blockage could result in limited APU run time for entry.
WSB BLR HTRS	2 of 2/ SYS	HYD-05	f	Boiler could freeze after APU shutdown.
WSB HYD BYPASS VLVS	1 of 1/ SYS	None	f	Failure of flow mode results in excessive H2O usage and limited APU lifetime.

APU/HYD, AIRFRAME AND PDRS SYSTEMS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
MECHANICAL				
ALL MECHANICAL, LANDING GEAR AND RELATED COMPONENTS, STRUCTURE, LINES, VALVES, FITTINGS, ACTUATORS, AND OTHER MECHANICAL AND ELECTRICAL DEVICES NECESSARY FOR FUNCTIONAL OPERATION OF THE MECHANICAL SYSTEMS ARE REQUIRED. ALL OF THE EQUIPMENT SPECIFICALLY CONSIDERED ARE INCLUDED FOR COMPLETENESS. EXCEPTIONS TO LAUNCH COMMIT REQUIREMENTS ARE HIGHLIGHTED.				
ET DR C/L LTCH MTRS	4 of 4	AFM-01	a,d,f	ET doors must be unlatched at centerlines in order to be closed and latched for safe entry.
ET DR DRIVE MTRS	4 of 4	AFM-02	a,d,f	Same as C/L latch motors.
ET DR LTCH MTRS	4 of 4	AFM-03	a,d,f	Same as C/L latch motors.
VENT DOOR MTRS	1 of 2/ Door	RSLS-01 (RSLS) AFM-30	a,f	Current Orbiter analysis indicates that single door closed situation (fwd,aft), or two doors closed (midbody), is acceptable for a nominal entry.
PLBD DRIVE MTRS	2 of 2/ Door	AFM-06	b,c	Launch day deorbit required if PLBDs cannot be opened.
PLBD C/L LTCH MTRS	2 of 2/ GANG	AFM-09	b,c	Same as drive motors.
PLBD BH LATCH MTRS	2 of 2/ GANG	AFM-07	b	Same as drive motors.
PLBD PNL SWITCH & tb	0 of 1	None		Can be adequately covered with PASS and BFS software.
RADIATOR LTCH/PNL MTRS	* of 2/ LCH and PNL	AFM-04 AFM-05	s,g	*Mission dependent. 2 0f 2 for planned DPY. 1 of 2 if not planned.
PRLA MTRS	* of 2/ LATCH	PAY-01	d,s	*Mission dependent.
PRLA tb	0 of 5	None		Can be adequately covered by software indications.

APU/HYD, AIRFRAME AND PDRS SYSTEMS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
MECHANICAL (Concluded)				
KU-BAND DEPLOY MTRS	* of 2	None	s	*Mission dependent.
LANDING GEAR PYRO DEPLOY SYS	2 of 2	EPDC-12	d	Refers to initiators and their circuitry.
NLG NO WOW PROX SENSORS	0 of 2	None		Can be adequately covered by nominal in-flight procedures.
Pnl F6, F8 LDG tb	0 of 6	None		No crew action based on tb status.
NOSE WHEEL STEERING AVIONICS CHANNELS	1 of 2	GNC-83 GNC-84	f	Required for abort sites and KSC landings.
BRAKES - HYD - ELEC	3 of 3 2 of 2	None GNC-80	f	Required for abort sites.
ANTISKID	2 of 2	None	f	Same as brakes.
TIRES	6 of 6	None	b	Loss of one tire will likely lead to loss of other tire on that truck at NG touchdown which could be catastrophic.

APU/HYD, AIRFRAME AND PDRS SYSTEMS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
PDRS				
ALL PAYLOAD DEPLOYMENT AND RETRIEVAL SYSTEM (PDRS) AND RELATED COMPONENTS, STRUCTURE, LINES, FITTINGS, ACTUATORS, AND OTHER MECHANICAL AND ELECTRICAL DEVICES NECESSARY FOR FUNCTIONAL OPERATION OF THE PDRS ARE REQUIRED. CERTAIN EXCEPTIONS ARE INCLUDED IN THE LIST BELOW. FOR COMPLETENESS, ALL OF THE EQUIPMENT SPECIFICALLY CONSIDERED ARE INCLUDED WHETHER OR NOT THEY WERE PROPOSED FOR EXCEPTION.				
SHOULDER BRACE RELEASE	*			*Mission dependent.
JETTISON SYS	2 of 2*			*If RMS deployed.
MPM MTRS	2* of 2			*Mission dependent.
MPM DPL/STOW CMD	SHLD*			*Mission dependent for safe configuration.
MRL MTRS	2* of 2			*Mission dependent.
MRLs LATCHED IND	2 of 3			Required for safe entry.
THC AXIS CNTL	*			*Mission dependent.
RHC AXIS CNTL	*			*Mission dependent.
AUTO MODE	*			*Mission dependent.
OPR CMDED MODE	*			*Mission dependent.
MAN AUG MODE	*			*Mission dependent.
DIRECT MODE	*			*Mission dependent.
SINGLE MODE	*			*Mission dependent.
BACKUP MODE	*			*Mission dependent.
BRAKES	*			*Mission dependent.
AUTO BRAKES	*			*Mission dependent.

APU/HYD, AIRFRAME AND PDRS SYSTEMS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
PDRS (Concluded)				
AUTO SAFING	*			*Mission dependent.
CAPTURE & RIGIDIZE	*			*Mission dependent.
DERIGIDIZE	*			*Mission dependent.
RELEASE	*			*Mission dependent.
BACKUP RELEASE	*			*Mission dependent.
HEATERS	*			*Mission dependent.

APU/HYD, AIRFRAME AND PDRS SYSTEMS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
SPDS				
ALL STABILIZED PAYLOAD DEPLOYMENT SYSTEM (SPDS) AND RELATED COMPONENTS, STRUCTURE AND OTHER MECHANICAL AND ELECTRICAL DEVICES NECESSARY FOR FUNCTIONAL OPERATION OF THE SPDS ARE REQUIRED. ALL OF THE EQUIPMENT SPECIFICALLY CONSIDERED ARE INCLUDED FOR COMPLETENESS. EXCEPTIONS TO LAUNCH COMMIT REQUIREMENTS ARE HIGHLIGHTED.				
Yo DRIVE MOTORS	2 of 2	None	s	These motors allow the payload to clear the keel trunnion and later provide the method of moving the SPDS inboard to allow payload bay door closure.
RDU MOTORS	3 of 4	None	s	These motors rotate the payload out of the bay and are required for safety and mission success. The payload cannot be released and, therefore, the payload bay doors cannot be closed if all RDU capability is lost before the minimum deployment angle is reached.
P/L REL SYSTEM PICS	3 of 4/ PEDESTAL	None	s	These PICs provide the meth for payload release and are required for mission success. 3 of 4 insure redundancy.
DRIVE XFR SYS PICS	1 of 2/ PEDESTAL	None	s	These PICS provide transfer to the secondary pedestal RDU and are required for mission success if the primary pedestal RDU fails.
P/L RELEASE STATUS	3 of 4	None	s	Satisfies safety requirement for verification of secure latched condition before and during deploy operations.

DPS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
DPS				
ALL DATA PROCESSING SYSTEM (DPS) AND RELATED COMPONENTS, STRUCTURE AND OTHER MECHANICAL AND ELECTRICAL DEVICES NECESSARY FOR FUNCTIONAL OPERATION OF THE DPS ARE REQUIRED. ALL OF THE EQUIPMENT SPECIFICALLY CONSIDERED ARE INCLUDED FOR COMPLETENESS. EXCEPTIONS TO LAUNCH COMMIT REQUIREMENTS ARE HIGHLIGHTED.				
GPC	5 of 5	DPS-02 BFS-04 BFS-05 BFS-06	f,g	
FF MDM	4 of 4	DPS-03 DPS-19 DPS-20	c,f,g	Redun ports not required. 19 of 20 MDM ports required for launch.
FA MDM	4 of 4	DPS-03 DPS-19 DPS-20	c,f,g	Redun ports not required. 19 of 20 MDM ports required for launch.
PF MDM	2 of 2	DPS-03 BFS-09	c,l	Redun ports not required. 19 of 20 MDM ports required for launch.
MTU ACCUM	2 of 3	DPS-10 DPS-16 BFS-03	g	GPCs must be on one of the MTU accumulators.
MTU IRIG-B	* of 1	INS-03	k,l,s	*Mission dependent.
MTU FREQ DIVIDERS				
1 - PL CLOCK	* of 1	INS-03	k,l,s	*Mission dependent.
1 - PSP CLOCK	* of 1	INS-03	k,l,s	*Mission dependent.
2 - PSP CLOCK	* of 1	INS-03	k,l,s	*Mission dependent.
3 - PL CLOCK	* of 1	INS-03	k,l,s	*Mission dependent.
IDP (FWD)	3 of 3	DPS-01a BFS-10a	e,g	
IDP4 (AFT)	* of 1	DPS-01a BFS-10a	k,s	*Mission dependent.

DPS MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
DPS (Concluded)				
MDU (FWD, CRT)	3 of 3	DPS-01a BFS-10a	e,g,l	
MDU (FWD, NON-CRT)	*5 of 6	DPS-01a BFS-10a	e,g,l	*1 failed non-CRT MDU or MDU port allowed for launch if all ADCs/ADC ports are functional. Otherwise, 6 of 6 required.
MDU CRT4	* of 1	DPS-01a BFS-10a	k,l,s	*Mission dependent
MDU AFD1	* of 1	DPS-01a BFS-10a	k,l,s	*1 of 1 Rndz/Prox Ops.
ADC	*3 of 4	DPS-01a BFS-10a	e, g	*1 failed ADC or ADC port allowed for launch if all fwd MDUs/MDU ports are functional. Otherwise, 4 of 4 required.
FWD KYBD	2 of 2	DPS-01a BFS-10a	e,g,h	
SSMM	2 of 2	DPS-06a DPS-07	b,c,l	
AFT KYBD	* of 1	DPS-01a BFS-10a	k,l,s	*Mission dependent.
BFC	3 of 3	DPS-11 BFS-01 BFS-02	g	Required to assure proper BFS engaged process.
EIU	3 of 3	DPS-18	a,e,f,g	All channels required.

INCO MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
INCO				
ALL COMMUNICATIONS AND INSTRUMENTATION COMPONENTS, STRUCTURE, ACTUATORS, AND OTHER MECHANICAL AND ELECTRICAL DEVICES NECESSARY FOR FUNCTIONAL OPERATION OF THE COMMUNICATIONS AND INSTRUMENTATION SYSTEMS ARE REQUIRED. ALL OF THE EQUIPMENT SPECIFICALLY CONSIDERED ARE INCLUDED FOR COMPLETENESS. EXCEPTIONS TO LAUNCH COMMIT REQUIREMENTS ARE HIGHLIGHTED.				
S-BND XPNDR (PM)	2 of 2	CT-02	g	IFM available for downlink recovery. Note: 1 of 2 frequencies selectable on mission dependent basis.
S-BND PRE AMP	2 of 2	CT-02	g,m,s	Required for TDRS communications.
S-BND PWR AMP	2 of 2	CT-09	g,m	Required for TDRS communications.
S-BAND QUAD ANT	4 of 4	None		
S-BAND ANTENNA SW	2 of 2	None		
S-BND SW BEAM CNTL ASSY	1 of 2	None		
UHF/EVCS XCVR	2 of 2*	None		*3 of 3 for missions with planned EVA and SSOR not installed.
SSOR	* of 2	None	s	*Mission Dependent.
SSER	* of 2	None	s	*Mission Dependent.
PCMMU	2 of 2	INS-01 BFS-15	c	
GCIL	1 of 2	CT-03	n	Required for S-Bnd switchover during ascent for S-Bnd failure.
NSP	2 of 2	DPS-14 CT-04	c	

INCO MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
INCO (Continued)				
COM SEC	0* of 2 1** of 2	CT-04	l	Loss of COMSEC requires use of uplink "GPC BLOCK" for Orbiter command protection. If one COMSEC failed, switch to string 1 until crew ingress. After crew ingress, switch to encryption "BYPASS" and switch back to string 2. *NASA Mission (encrypted uplink requirement); but 1 of 2 required until end of comm activation (approx T-14 hr) and 0 of 2 thereafter. **DOD Mission requires 2 of 2 until end of comm activation and 1 of 2 thereafter.
OI MDMs	7** of 7	INS-05	b,c	**Single port required.
OI DSCs (Except OP1, OP2)	14 of 14	INS-04	c	Single power supply required.
DSCs OP1, OP2	1 of 2	INS-04		When EDO Pallet is manifested. Single power supply required.
OPS RCDRs	1 of 2	INS-02	l	IFM available, vehicle dependent.
PL RCDR	0* of 1	None	l,s	*Mission and vehicle dependent.
SSR	1 of 2	INS-02a	l,s	Vehicle dependent.

INCO MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
INCO (Concluded)				
UHF (296.8, 259.7)	1 of 2	CT-05		Landing site voice communication capability.
UHF (Guard Freq)	1 of 1	None		ELS communication capability.
PI	* of 2	None	l,s	*Mission dependent.
PSP	* of 2	None	l,s	*Mission dependent.
PDI	* of 1	None	l,s	*Mission dependent.
TIPS	* of 1	None	l,s	*Mission dependent.
KU-BAND COMM/RADAR	* of 1	None	l,m,s	*Mission dependent.
CCTV SYSTEM				
CAMERAS	*	None	s	*Camera A or D used for backup to the forward PLBD bulkhead latch microswitches. Camera B or C used for backup to the aft bulkhead latch microswitches.
MONITORS	* of 2	None	s	*TV monitors may be required for monitoring Orbiter Payload Bay Door latches (see Cameras above). Ground monitoring of TV is limited with the Ku-Band not deployed. Payload requirements may increase the number required on specific missions.
MADS	0 of 1	None		

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CREW WORN EQUIPMENT MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
ALL CREW WORN AND RELATED EQUIPMENT, STRUCTURE AND OTHER MECHANICAL AND ELECTRICAL DEVICES NECESSARY FOR FUNCTIONAL OPERATION OF THE CREW WORN EQUIPMENT ARE REQUIRED. ALL OF THE EQUIPMENT SPECIFICALLY CONSIDERED ARE INCLUDED FOR COMPLETENESS. EXCEPTIONS TO LAUNCH COMMIT REQUIREMENTS ARE HIGHLIGHTED.				
ACES (EXCEPT GLOVES)	See Notes	None		Suits are required to support safe environment for crew egress, safe breathing environment in the event of cabin leak or contaminated atmosphere, and acceptable anti-g environment. Suit integrity refers to proper operation of the main seal zipper, the suit bladder, Bio-Inst Pass-through (BIP), anti-G suit, and the Orbiter O2 flow through the suit. Loss of suit integrity is a No Go for launch.
ACES GLOVES	See Notes	None		Aces gloves must be properly mated and locked to ensure suit integrity. Loss of ACES glove(s) integrity is a No Go for launch.
LAUNCH/ENTRY HELMETS	See Notes	None		Helmets are required to support safe environment for crew egress, safe breathing environment in the event of cabin leak or contaminated atmosphere and provide for crew communication. Loss of helmet integrity is a No Go for launch.

CREW WORN EQUIPMENT MINIMUM EQUIPMENT LIST

LRU/FUNCTION	REQ'T	SSID	GDLINE REF	NOTES
EMERGENCY O2 SYSTEM (EOS)	See Notes	None		Required for crew breathing during emergency egress conditions. Loss of the EOS is a No Go for launch.
SEAT HARNESS & CONNECTORS	See Notes	None		All five point seat belt harnesses are required. Any broken belt or belt connector is a No Go for launch.
PARACHUTE	See Notes	None		Parachute must be properly packed. All four attach points to harness intact and secure. Inadvertent deployment, attach point failure, or red knob pulled is a No Go for launch.
LIFE RAFT	See Notes	None		Required for bailout over water. Inadvertent deployment is a No Go for launch.
LIFE PRESERVER UNIT (LPU)	See Notes	None		Inadvertent inflation is a No Go for launch.
ICU/TELCU	See Notes	None		Used for thermal control. This is a crew comfort issue only and loss of ICU/TELCU is a GO for launch.

Minimum Equipment List STS-124
Mission Specific Exceptions

Minimum Equipment List STS-124 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
GNC				
AFT RHC XDCRS	3 of 3/ Axis	None	MEL-04	One fault tolerance required in all axes for nominal procedures.
AFT THC CNTCTS	3 of 3/ Axis	None	MEL-04	One fault tolerance required in all axes for nominal procedures.
AFT DDU				
PWR SUP A,B,C	3 of 3	None	MEL-04	Reqd for THC and RHC for mission success. Device Driver Units do not have Power Supplies D & E.
HUD	1* of 2	None	MEL-04	*CDR HUD reqd for night landing capability. *0 of 2 if no night landing.
FWD,AFT DAP PRI	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during RNDZ/Prox Ops.
FWD,AFT TRANS X NORM	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANS X PULSE	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANS Y NORM	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANS Y PULSE	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANSL LO Z	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANSL Z NORM	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANSL Z PULSE	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANSL Z HIGH	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT DAP CNTL LVLH	4 of 6	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT DAP ALT	4 of 4	None	MEL-04	ALT DAP required for nominal ops.
FWD,AFT DAP SPARE PBI	4 of 4	None	MEL-04	Required for docking.
TCS	1 of 1	None	None	Required for range and range rate during ISS approach and fly-around.

Minimum Equipment List STS-124 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
PROP				
AFT JET HTRS	24 of 24	RCS-06	MEL-05	Periodic RCS firings not acceptable.
FWD JET HTRS	14 of 14	RCS-06	MEL-05	Periodic RCS firings not acceptable.
VERNIER JETS	6 of 6	RCS-07	MEL-05	Not all primary flight objectives can be accomplished after loss of verniers.
VERN DRIVER	1 of 1	GNC-46	MEL-05	Same note as VERNIER JETS.
VERN JET HTRS	6 of 6	None	MEL-05	Same note as VERNIER JETS.
EPDC				
PL BAY LIGHTS 1 & 2	1 of 2	None	MEL-07	Required for PLBD forward Bulkhead latch verification.
FWD BLKHD	0 of 0	None	MEL-07	Not installed.
3 & 4	1 of 2	None	MEL-07	Required for PLBD latch verification.
5 & 6	1 of 2	None	MEL-07	Required for PLBD latch verification.
Cabin Lighting	0*	None	MEL-07	* Crew discretion
ACA 4,5	2 of 2	None	MEL-07	Reqd for Aft DAP panel
PL PRI bus	0 of 1	None	None	Not required for STS-124.
PL CAB 1	1 of 1	None	None	Required for Secondary C/L Camera.
PL CAB 2	1 of 1	None	None	Required for PDIPs (1& 2).
PL CAB 3	1 of 1	None	None	Required for Primary C/L Camera, OIU-1, PL Timing Buffer, OBSS control power.

Minimum Equipment List STS-124 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
PL AUX B	1 of 1	None	None	Required for OIU-2 and TCS.
PL AUX A	1 of 1	None	None	Required for DTV MUX.
PL AFT MNB	0 of 1	None	None	Not required for STS-124.
PL AFT MNC	0 of 1	None	None	Not required for STS-124.
PL AC2	1 of 1	None	None	Phase A required for DTV VIP.
PL AC3	0 of 1	None	None	Not required for STS-124.
SSPTS PTU 1 & 2	2 of 2	None	None	APCU1 function of PTU1 is required for JEM PM. The APCU2 function of PTU2 is required for LCS/IDC and JEM PM. PTU1 OPCU1 and PTU2 OPCU2 required for Station to Shuttle power transfer.
MMACS				
RADIATOR LTCH/PNL MTRS	1*of 2/ panel	AFM-05	MEL-09	Rad deploy not planned for STS-124. (*2 of 2 if deploy required - may be required for water transfer requirements.)
	1*of 2/ latch actuator	AFM-06	MEL-09	Rad deploy not planned for STS-124. (*2 of 2 if deploy required. - may be required for water transfer requirements.)
PRLA MTRS, AKA MTRS	2 of 2/	PAY-01	MEL-09	Four longeron latches and Latch one keel latch(JEM PM).
KU-BAND DEPLOY MTRS	2 of 2	None	MEL-09	Required to support ISS Rndz.
DPS				
AFT KYBD	0 of 1	DPS-01a BFS-10a	MEL-10	Not Reqd for STS-124.
IDP(AFT)	0 OF 1	DPS-01a BFS-01a	MEL-10	Not Reqd for STS-124.
MDU CRT4	0 OF 1	DPS-01a BFS-01a	MEL-10	Not Reqd for STS-124.
MDU AFD1	1 OF 1	DPS-01a BFS-01a	MEL-10	AFD1 required to provide. ADI functionality at Aft Flight Station.
MTU IRIG-B	0 of 1	INS-03	MEL-10	Highly desired but not Reqd for STS-124.
FREQ DIV 1-PL CLOCK	0 of 1	INS-03	MEL-10	Not Reqd for STS-124.
FREQ DIV 1,2 PSP CLOCK	2 of 2	INS-03	MEL-10	Reqd for ISS commanding via OIU's.
FREQ DIV 3-PL CLOCK	0 of 1	INS-03	MEL-10	Not Reqd for STS-124.

Minimum Equipment List STS-124 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
INCO				
S-BND PWR AMP	2 of 2	CT-09	MEL-11	For STS-124, hi or low freq is acceptable. Low freq will be used for launch.
S-BND PRE AMP	2 of 2	CT-03	MEL-11	For STS-124, hi or low freq is acceptable. Low freq will be used for launch.
S-BND XPNDR (PM)	2 of 2	CT-02	MEL-11	For STS-124, hi or low freq is acceptable. Low freq will be used for launch.
SOLID STATE RCDR	1 of 2	INS-02a	MEL-11	Required to record and playback LOS data.
PSP	2 of 2	None	MEL-11	Required for ISS commanding (including OIU Configuration control).
PDI	1 of 1	None	MEL-11	PDI required for SSV, ISS TLM and TCS.
OIU	1 of 2	None	None	Required to support SSRMS downlink during ISS LOS periods. ISS command & TLM is available via ISS S-Band system.
KU-BAND COMM/RADAR	1 of 1	None	MEL-11	The KU-Band is required for ISS rendezvous, docking, undocking and TV activities.
SSV	1 of 1	None	None	Required as backup for loss of Ku-Band downlink video.
SPACE TO SPACE ORBITER RADIO	1 of 1	None	None	The SSOR is required for scheduled and contingency EVAs and during ISS rendezvous and separation for ship-to-ship communications. (This includes two strings with two frequencies on each string).
SPACE TO SPACE EMU RADIOS	2 of 2	None	None	Two SSERs are required for scheduled EVAs. (This includes two strings with two frequencies on each string).

Minimum Equipment List STS-124 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
WIRELESS VIDEO SYSTEM				
WVS S-BAND ANT	7 of 7	None	None	Due to uncertainty in the ISS powerdown plan shuttle WVS may be required for EVA situational awareness during some EVAs. This will have to be a real time call during EVA Prep.
WVS UHF ANT	1 of 1	None	None	Required for EVA situational awareness. ISS WVS may be powered off for some EVAs.
WVS TRANSCEIVER	2 of 2	None	None	Required for EVA situational awareness. ISS WVS may be powered off for some EVAs.
WVS INTERFACE BOX	1 of 1	None	None	Required for EVA situational awareness. ISS WVS may be powered off for some EVAs.
CCTV SYSTEM				
CAMERAS A,D	2 of 2	None	MEL-11	Payload bay cameras A,B, C & D are all required for assembly and TPS survey operations and are used as backup to the PLBD bulkhead microswitches. A or D can cover the fwd bulkhead latches. B or C can cover the aft bulkhead latches. ODS centerline camera is required for ISS Rndz/undock. RMS cameras are used for ISS survey and assembly operations.
B,C	2 of 2	None	MEL-11	
ODS Centerline	1 of 2	None	None	
RMS Elbow	1 of 1	None	None	
RMS Wrist	1 of 1	None	None	
RSC	1 of 1	None	None	Required for clearance views during TPS survey and focused inspections.
MONITORS	2 of 2	None	MEL-11	Both monitors required for STS-124 for RMS and EVA task monitoring.
VPU	1 of 1	None	None	Required for centerline camera, WVS camera, RSC, OBSS Sensor Package 1 and ISS video routing.
DIGITAL TELEVISION (DTV)				
DSR-25 VTR	1 of 1	None	None	Required for CCTV recording.

Minimum Equipment List STS-124 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
VERTICAL INTERVAL PROCESSOR (VIP)	1 OF 1	None	None	Required for recording and downlink of camera data.
MUX	1 of 1	None	None	Required to provide power to VTR and the interface for downlink digital video
PDRS				
SHOULDER BRACE RELEASE	1 of 1	None	MEL-09	RMS Reqd for nominal mission.
PORT JETTISON SYS	2 of 2	None	MEL-09	Safety requirement.
PORT MPM MOTORS	2 of 2	AFM-12	MEL-09	MPM deploy required for mission success.
PORT MPM DPL/STOW CMD	Reqd	None	MEL-09	Required for mission success.
PORT MRL MOTORS	2*of 2	AFM-13	MEL-09	*Full redundancy needed to maintain ops margin for mission critical RMS.
PORT MRL LATCH IND	1 of 2 per pedestal	AFM-13	MEL-09	SODB states req't for 3 of 3 latches for entry. Flt specific analysis Reqd to allow 2 of 3 latches for entry.
THC AXIS CNTL	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives. Timeline impacted.
RHC AXIS CNTL	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives. Timeline impacted.
AUTO MODE	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives. Timeline impacted.
OPR CMDED MODE	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives. Timeline impacted.
MAN AUG MODE	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives. Timeline impacted.

Minimum Equipment List STS-124 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
SINGLE MODE	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives. Timeline impacted.
DIRECT MODE	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives.
BACKUP MODE	Reqd	None	MEL-09	Required for redundancy for primary mission objectives.
BRAKES	Reqd	None	MEL-09	Safety requirement.
AUTO BRAKES	Reqd	None	MEL-09	Safety requirement.
CAPTURE AND RIGIDIZE	Reqd	None	MEL-09	EE operations required for primary mission objectives.
DERIGIDIZE	Reqd	None	MEL-09	EE operations required for primary mission objectives.
RELEASE	Reqd	None	MEL-09	EE operations required for primary mission objectives.
BACKUP RELEASE	*Not Reqd	None	MEL-09	*Not Reqd for primary mission objectives provided manual or auto capability exists.
RMS HEATERS	1*of 2	None	MEL-09	*Single system is acceptable.
OBSS				
STBD JETTISON SYS	2 of 2	None	None	Safety requirement.
STBD MPM MOTORS	2 of 2	None	None	MPM deploy required for mission success.
STBD MPM DPL/STOW CMD	Reqd	None	None	Required for mission success.
STBD MRL MOTORS	2*of 2	None	None	*Full redundancy needed to maintain ops margin for OBSS latching.
STBD MRL LATCH IND	1 of 2 per pedestal	None	None	3 of 3 latches Reqd for entry.
OBSS HEATERS	1*of 2	None	None	*Single system is acceptable.
LDRI	Reqd	None	None	Reqd for critical damage detection.
LCS	Reqd	None	None	Reqd for critical damage detection.

Minimum Equipment List STS-124 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
ITVC	Reqd	None	None	Reqd as mounting and pan/tilt interface for LDRI.
IDC	Reqd	None	None	Reqd for critical damage detection
AIRLOCK/DOCKING SYS				
ODS APDS HOOK MTRS	2 of 2/ gang	None	None	Reqd for shuttle/ISS stage dock/undock.
RING MTRS	2 of 2	None	None	Reqd for shuttle/ISS stage dock/undock.
CAP LAT MTRS	1 of 1/ Latch	None	None	Reqd for shuttle/ISS stage dock/undock.
PMA 1 APDS HOOK MTRS	0 of 2/ Latch	None	None	Not Reqd for STS-124.
PMA 2 APDS HOOK MTRS	0 of 2/ Latch	None	None	Not Reqd for STS-124.
ODS Vestibule Lights	2 of 2	None	None	Required for docking operations.
ODS Truss Lights	2 of 2	None	None	Required for docking operations.
ECLS				
EXT AIRLK				
MNA & MNB H2O LINE HTRS	1 of 2	None	None	Loss of heaters will cause freezing of external water lines.
MNC H2O LINE HTRS	1 of 1	None	None	Loss of heaters will cause freezing of external water lines.
STRUCT HTRS	1 of 2	None	None	Loss of heaters will cause freezing of internal airlock water lines resulting in loss of EMU servicing. Passive thermal control via attitude changes may not be possible due to PL constraints.
TUNNEL BOOSTER FAN	1 of 2	None	None	Reqd for condensate cntl and air quality.
VESTIBULE VENT VALVES	2 of 4	None	None	Reqd to depress ISS/ Shuttle vestibule prior to undocking. VENT and VENT ISOL valves required on same system.
FLOW PROP MODULE	0 of 2	ECL-40	None	Nominal configuration for STS-124 is both FPV's in ICH.

Minimum Equipment List STS-124 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
GO2 XFER ISOLATION VLV	1 of 1	None	None	Required for transfer of GO2 to ISS high pressure GO2 tanks.
MMU GN2 SPLY ISOL VLV A	1 of 1	None	None	Required for transfer of GN2 to ISS high pressure GN2 tanks.
ODS GN2 XFER PANEL FLOW VLV	1 of 1	None	None	Required for transfer of GN2 to ISS high pressure GN2 tanks.
ODS GO2 XFER PANEL FLOW VLV	1 of 1	None	None	Required for transfer of GO2 to ISS high pressure GO2 tanks.
EMU O2 ISOL VLV	1 of 1	None	None	Required for transfer of GO2 to ISS high pressure GO2 tanks.

Minimum Equipment List STS-125
Mission Specific Exceptions

Minimum Equipment List STS-125 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
GNC				
AFT RHC XDCRS	3 of 3/ Axis	None	MEL-04	One fault tolerance required in all axes for nominal procedures.
AFT THC CNTCTS	3 of 3/ Axis	None	MEL-04	One fault tolerance required in all axes for nominal procedures.
AFT DDU				
PWR SUP A,B,C	3 of 3	None	MEL-04	Reqd for THC and RHC for mission success. Device Driver Units do not have Power Supplies D & E.
HUD	1* of 2	None	MEL-04	*CDR HUD reqd for night landing capability. *0 of 2 if no night landing.
FWD,AFT DAP PRI	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during RNDZ/Prox Ops.
FWD,AFT TRANS X NORM	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANS X PULSE	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANS Y NORM	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANS Y PULSE	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANSL LO Z	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANSL Z NORM	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANSL Z PULSE	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANSL Z HIGH	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT DAP CNTL LVLH	4 of 6	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT DAP ALT	4 of 4	None	MEL-04	ALT DAP required for nominal ops.
FWD,AFT DAP SPARE PBI	4 of 4	None	MEL-04	Required for docking.
TCS	0 of 1	None	None	Not required for STS-125.

Minimum Equipment List STS-125 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
PROP				
AFT JET HTRS	24 of 24	RCS-06	MEL-05	Periodic RCS firings not acceptable.
FWD JET HTRS	14 of 14	RCS-06	MEL-05	Periodic RCS firings not acceptable.
VERNIER JETS	6 of 6	RCS-07	MEL-05	Not all primary flight objectives can be accomplished after loss of verniers.
VERN DRIVER	1 of 1	GNC-46	MEL-05	Same note as VERNIER JETS.
VERN JET HTRS	6 of 6	None	MEL-05	Same note as VERNIER JETS.
EPDC				
PL BAY LIGHTS 1 & 2	1 of 2	None	MEL-07	Required for PLBD forward Bulkhead latch verification.
FWD BLKHD	0 of 1	None	MEL-07	Not required.
3 & 4	0 of 2	None	MEL-07	Mid PLB lights are constrained to be OFF for STS-125.
5 & 6	1 of 2	None	MEL-07	Required for PLBD latch verification.
Cabin Lighting	0*	None	MEL-07	* Crew discretion
ACA 4,5	2 of 2	None	MEL-07	Reqd for Aft DAP panel
PL PRI bus	1 of 1	None	None	Required FSS, MULE, and SLIC power.
PL CAB 1	1 of 1	None	None	Required for FSS/ORUC SSP 1B control power, APCU 1 control power, ICBC 3D IMAX control power, PI DOD mode control.
PL CAB 2	1 of 1	None	None	Required for PDIPs (1& 2) and KEEL camera power.
PL CAB 3	1 of 1	None	None	Required for HST Spacetelescope control power on SSP 1, SLIC Heater PWR A, MULE MDM-B PWR and Survey Heater B pwr, PL Timing Buffer, OBSS control power, SPASP and RSC camera.

Minimum Equipment List STS-125 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
PL AUX B	1 of 1	None	None	Required for APCU 2.
PL AUX A	1 of 1	None	None	Required for DTV MUX.
PL AFT MNB	1 of 1	None	None	Required for APCU 1 and ICBC 3D IMAX Camera.
PL AFT MNC	1 of 1	None	None	Required for APCU 2.
PL AC2	1 of 1	None	None	Phase A required for DTV VIP.
PL AC3	0 of 1	None	None	Not Required for STS-125.
APCU 1	1 of 1	None	None	Required for primary power for OBSS Sensor Package 2 LCS and IDC.
APCU 2	1 of 1	None	None	Required for backup power for OBSS Sensor Package 2 LCS and IDC.
MMACS				
RADIATOR LTCH/PNL MTRS	1*of 2/ panel	AFM-04	MEL-09	Rad deploy not planned for STS-125.
	1*of 2/ latch actuator	AFM-05	MEL-09	Rad deploy not planned for STS-125.
PRLA MTRS, AKA MTRS	2 of 2/	PAY-01	MEL-09	Not Required for STS-125. (Jettison operations only)
KU-BAND DEPLOY MTRS	2 of 2	None	MEL-09	Required to support HST Rndz.
DPS				
AFT KYBD	0 of 1	DPS-01a BFS-10a	MEL-10	Not Reqd for STS-125.
IDP(AFT)	0 OF 1	DPS-01a BFS-01a	MEL-10	Not Reqd for STS-125.
MDU CRT4	0 OF 1	DPS-01a BFS-01a	MEL-10	Not Reqd for STS-125.
MDU AFD1	1 OF 1	DPS-01a BFS-01a	MEL-10	AFD1 required to provide. ADI functionality at Aft Flight Station.
MTU IRIG-B	0 of 1	INS-03	MEL-10	Highly desired but not Reqd for STS-125.
FREQ DIV 1-PL CLOCK	0 of 1	INS-03	MEL-10	Not Reqd for STS-125.
FREQ DIV 1,2 PSP CLOCK	0 of 2	INS-03	MEL-10	Not Reqd for STS-125.
FREQ DIV 3-PL CLOCK	0 of 1	INS-03	MEL-10	Not Reqd for STS-125.

Minimum Equipment List STS-125 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
INCO				
S-BND PWR AMP	2 of 2	CT-09	MEL-11	For STS-125, hi or low freq is acceptable. Low freq will be used for launch.
S-BND PRE AMP	2 of 2	CT-03	MEL-11	For STS-125, hi or low freq is acceptable. Low freq will be used for launch.
S-BND XPNDR (PM)	2 of 2	CT-02	MEL-11	For STS-125, hi or low freq is acceptable. Low freq will be used for launch.
SOLID STATE RCDR	1 of 2	INS-02a	MEL-11	Required to record and playback LOS data.
PSP	2 of 2	None	MEL-11	Required to RF command link to HST and hardline command link to RNS.
PI	2 of 2	None	MEL-11	Required to RF command and telemetry link to HST.
PDI	1 of 1	None	MEL-11	PDI required for SSV, HST, and RNS telemetry (Spare PDI is also required).
OIU	0 of 2	None	None	Not Required for STS-125.
KU-BAND COMM/RADAR	1 of 1	None	MEL-11	The KU-Band is required for HST rendezvous, grapple, ungrapple and TV activities.
SSV	1 of 1	None	None	Required as backup for loss of Ku-Band downlink video.
SPACE TO SPACE ORBITER RADIO	1 of 1	None	None	The SSOR is required for scheduled and contingency EVAs.(This includes two strings with two frequencies on each string).
SPACE TO SPACE EMU RADIOS	2 of 2	None	None	Two SSERs are required for scheduled EVAs. (This includes two strings with two frequencies on each string).

Minimum Equipment List STS-125 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
WIRELESS VIDEO SYSTEM				
WVS S-BAND ANT	5 of 5	None	None	Required for STS-125.
WVS UHF ANT	1 of 1	None	None	Required for STS-125.
WVS TRANSCEIVER	2 of 2	None	None	Required for STS-125.
WVS INTERFACE BOX	1 of 1	None	None	Required for STS-125.
CCTV SYSTEM				
CAMERAS A,D	2 of 2	None	MEL-11	Payload bay cameras A,B, C & D are all required for HST EVA Viewing
B,C	2 of 2	None	MEL-11	
KEEL	1 of 1	None	None	
RMS Elbow	1 of 1	None	None	TPS survey operations and are used as backup to the PLBD bulkhead microswitches. A or D can cover the fwd bulkhead latches. B or C can cover the aft bulkhead latches. KEEL camera is required for Rndz/grapple/berth/ unberth. RMS cameras are used for HST grapple and berthing operations and surveys.
RMS Wrist	1 of 1	None	None	
RSC	1 of 1	None	None	Required for clearance views during TPS survey and focused inspections.
MONITORS	2 of 2	None	MEL-11	Both monitors required for STS-125 for RMS and EVA task monitoring.
VPU	1 of 1	None	None	Required for FSS, RSC, and OBSS Sensor Package 1 commanding and video.
DIGITAL TELEVISION (DTV)				
DSR-25 VTR	1 of 1	None	None	Required for CCTV recording.
VERTICAL INTERVAL PROCESSOR (VIP)	1 OF 1	None	None	Required for recording and downlink of camera data.
MUX	1 of 1	None	None	Required to provide power to VTR and the interface for downlink digital video.

Minimum Equipment List STS-125 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
PDRS				
SHOULDER BRACE RELEASE	1 of 1	None	MEL-09	RMS Reqd for nominal mission.
PORT JETTISON SYS	2 of 2	None	MEL-09	Safety requirement.
PORT MPM MOTORS	2 of 2	AFM-12	MEL-09	MPM deploy required for mission success.
PORT MPM DPL/STOW CMD	Reqd	None	MEL-09	Required for mission success.
PORT MRL MOTORS	2*of 2	AFM-13	MEL-09	*Full redundancy needed to maintain ops margin for mission critical RMS.
PORT MRL LATCH IND	1 of 2 per pedestal	AFM-13	MEL-09	SODB states req’t for 3 of 3 latches for entry. Flt specific analysis Reqd to allow 2 of 3 latches for entry.
THC AXIS CNTL	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives. Timeline impacted.
RHC AXIS CNTL	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives. Timeline impacted.
AUTO MODE	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives. Timeline impacted.
OPR CMDED MODE	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives. Timeline impacted.
MAN AUG MODE	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives. Timeline impacted.

Minimum Equipment List STS-125 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
SINGLE MODE	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives. Timeline impacted.
DIRECT MODE	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives.
BACKUP MODE	Reqd	None	MEL-09	Required for redundancy for primary mission objectives.
BRAKES	Reqd	None	MEL-09	Safety requirement.
AUTO BRAKES	Reqd	None	MEL-09	Safety requirement.
CAPTURE AND RIGIDIZE	Reqd	None	MEL-09	EE operations required for primary mission objectives.
DERIGIDIZE	Reqd	None	MEL-09	EE operations required for primary mission objectives.
RELEASE	Reqd	None	MEL-09	EE operations required for primary mission objectives.
BACKUP RELEASE	*Not Reqd	None	MEL-09	*Not Reqd for primary mission objectives provided manual or auto capability exists.
RMS HEATERS	1*of 2	None	MEL-09	*Single system is acceptable.
OBSS				
STBD JETTISON SYS	2 of 2	None	None	Safety requirement.
STBD MPM MOTORS	2 of 2	None	None	MPM deploy required for mission success.
STBD MPM DPL/STOW CMD	Reqd	None	None	Required for mission success.
STBD MRL MOTORS	2*of 2	None	None	*Full redundancy needed to maintain ops margin for OBSS latching.
STBD MRL LATCH IND	1 of 2 per pedestal	None	None	3 of 3 latches Reqd for entry.
OBSS HEATERS	1*of 2	None	None	*Single system is acceptable.
LDRI	Reqd	None	None	Reqd for critical damage detection.
LCS	Reqd	None	None	Reqd for critical damage detection.

Minimum Equipment List STS-125 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
ITVC	Reqd	None	None	Reqd as mounting and pan/tilt interface for LDRI.
IDC	Reqd	None	None	Reqd for critical damage detection
ECLS				
EXT AIRLK				
MNA & MNB H2O				
LINE HTRS	1 of 2	None	None	Loss of heaters will cause freezing of external water lines.
MNC H2O				
LINE HTRS	1 of 1	None	None	Loss of heaters will cause freezing of external water lines.
STRUCT HTRS	1 of 2	None	None	Loss of heaters will cause freezing of internal airlock water lines resulting in loss of EMU servicing. Passive thermal control via attitude changes may not be possible due to PL constraints.
TUNNEL BOOSTER FAN	0 of 2	None	None	Not required for STS-125.
VESTIBULE VENT VALVES	0 of 4	None	None	Not required for STS-125.
FLOW PROP MODULE	0 of 2	ECL-40	None	Nominal configuration for STS-125 is both FPV's in ICH.

Minimum Equipment List STS-125 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
GO2 XFER ISOLATION VLV	0 of 1	None	None	Not required for STS-125.
MMU GN2 SPLY ISOL VLV A	0 of 1	None	None	Not required for STS-125.
ODS GN2 XFER PANEL FLOW VLV	0 of 1	None	None	Not required for STS-125.
ODS GO2 XFER PANEL FLOW VLV	0 of 1	None	None	Not required for STS-125.
EMU O2 ISOL VLV	1 of 1	None	None	Required for STS-125 EVAs.

Minimum Equipment List STS-126
Mission Specific Exceptions

Minimum Equipment List STS-126 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
GNC				
AFT RHC XDCRS	3 of 3/ Axis	None	MEL-04	One fault tolerance required in all axes for nominal procedures.
AFT THC CNTCTS	3 of 3/ Axis	None	MEL-04	One fault tolerance required in all axes for nominal procedures.
AFT DDU				
PWR SUP A,B,C	3 of 3	None	MEL-04	Reqd for THC and RHC for mission success. Device Driver Units do not have Power Supplies D & E.
HUD	1* of 2	None	MEL-04	*CDR HUD reqd for night landing capability. *0 of 2 if no night landing.
FWD,AFT DAP PRI	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during RNDZ/Prox Ops.
FWD,AFT TRANS X NORM	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANS X PULSE	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANS Y NORM	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANS Y PULSE	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANSL LO Z	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANSL Z NORM	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANSL Z PULSE	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANSL Z HIGH	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT DAP CNTL LVLH	4 of 6	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT DAP ALT	4 of 4	None	MEL-04	ALT DAP required for nominal ops.
FWD,AFT DAP SPARE PBI	4 of 4	None	MEL-04	Required for docking.
TCS	1 of 1	None	None	Required for range and range rate during ISS approach and fly-around.

Minimum Equipment List STS-126 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
PROP				
AFT JET HTRS	24 of 24	RCS-06	MEL-05	Periodic RCS firings not acceptable.
FWD JET HTRS	14 of 14	RCS-06	MEL-05	Periodic RCS firings not acceptable.
VERNIER JETS	6 of 6	RCS-07	MEL-05	Not all primary flight objectives can be accomplished after loss of verniers.
VERN DRIVER	1 of 1	GNC-46	MEL-05	Same note as VERNIER JETS.
VERN JET HTRS	6 of 6	None	MEL-05	Same note as VERNIER JETS.
EPDC				
PL BAY LIGHTS 1 & 2	1 of 2	None	MEL-07	Required for PLBD forward Bulkhead latch verification.
FWD BLKHD	0 of 1	None	MEL-07	Not required.
3 & 4	1 of 2	None	MEL-07	Required for PLBD latch verification.
5 & 6	1 of 2	None	MEL-07	Required for PLBD latch verification.
Cabin Lighting	0*	None	MEL-07	* Crew discretion
ACA 4,5	2 of 2	None	MEL-07	Reqd for Aft DAP panel
PL PRI bus	1 of 1	None	None	Required for 28 V MPLM heaters
PL CAB 1	1 of 1	None	None	Required for Secondary C/L Camera & Keel Camera & Illum. Assy.
PL CAB 2	1 of 1	None	None	Required for PDIPs (1& 2) & SSPL/PSSC
PL CAB 3	1 of 1	None	None	Required for Primary C/L Camera, OIU-1, PL Timing Buffer, SSPL/PSSC, SPEE and OBSS control power.

Minimum Equipment List STS-126 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
PL AUX B	1 of 1	None	None	Required for OIU-2, and TCS.
PL AUX A	1 of 1	None	None	Required for DTV MUX.
PL AFT MNB	1 of 1	None	None	Required for SSPL/PSSC.
PL AFT MNC	1 of 1	None	None	Required for LMC.
PL AC2	1 of 1	None	None	Phase A required for DTV VIP.
PL AC3	0 of 1	None	None	Not Required for STS-126.
SSPTS PTU 1 & 2	2 of 2	None	None	APCU1 function of PTU1 is required for MPLM. The APCU2 function of PTU2 is required for LCS/IDC. PTU1 OPCU1 and PTU2 OPCU2 required for Station to Shuttle power transfer.
MMACS				
RADIATOR LTCH/PNL MTRS	1*of 2/ panel	AFM-04	MEL-09	Rad deploy not planned for STS-126. (*2 of 2 if deploy required – may be required for water transfer requirements.)
	1*of 2/ latch actuator	AFM-05	MEL-09	Rad deploy not planned for STS-126. (*2 of 2 if deploy required. – may be required for water transfer requirements.)
PRLA MTRS, AKA MTRS	2 of 2/	PAY-01	MEL-09	Four longeron latches and one keel latch(MPLM).
KU-BAND DEPLOY MTRS	2 of 2	None	MEL-09	Required to support ISS Rndz.
ROEU	1 of 1	ROEU-01 ROEU-02 ROEU-03	None None None	Required for power and data to the MPLM.
DPS				
AFT KYBD	0 of 1	DPS-01a BFS-10a	MEL-10	Not Reqd for STS-126.
IDP(AFT)	0 OF 1	DPS-01a BFS-01a	MEL-10	Not Reqd for STS-126.
MDU CRT4	0 OF 1	DPS-01a BFS-01a	MEL-10	Not Reqd for STS-126.
MDU AFD1	1 OF 1	DPS-01a BFS-01a	MEL-10	AFD1 required to provide. ADI functionality at Aft Flight Station.
MTU IRIG-B	0 of 1	INS-03	MEL-10	Highly desired but not Reqd for STS-126.
FREQ DIV 1-PL CLOCK	0 of 1	INS-03	MEL-10	Not Reqd for STS-126.
FREQ DIV 1,2 PSP CLOCK	2 of 2	INS-03	MEL-10	Reqd for ISS commanding via OIU's. commanding through PSP.
FREQ DIV 3-PL CLOCK	0 of 1	INS-03	MEL-10	Not Reqd for STS-126.

Minimum Equipment List STS-126 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
INCO				
S-BND PWR AMP	2 of 2	CT-09	MEL-11	For STS-126, hi or low freq is acceptable. Low freq will be used for launch.
S-BND PRE AMP	2 of 2	CT-03	MEL-11	For STS-126, hi or low freq is acceptable. Low freq will be used for launch.
S-BND XPNDR (PM)	2 of 2	CT-02	MEL-11	For STS-126, hi or low freq is acceptable. Low freq will be used for launch.
SOLID STATE RCDR	1 of 2	INS-02a	MEL-11	Required to record and playback LOS data.
PSP	2 of 2	None	MEL-11	Required for ISS commanding (including OIU Configuration control).
PDI	1 of 1	None	MEL-11	PDI required for SSV, ISS TLM and TCS.
OIU	1 of 2	None	None	Required to support SSRMS downlink during ISS LOS periods. ISS command & TLM is available via ISS S-Band system. MPLM commands and data are sent through OIU while MPLM is in the shuttle PLB.
KU-BAND COMM/RADAR	1 of 1	None	MEL-11	The KU-Band is required for ISS rendezvous, docking, undocking and TV activities.
SSV	1 of 1	None	None	Required as backup for loss of Ku-Band downlink video.
SPACE TO SPACE ORBITER RADIO	1 of 1	None	None	The SSOR is required for scheduled and contingency EVAs and during ISS rendezvous and separation for ship-to-ship communications. (This includes two strings with two frequencies on each string).
SPACE TO SPACE EMU RADIOS	2 of 2	None	None	Two SSERs are required for scheduled EVAs. (This includes two strings with two frequencies on each string).

Minimum Equipment List STS-126 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
WIRELESS VIDEO SYSTEM				
WVS S-BAND ANT	7 of 7	None	None	Due to uncertainty in the ISS powerdown plan shuttle WVS may be required for EVA situational awareness during some EVAs. This will have to be a real time call during EVA Prep.
WVS UHF ANT	1 of 1	None	None	Required for EVA situational awareness. ISS WVS may be powered off for some EVAs.
WVS TRANSCEIVER	2 of 2	None	None	Required for EVA situational awareness. ISS WVS may be powered off for some EVAs.
WVS INTERFACE BOX	1 of 1	None	None	Required for EVA situational awareness. ISS WVS may be powered off for some EVAs.
CCTV SYSTEM				
CAMERAS A,D	2 of 2	None	MEL-11	Payload bay cameras A,B, C & D are all required for assembly and TPS survey operations and are used as backup to the PLBD bulkhead microswitches. A or D can cover the fwd bulkhead latches. B or C can cover the aft bulkhead latches. ODS centerline camera is required for ISS Rndz/undock. RMS cameras are used for ISS survey and assembly operations.
B,C	2 of 2	None	MEL-11	
ODS Centerline	1 of 2	None	None	
RMS Elbow	1 of 1	None	None	
RMS Wrist	1 of 1	None	None	
RSC	1 of 1	None	None	Required for clearance views during TPS survey and focused inspections.
MONITORS	2 of 2	None	MEL-11	Both monitors required for STS-126 for RMS and EVA task monitoring.
VPU	1 of 1	None	None	Required for centerline, WVS camera, RSC OBSS Sensor Package 1 and ISS video routing.
DIGITAL TELEVISION (DTV)				
DSR-25 VTR	1 of 1	None	None	Required for CCTV recording.

Minimum Equipment List STS-126 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
VERTICAL INTERVAL PROCESSOR (VIP)	1 OF 1	None	None	Required for recording and downlink of camera data.
MUX	1 of 1	None	None	Required to provide power to VTR and the interface for downlink digital video.
PDRS				
SHOULDER BRACE RELEASE	1 of 1	None	MEL-09	RMS Reqd for nominal mission.
PORT JETTISON SYS	2 of 2	None	MEL-09	Safety requirement.
PORT MPM MOTORS	2 of 2	AFM-12	MEL-09	MPM deploy required for mission success.
PORT MPM DPL/STOW CMD	Reqd	None	MEL-09	Required for mission success.
PORT MRL MOTORS	2*of 2	AFM-13	MEL-09	*Full redundancy needed to maintain ops margin for mission critical RMS.
PORT MRL LATCH IND	1 of 2 per pedestal	AFM-13	MEL-09	SODB states req't for 3 of 3 latches for entry. Flt specific analysis Reqd to allow 2 of 3 latches for entry.
THC AXIS CNTL	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives. Timeline impacted.
RHC AXIS CNTL	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives. Timeline impacted.
AUTO MODE	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives. Timeline impacted.
OPR CMDED MODE	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives. Timeline impacted.
MAN AUG MODE	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives. Timeline impacted.

Minimum Equipment List STS-126 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
SINGLE MODE	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives. Timeline impacted.
DIRECT MODE	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives.
BACKUP MODE	Reqd	None	MEL-09	Required for redundancy for primary mission objectives.
BRAKES	Reqd	None	MEL-09	Safety requirement.
AUTO BRAKES	Reqd	None	MEL-09	Safety requirement.
CAPTURE AND RIGIDIZE	Reqd	None	MEL-09	EE operations required for primary mission objectives.
DERIGIDIZE	Reqd	None	MEL-09	EE operations required for primary mission objectives.
RELEASE	Reqd	None	MEL-09	EE operations required for primary mission objectives.
BACKUP RELEASE	*Not Reqd	None	MEL-09	*Not Reqd for primary mission objectives provided manual or auto capability exists.
RMS HEATERS	1*of 2	None	MEL-09	*Single system is acceptable.
OBSS				
STBD JETTISON SYS	2 of 2	None	None	Safety requirement.
STBD MPM MOTORS	2 of 2	None	None	MPM deploy required for mission success.
STBD MPM DPL/STOW CMD	Reqd	None	None	Required for mission success.
STBD MRL MOTORS	2*of 2	None	None	*Full redundancy needed to maintain ops margin for OBSS latching.
STBD MRL LATCH IND	1 of 2 per pedestal	None	None	3 of 3 latches Reqd for entry.
OBSS HEATERS	1*of 2	None	None	*Single system is acceptable.
LDRI	Reqd	None	None	Reqd for critical damage detection.
LCS	Reqd	None	None	Reqd for critical damage detection.

Minimum Equipment List STS-126 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
ITVC	Reqd	None	None	Reqd as mounting and pan/tilt interface for LDRI.
IDC	Reqd	None	None	Reqd for critical damage detection
AIRLOCK/DOCKING SYS				
ODS APDS HOOK MTRS	2 of 2/ gang	None	None	Reqd for shuttle/ISS stage dock/undock.
RING MTRS	2 of 2	None	None	Reqd for shuttle/ISS stage dock/undock.
CAP LAT MTRS	1 of 1/ Latch	None	None	Reqd for shuttle/ISS stage dock/undock.
PMA 1 APDS HOOK MTRS	0 of 2/ Latch	None	None	Not Reqd for STS-126.
PMA 2 APDS HOOK MTRS	0 of 2/ Latch	None	None	Not Reqd for STS-126.
ODS Vestibule Lights	2 of 2	None	None	Required for docking operations.
ODS Truss Lights	2 of 2	None	None	Required for docking operations.
ECLS				
EXT AIRLK				
MNA & MNB H2O LINE HTRS	1 of 2	None	None	Loss of heaters will cause freezing of external water lines.
MNC H2O LINE HTRS	1 of 1	None	None	Loss of heaters will cause freezing of external water lines.
STRUCT HTRS	1 of 2	None	None	Loss of heaters will cause freezing of internal airlock water lines resulting in loss of EMU servicing. Passive thermal control via attitude changes may not be possible due to PL constraints.
TUNNEL BOOSTER FAN	1 of 2	None	None	Reqd for condensate cntl and air quality.
VESTIBULE VENT VALVES	2 of 4	None	None	Reqd to depress ISS/ Shuttle vestibule prior to undocking. VENT and VENT ISOL valves required on same system.
FLOW PROP MODULE	0 of 2	ECL-40	None	Nominal configuration for STS-126 is both FPV's in ICH.

Minimum Equipment List STS-126 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
GO2 XFER ISOLATION VLV	1 of 1	None	None	Required for transfer of GO2 to ISS high pressure GO2 tanks.
MMU GN2 SPLY ISOL VLV A	1 of 1	None	None	Required for transfer of GN2 to ISS high pressure GN2 tanks.
ODS GN2 XFER PANEL FLOW VLV	1 of 1	None	None	Required for transfer of GN2 to ISS high pressure GN2 tanks.
ODS GO2 XFER PANEL FLOW VLV	1 of 1	None	None	Required for transfer of GO2 to ISS high pressure GO2 tanks.
EMU O2 ISOL VLV	1 of 1	None	None	Required for transfer of GO2 to ISS high pressure GO2 tanks.

Minimum Equipment List STS-400
Mission Specific Exceptions

Minimum Equipment List STS-400 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
GNC				
AFT RHC XDCRS	3 of 3/ Axis	None	MEL-04	One fault tolerance required in all axes for nominal procedures.
AFT THC CNTCTS	3 of 3/ Axis	None	MEL-04	One fault tolerance required in all axes for nominal procedures.
AFT DDU				
PWR SUP A,B,C	3 of 3	None	MEL-04	Reqd for THC and RHC for mission success. Device Driver Units do not have Power Supplies D & E.
HUD	1* of 2	None	MEL-04	*CDR HUD reqd for night landing capability. *0 of 2 if no night landing.
FWD,AFT DAP PRI	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during RNDZ/Prox Ops.
FWD,AFT TRANS X NORM	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANS X PULSE	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANS Y NORM	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANS Y PULSE	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANSL LO Z	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANSL Z NORM	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANSL Z PULSE	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT TRANSL Z HIGH	4 of 4	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT DAP CNTL LVLH	4 of 6	None	MEL-04	Reqd for 1 fault tolerance during proximity ops.
FWD,AFT DAP ALT	4 of 4	None	MEL-04	ALT DAP required for nominal ops.
FWD,AFT DAP SPARE PBI	4 of 4	None	MEL-04	Required for docking.
TCS	0 of 1	None	None	Not required for STS-400.

Minimum Equipment List STS-400 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
PROP				
AFT JET HTRS	24 of 24	RCS-06	MEL-05	Periodic RCS firings not acceptable.
FWD JET HTRS	14 of 14	RCS-06	MEL-05	Periodic RCS firings not acceptable.
VERNIER JETS	6 of 6	RCS-07	MEL-05	Not all primary flight objectives can be accomplished after loss of verniers.
VERN DRIVER	1 of 1	GNC-46	MEL-05	Same note as VERNIER JETS.
VERN JET HTRS	6 of 6	None	MEL-05	Same note as VERNIER JETS.
EPDC				
PL BAY LIGHTS 1 & 2	1 of 2	None	MEL-07	Required for PLBD forward Bulkhead latch verification.
FWD BLKHD	0 of 1	None	MEL-07	Not required.
3 & 4	1 of 2	None	MEL-07	Required for PLBD latch verification.
5 & 6	1 of 2	None	MEL-07	Required for PLBD latch verification.
Cabin Lighting	0*	None	MEL-07	* Crew discretion
ACA 4,5	2 of 2	None	MEL-07	Reqd for Aft DAP panel
PL PRI bus	0 of 1	None	None	Not required for STS-400.
PL CAB 1	0 of 1	None	None	Not required for STS-400.
PL CAB 2	1 of 1	None	None	Required for PDIPs (1& 2).
PL CAB 3	1 of 1	None	None	Required for rescue.

Minimum Equipment List STS-400 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
PL AUX B	0 of 1	None	None	Not required for STS-400.
PL AUX A	1 of 1	None	None	Required for DTV MUX.
PL AFT MNB	0 of 1	None	None	Used by SSPL/PSSC heaters.
PL AFT MNC	0 of 1	None	None	Not required for STS-400.
PL AC2	1 of 1	None	None	Phase A required for DTV VIP.
PL AC3	0 of 1	None	None	Not required for STS-400.
SSPTS PTU 1 & 2	1 of 2	None	None	APCU function required for OBSS. Provides power for LCS/IDC.
MMACS				
RADIATOR LTCH/PNL MTRS	1*of 2/ panel	AFM-04	MEL-09	Rad deploy not planned for STS-400.
	1*of 2/ latch actuator	AFM-05	MEL-09	Rad deploy not planned for STS-400.
PRLA MTRS, AKA MTRS	0 of 2/	PAY-01	MEL-09	Not Required for STS-400.
KU-BAND DEPLOY MTRS	2 of 2	None	MEL-09	Required to support rescue Rndz.
ROEU	0 of 1	ROEU-01 ROEU-02 ROEU-03	None None None	Not required for STS-400.
DPS				
AFT KYBD	0 of 1	DPS-01a BFS-10a	MEL-10	Not Reqd for STS-400.
IDP(AFT)	0 OF 1	DPS-01a BFS-01a	MEL-10	Not Reqd for STS-400.
MDU CRT4	0 OF 1	DPS-01a BFS-01a	MEL-10	Not Reqd for STS-400.
MDU AFD1	1 OF 1	DPS-01a BFS-01a	MEL-10	AFD1 required to provide. ADI functionality at Aft Flight Station.
MTU IRIG-B	0 of 1	INS-03	MEL-10	Highly desired but not Reqd for STS-400.
FREQ DIV 1-PL CLOCK	0 of 1	INS-03	MEL-10	Not Reqd for STS-400.
FREQ DIV 1,2 PSP CLOCK	0 of 2	INS-03	MEL-10	Not Reqd for STS-400.
FREQ DIV 3-PL CLOCK	0 of 1	INS-03	MEL-10	Not Reqd for STS-400.

Minimum Equipment List STS-400 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
INCO				
S-BND PWR AMP	2 of 2	CT-09	MEL-11	For STS-400, hi or low freq is acceptable. Low freq will be used for launch.
S-BND PRE AMP	2 of 2	CT-03	MEL-11	For STS-400, hi or low freq is acceptable. Low freq will be used for launch.
S-BND XPNDR (PM)	2 of 2	CT-02	MEL-11	For STS-400, hi or low freq is acceptable. Low freq will be used for launch.
SOLID STATE RCDR	1 of 2	INS-02a	MEL-11	Required to record and playback LOS data.
PSP	0 of 2	None	MEL-11	Not required for STS-400.
PI	0 of 2	None	MEL-11	Not required for STS-400.
PDI	1 of 1	None	MEL-11	PDI required for SSV.
OIU	0 of 2	None	None	Not Required for STS-400.
KU-BAND COMM/RADAR	1 of 1	None	MEL-11	The KU-Band is required for HST rendezvous, and TV activities.
SSV	1 of 1	None	None	Required as backup for loss of Ku-Band downlink video.
SPACE TO SPACE ORBITER RADIO	1 of 1	None	None	The SSOR is required for scheduled and contingency EVAs and during HST rendezvous and separation for ship-to-ship communications. (This includes two strings with two frequencies on each string).
SPACE TO SPACE EMU RADIOS	2 of 2	None	None	Two SSERs are required for scheduled EVAs. (This includes two strings with two frequencies on each string).

Minimum Equipment List STS-400 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
WIRELESS VIDEO SYSTEM				
WVS S-BAND ANT	0 of 7	None	None	Not required for STS-400.
WVS UHF ANT	0 of 1	None	None	Not required for STS-400.
WVS TRANSCEIVER	0 of 2	None	None	Not required for STS-400.
WVS INTERFACE BOX	0 of 1	None	None	Not required for STS-400.
CCTV SYSTEM				
CAMERAS A,D	2 of 2	None	MEL-11	Payload bay cameras A,B, C & D are all required for rescue EVA Viewing TPS survey operations and are used as backup to the PLBD bulkhead microswitches. A or D can cover the fwd bulkhead latches. B or C can cover the aft bulkhead latches. RMS cameras are used for rescue operations and surveys. Keel camera is not required for STS-400.
B,C	2 of 2	None	MEL-11	
KEEL	0 of 1	None	None	
RMS Elbow	1 of 1	None	None	
RMS Wrist	1 of 1	None	None	
RSC	1 of 1	None	None	Required for clearance views during TPS survey and focused inspections.
MONITORS	2 of 2	None	MEL-11	Both monitors required for STS-400 for RMS and EVA task monitoring.
VPU	1 of 1	None	None	Required for RSC, and OBSS Sensor Package 1 commanding and video.
DIGITAL TELEVISION (DTV)				
DSR-25 VTR	1 of 1	None	None	Required for CCTV recording.
VERTICAL INTERVAL PROCESSOR (VIP)	1 OF 1	None	None	Required for recording and downlink of camera data.
MUX	1 of 1	None	None	Required to provide power to VTR and the interface for downlink digital video.

Minimum Equipment List STS-400 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
PDRS				
SHOULDER BRACE RELEASE	1 of 1	None	MEL-09	RMS Reqd for nominal mission.
PORT JETTISON SYS	2 of 2	None	MEL-09	Safety requirement.
PORT MPM MOTORS	2 of 2	AFM-12	MEL-09	MPM deploy required for mission success.
PORT MPM DPL/STOW CMD	Reqd	None	MEL-09	Required for mission success.
PORT MRL MOTORS	2*of 2	AFM-13	MEL-09	*Full redundancy needed to maintain ops margin for mission critical RMS.
PORT MRL LATCH IND	1 of 2 per pedestal	AFM-13	MEL-09	SODB states req't for 3 of 3 latches for entry. Flt specific analysis Reqd to allow 2 of 3 latches for entry.
THC AXIS CNTL	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives. Timeline impacted.
RHC AXIS CNTL	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives. Timeline impacted.
AUTO MODE	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives. Timeline impacted.
OPR CMDED MODE	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives. Timeline impacted.
MAN AUG MODE	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives. Timeline impacted.

Minimum Equipment List STS-400 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
SINGLE MODE	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives. Timeline impacted.
DIRECT MODE	*Not Reqd	None	MEL-09	*Assumes this is the only mode lost. Can use other RMS modes to accomplish primary mission objectives.
BACKUP MODE	Reqd	None	MEL-09	Required for redundancy for primary mission objectives.
BRAKES	Reqd	None	MEL-09	Safety requirement.
AUTO BRAKES	Reqd	None	MEL-09	Safety requirement.
CAPTURE AND RIGIDIZE	Reqd	None	MEL-09	EE operations required for primary mission objectives.
DERIGIDIZE	Reqd	None	MEL-09	EE operations required for primary mission objectives.
RELEASE	Reqd	None	MEL-09	EE operations required for primary mission objectives.
BACKUP RELEASE	*Not Reqd	None	MEL-09	*Not Reqd for primary mission objectives provided manual or auto capability exists.
RMS HEATERS	1*of 2	None	MEL-09	*Single system is acceptable.
OBSS				
STBD JETTISON SYS	2 of 2	None	None	Safety requirement.
STBD MPM MOTORS	2 of 2	None	None	MPM deploy required for mission success.
STBD MPM DPL/STOW CMD	Reqd	None	None	Required for mission success.
STBD MRL MOTORS	2*of 2	None	None	*Full redundancy needed to maintain ops margin for OBSS latching.
STBD MRL LATCH IND	1 of 2 per pedestal	None	None	3 of 3 latches Reqd for entry.
OBSS HEATERS	1*of 2	None	None	*Single system is acceptable.
LDRI	Reqd	None	None	Reqd for critical damage detection.
LCS	Reqd	None	None	Reqd for critical damage detection.

Minimum Equipment List STS-400 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
ITVC	Reqd	None	None	Reqd as mounting and pan/tilt interface for LDRI.
IDC	Reqd	None	None	Reqd for critical damage detection
AIRLOCK/DOCKING SYS				
ODS APDS HOOK MTRS	0 of 2/	None	None	Not Reqd for STS-400.
RING MTRS	0 of 2	None	None	Not Reqd for STS-400.
CAP LAT MTRS	0 of 1/	None	None	Not Reqd for STS-400.
PMA 1 APDS HOOK MTRS	0 of 2/ Latch	None	None	Not Reqd for STS-400.
PMA 2 APDS HOOK MTRS	0 of 2/ Latch	None	None	Not Reqd for STS-400.
ODS Vestibule Lights	0 of 2	None	None	Not Reqd for STS-400.
ODS Truss Lights	0 of 2	None	None	Not Reqd for STS-400.
ECLS				
EXT AIRLK				
MNA & MNB H2O LINE HTRS	1 of 2	None	None	Loss of heaters will cause freezing of external water lines.
MNC H2O LINE HTRS	1 of 1	None	None	Loss of heaters will cause freezing of external water lines.
STRUCT HTRS	1 of 2	None	None	Loss of heaters will cause freezing of internal airlock water lines resulting in loss of EMU servicing. Passive thermal control via attitude changes may not be possible due to PL constraints.
TUNNEL BOOSTER FAN	0 of 2	None	None	Not required for STS-400.
VESTIBULE VENT VALVES	0 of 4	None	None	Not required for STS-400.
FLOW PROP MODULE	0 of 2	ECL-40	None	Nominal configuration for STS-400 is both FPV's in ICH.

Minimum Equipment List STS-400 Mission Specific Exceptions

LRU/Function	Req't	SSID	MEL Ref	Notes
GO2 XFER ISOLATION VLV	0 of 1	None	None	Not required for STS-400.
MMU GN2 SPLY ISOL VLV A	0 of 1	None	None	Not required for STS-400.
ODS GN2 XFER PANEL FLOW VLV	0 of 1	None	None	Not required for STS-400.
ODS GO2 XFER PANEL FLOW VLV	0 of 1	None	None	Not required for STS-400.
EMU O2 ISOL VLV	1 of 1	None	None	Required for STS-400 EVAs.

APPENDIX I

MANDATORY INSTRUMENTATION LIST

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APPENDIX I: MANDATORY INSTRUMENTATION LIST

SSID No.	Description/Violation Call	Page
MIL-01	Flight Operations Mandatory Instrumentation List Assumptions and Guidelines	I-01.1
MIL-02	Guidance, Navigation and Control (GNC) Mandatory Instrumentation List	I-02.1
MIL-03	OMS/RCS Mandatory Instrumentation List	I-03.1
MIL-04	Booster Mandatory Instrumentation List	I-04.1
MIL-05	Electrical Power Distribution and Control Mandatory Instrumentation List	I-05.1
MIL-06	Life Support Systems Mandatory Instrumentation List	I-06.1
MIL-07	APU/HYD, Mechanical, RMS Mandatory Instrumentation List	I-07.1
MIL-08	Data Processing System Mandatory Instrumentation List	I-08.1
MIL-09	Communications and Instrumentation (INCO) Mandatory Instrumentation List	I-09.1

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Flight Operations Mandatory Instrumentation List Assumptions and Guidelines

Assumptions

A. The intent of this listing is to define those measurements required for system health and configuration monitoring and control post lift-off. As such, it is NOT an exhaustive listing of all measurements required to adequately checkout and verify the SSV capability for launch and does not duplicate all measurements currently in the LCC sections.

B. Some of the mandatory measurements are not monitorable during the period the LCC applies. Their performance or status is covered by OMRSD requirements which, at this time, do not accept any failure condition except by explicit waiver. Regardless of the minimum set of measurements finally agreed to, the OMRSD and in-flight checkout requirements will remain as is (i.e., any deviation from normal operating limits must be reported and, if accepted, waived) and any change from a full set must be formally waived based on the conditions at that time.

C. The PASS and BFS downlists are required. Parameters generated within the General Purpose Computers are not listed separately, but are considered part of the downlist.

D. The Downlink is also required and measurements specifically associated with it, such as synchronization and time, are also required. Specific subsystem measurements that could be individually lost and not affect the integrity of the downlink are treated within this listing.

Guidelines

A. Measurements required include those necessary to make ascent procedural and mission decisions. If a measurement loss only affects critical systems for ascent monitoring functions, telemetry (TM) and ground monitoring are acceptable provided required response times can be met. The mandatory category column will indicate whether the parameter is required on the ground (G, GRND or Ground), onboard (ONBD), both (BOTH) or either (blank).

B. Measurements required include those necessary to make in-flight GO/NO GO decisions for early flight termination. Judgement should be used where the failure mode is highly improbable, particularly if a single mandatory measurement is required.

C. Measurements required include those necessary to support CIL items for which mandatory Ops retention rationale is identified.

D. Where the GO/NO GO decision requires information on multiple redundant Line Replaceable Units (LRUs), enough instrumentation is required to allow a GO/NO GO decision consistent with the number of LRUs required.

E. For continuously operated systems, only end-item measurements are used to assure overall function of the system.

F. Caution and Warning (C&W) on an individual parameter is not necessarily mandatory. Each parameter to C&W is judged on its own merit.

G. Crew procedures impact to loss of instrumentation redundancy is generally acceptable. The assumption is that either the crew will take action on the simplex transducer or the critical procedure will be rewritten.

H. SSV measurements required to successfully complete primary mission objectives will be included in an addendum on a flight by flight basis. The addendum will be presented at the Flight Operations Review (FOR).

NOTE: The "GDLINE REF" designations in the tabular data to follow, relates to specific paragraphs on this page.

Where applicable, LCC page number references have been replaced with subsystem identifiers (SSIDs); i.e., GNC-XX.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V79A2040C	AA 1 LAT ACC UNCOMP	ONBD (1)	d			
V79A2041C	AA 1 NORM ACC UNCOMP					
V79A2043C	AA 2 LAT ACC UNCOMP					
V79A2044C	AA 2 NORM ACC UNCOMP					
V79A2046C	AA 3 LAT ACC UNCOMP					
V79A2047C	AA 3 NORM ACC UNCOMP					
V79A2048C	AA 4 LAT ACC UNCOMP					
V79A2049C	AA 4 NORM ACC UNCOMP					
V93X4435X	AA 1 FAIL/DES		d	GNC-13		
V93X4436X	AA 2 FAIL/DES					
V93X4437X	AA 3 FAIL/DES					
V93X4438X	AA 4 FAIL/DES					
V79R1830C	RGA 1 R RATE UNCOMP	ONBD (1)	d			(1)
V79R1831C	RGA 1 P RATE UNCOMP					
V79R1832C	RGA 1 Y RATE UNCOMP					
V79R1835C	RGA 2 R RATE UNCOMP					
V79R1836C	RGA 2 P RATE UNCOMP					
V79R1837C	RGA 2 Y RATE UNCOMP					
V79R1840C	RGA 3 R RATE UNCOMP					
V79R1841C	RGA 3 P RATE UNCOMP					
V79R1842C	RGA 3 Y RATE UNCOMP					
V79R1845C	RGA 4 R RATE UNCOMP					
V79R1846C	RGA 4 P RATE UNCOMP					
V79R1847C	RGA 4 Y RATE UNCOMP					

(1) Applies to all measurements.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V79X1860X	RGA 1 ROLL SMRD	GND (1)	d	GNC-11		
V79X1861X	RGA 1 PITCH SMRD					
V79X1862X	RGA 1 YAW SMRD					
V79X1865X	RGA 2 ROLL SMRD					
V79X1866X	RGA 2 PITCH SMRD					
V79X1867X	RGA 2 YAW SMRD					
V79X1870X	RGA 3 ROLL SMRD					
V79X1871X	RGA 3 PITCH SMRD					
V79X1872X	RGA 3 YAW SMRD					
V79X1875X	RGA 4 ROLL SMRD					
V79X1876X	RGA 4 PITCH SMRD					
V79X1877X	RGA 4 YAW SMRD					
V93X4516X	SEL/DES RATE GYRO 1		d	GNC-12		
V93X4518X	SEL/DES RATE GYRO 2					
V93X4520X	SEL/DES RATE GYRO 3					
V93X4522X	SEL/DES RATE GYRO 4					
V57H0065C	BODY FLAP POS FDBK 1		d	GNC-30		(2)
V57H0066C	BODY FLAP POS FDBK 2					
V57H0067C	BODY FLAP POS FDBK 3					
V57H0068C	BODY FLAP POS FDBK 4					
V57H0101C	RUDDER POS FDBK 1		d			(3)
V57H0102C	RUDDER POS FDBK 2					
V57H0103C	RUDDER POS FDBK 3					
V57H0104C	RUDDER POS FDBK 4					

(1) Applies to all measurements.
(2) Also SSID GNC-31.
(3) Related to SSID GNC-26.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V57H0150A	RUDDER CHAN 1 POS	3 of 4	d	GNC-26		(1)
V57H0151A	RUDDER CHAN 2 POS	(GND)				
V57H0152A	RUDDER CHAN 3 POS					
V57H0153A	RUDDER CHAN 4 POS					
V57P0160A	RUDDER DELTA PRESS 1	3 of 4	d	GNC-27		
V57P0161A	RUDDER DELTA PRESS 2	(GND)				
V57P0162A	RUDDER DELTA PRESS 3					
V57P0163A	RUDDER DELTA PRESS 4					
V57H0201C	SPD BK POS FDBK 1		d			(2)
V57H0202C	SPD BK POS FDBK 2					
V57H0203C	SPD BK POS FDBK 3					
V57H0204C	SPD BK POS FDBK 4					
V57H0250A	SPD BK CHAN 1 POS	3 of 4	d	GNC-26		(1)
V57H0251A	SPD BK CHAN 2 POS	(GND)				
V57H0252A	SPD BK CHAN 3 POS					
V57H0253A	SPD BK CHAN 4 POS					
V57P0260A	SPD BK DELTA PRESS 1	3 of 4	d	GNC-27		
V57P0261A	SPD BK DELTA PRESS 2	(GND)				
V57P0262A	SPD BK DELTA PRESS 3					
V57P0263A	SPD BK DELTA PRESS 4					
V58H0802A	LIB ELVN CHAN 1 POS	3 of 4	d	GNC-22		(3)
V58H0803A	LIB ELVN CHAN 2 POS	(GND)				
V58H0804A	LIB ELVN CHAN 3 POS					
V58H0805A	LIB ELVN CHAN 4 POS					

(1) Also SSID GNC-28.
(2) Related to SSID GNC-26.
(3) Also SSID GNC-25.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V58H0806C	LIB ELVN POS FDBK 1		d			(1)
V58H0807C	LIB ELVN POS FDBK 2					
V58H0808C	LIB ELVN POS FDBK 3					
V58H0809C	LIB ELVN POS FDBK 4					
V58P0812A	LIB ELVN SEC DEL P 1	3 of 4	d	GNC-24		
V58P0813A	LIB ELVN SEC DEL P 2	(GND)				
V58P0814A	LIB ELVN SEC DEL P 3					
V58P0815A	LIB ELVN SEC DEL P 4					
V58P0816C	LIB ELVN PRI DEL P 1		d	GNC-23		
V58P0817C	LIB ELVN PRI DEL P 2					
V58P0818C	LIB ELVN PRI DEL P 3					
V58P0819C	LIB ELVN PRI DEL P 4					
V58H0852A	LOB ELVN CHAN 1 POS	3 of 4	d	GNC-22		(2)
V58H0853A	LOB ELVN CHAN 2 POS	(GND)				
V58H0854A	LOB ELVN CHAN 3 POS					
V58H0855A	LOB ELVN CHAN 4 POS					
V58H0856C	LOB ELVN POS FDBK 1		d			(1)
V58H0857C	LOB ELVN POS FDBK 2					
V58H0858C	LOB ELVN POS FDBK 3					
V58H0859C	LOB ELVN POS FDBK 4					
V58P0862A	LOB ELVN SEC DEL P 1	3 of 4	d	GND-24		
V58P0863A	LOB ELVN SEC DEL P 2	(GND)				
V58P0864A	LOB ELVN SEC DEL P 3					
V58P0865A	LOB ELVN SEC DEL P 4					

(1) Related to SSID GNC-22.
(2) Also SSID GNC-25.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V58P0866C	LOB ELVN PRI DEL P 1		d	GNC-23		
V58P0867C	LOB ELVN PRI DEL P 2					
V58P0868C	LOB ELVN PRI DEL P 3					
V58P0869C	LOB ELVN PRI DEL P 4					
V58H0902A	RIB ELVN CHAN 1 POS	3 of 4	d	GNC-22		(1)
V58H0903A	RIB ELVN CHAN 2 POS	(GND)				
V58H0904A	RIB ELVN CHAN 3 POS					
V58H0905A	RIB ELVN CHAN 4 POS					
V58H0906C	RIB ELVN POS FDBK 1		d			(2)
V58H0907C	RIB ELVN POS FDBK 2					
V58H0908C	RIB ELVN POS FDBK 3					
V58H0909C	RIB ELVN POS FDBK 4					
V58P0912A	RIB ELVN SEC DEL P 1	3 of 4	d	GNC-24		
V58P0913A	RIB ELVN SEC DEL P 2	(GND)				
V58P0914A	RIB ELVN SEC DEL P 3					
V58P0915A	RIB ELVN SEC DEL P 4					
V58P0916C	RIB ELVN PRI DEL P 1		d	GNC-23		
V58P0917C	RIB ELVN PRI DEL P 2					
V58P0918C	RIB ELVN PRI DEL P 3					
V58P0919C	RIB ELVN PRI DEL P 4					
V58H0952A	ROB ELVN CHAN 1 POS	3 of 4	d	GNC-22		(1)
V58H0953A	ROB ELVN CHAN 2 POS	(GND)				
V58H0954A	ROB ELVN CHAN 3 POS					
V58H0955A	ROB ELVN CHAN 4 POS					

(1) Also SSID GNC-25.
(2) Related to SSID GNC-22.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V58H0956C	ROB ELVN POS FDBK 1		d			(2)
V58H0957C	ROB ELVN POS FDBK 2					
V58H0958C	ROB ELVN POS FDBK 3					
V58H0959C	ROB ELVN POS FDBK 4					
V58P0962A	ROB ELVN SEC DEL P 1	3 of 4	d	GNC-24		
V58P0963A	ROB ELVN SEC DEL P 2	(GND)				
V58P0964A	ROB ELVN SEC DEL P 3					
V58P0965A	ROB ELVN SEC DEL P 4					
V58P0966C	ROB ELVN PRI DEL P 1		d	GNC-23		
V58P0967C	ROB ELVN PRI DEL P 2					
V58P0968C	ROB ELVN PRI DEL P 3					
V58P0969C	ROB ELVN PRI DEL P 4					
V79X3201E	ASA ENA CMD 1	GND (1)	d	GNC-29		
V79X3202E	ASA UP CMD 1					
V79X3203E	ASA DN CMD 1					
V79X3204E	ASA ENA CMD 2					
V79X3205E	ASA UP CMD 2					
V79X3206E	ASA DN CMD 2					
V79X3207E	ASA ENA CMD 3					
V79X3208E	ASA UP CMD 3					
V79X3209E	ASA DN CMD 3					

(1) Applies to all measurements.
(2) Related to SSID GNC-22.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V72X4550X	FCS CHANNEL FAILURE		d	GNC-38		
V79X3260X	LIB ELVN ACTR 1 FAIL		d	GNC-38		
V79X3261X	LIB ELVN ACTR 2 FAIL					
V79X3262X	LIB ELVN ACTR 3 FAIL					
V79X3263X	LIB ELVN ACTR 4 FAIL					
V79X3265X	LOB ELVN ACTR 1 FAIL					
V79X3266X	LOB ELVN ACTR 2 FAIL					
V79X3267X	LOB ELVN ACTR 3 FAIL					
V79X3268X	LOB ELVN ACTR 4 FAIL					
V79X3270X	RIB ELVN ACTR 1 FAIL					
V79X3271X	RIB ELVN ACTR 2 FAIL					
V79X3272X	RIB ELVN ACTR 3 FAIL					
V79X3273X	RIB ELVN ACTR 4 FAIL					
V79X3275X	ROB ELVN ACTR 1 FAIL					
V79X3276X	ROB ELVN ACTR 2 FAIL					
V79X3277X	ROB ELVN ACTR 3 FAIL					
V79X3278X	ROB ELVN ACTR 4 FAIL					
V79X3331X	RUDDER ACTR 1 FAIL					
V79X3332X	RUDDER ACTR 2 FAIL					
V79X3333X	RUDDER ACTR 3 FAIL					
V79X3334X	RUDDER ACTR 4 FAIL					
V79X3336X	SPD BK ACTR 1 FAIL					
V79X3337X	SPD BK ACTR 2 FAIL					
V79X3338X	SPD BK ACTR 3 FAIL					
V79X3339X	SPD BK ACTR 4 FAIL					

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V58H1100A	CTR ME P ACTR POSN	5 of 6	d	GNC-40		(1)
V58H1150A	CTR ME Y ACTR POSN	(GND)				
V58H1200A	L ME P ACTR POSN					
V58H1250A	L ME Y ACTR POSN					
V58H1300A	R ME P ACTR POSN					
V58H1350A	R ME Y ACTR POSN					
V58P1181A	CTR ME P SEC DEL P A	3 of 4	d	GNC-41		
V58P1182A	CTR ME P SEC DEL P B	(GND)				
V58P1183A	CTR ME P SEC DEL P C					
V58P1184A	CTR ME P SEC DEL P D					
V58P1186A	CTR ME Y SEC DEL P A	3 of 4	d	GNC-41		
V58P1187A	CTR ME Y SEC DEL P B	(GND)				
V58P1188A	CTR ME Y SEC DEL P C					
V58P1189A	CTR ME Y SEC DEL P D					
V58P1281A	L ME P SEC DEL P A	3 of 4	d	GNC-41		
V58P1282A	L ME P SEC DEL P B	(GND)				
V58P1283A	L ME P SEC DEL P C					
V58P1284A	L ME P SEC DEL P D					
V58P1286A	L ME Y SEC DEL P A	3 of 4	d	GNC-41		
V58P1287A	L ME Y SEC DEL P B	(GND)				
V58P1288A	L ME Y SEC DEL P C					
V58P1289A	L ME Y SEC DEL P D					

(1) Also SSID GNC-42.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V58P1381A	R ME P SEC DEL P A	3 of 4 (GND)	d	GNC-41		
V58P1382A	R ME P SEC DEL P B					
V58P1383A	R ME P SEC DEL P C					
V58P1384A	R ME P SEC DEL P D					
V58P1386A	R ME Y SEC DEL P A	3 of 4 (GND)	d	GNC-41		
V58P1387A	R ME Y SEC DEL P B					
V58P1388A	R ME Y SEC DEL P C					
V58P1389A	R ME Y SEC DEL P D					

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V79X1170X	CTR ME P ACTR A FAIL		d	GNC-38		
V79X1171X	CTR ME Y ACTR A FAIL					
V79X1173X	CTR ME P ACTR B FAIL					
V79X1174X	CTR ME Y ACTR B FAIL					
V79X1176X	CTR ME P ACTR C FAIL					
V79X1177X	CTR ME Y ACTR C FAIL					
V79X1178X	CTR ME P ACTR D FAIL					
V79X1179X	CTR ME Y ACTR D FAIL					
V79X1270X	L ME P ACTR A FAIL					
V79X1271X	L ME Y ACTR A FAIL					
V79X1273X	L ME P ACTR B FAIL					
V79X1274X	L ME Y ACTR B FAIL					
V79X1276X	L ME P ACTR C FAIL					
V79X1277X	L ME Y ACTR C FAIL					
V79X1278X	L ME P ACTR D FAIL					
V79X1279X	L ME Y ACTR D FAIL					
V79X1370X	R ME P ACTR A FAIL					
V79X1371X	R ME Y ACTR A FAIL					
V79X1373X	R ME P ACTR B FAIL					
V79X1374X	R ME Y ACTR B FAIL					
V79X1376X	R ME P ACTR C FAIL					
V79X1377X	R ME Y ACTR C FAIL					
V79X1378X	R ME P ACTR D FAIL					
V79X1379X	R ME Y ACTR D FAIL					

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V43H2500C	L OMS PRI P ACTR POS		d	GNC-43		(1)
V43H2502C	L OMS PRI Y ACTR POS					
V43H2504C	L OMS SEC P ACTR POS					
V43H2506C	L OMS SEC Y ACTR POS					
V43H2550C	R OMS PRI P ACTR POS					
V43H2552C	R OMS PRI Y ACTR POS					
V43H2554C	R OMS SEC P ACTR POS					
V43H2556C	R OMS SEC Y ACTR POS					
V72K1155C	LH RHC ROLL CMD A		d	GNC-01		
V72K1156C	LH RHC PITCH CMD A					
V72K1157C	LH RHC YAW CMD A					
V72K1170C	LH RHC ROLL CMD B					
V72K1171C	LH RHC PITCH CMD B					
V72K1172C	LH RHC YAW CMD B					
V72K1185C	LH RHC ROLL CMD C					
V72K1186C	LH RHC PITCH CMD C					
V72K1187C	LH RHC YAW CMD C					
V72K1205C	RH RHC ROLL CMD A		d	GNC-01		
V72K1206C	RH RHC PITCH CMD A					
V72K1207C	RH RHC YAW CMD A					
V72K1220C	RH RHC ROLL CMD B					
V72K1221C	RH RHC PITCH CMD B					
V72K1222C	RH RHC YAW CMD B					
V72K1235C	RH RHC ROLL CMD C					
V72K1236C	RH RHC PITCH CMD C					
V72K1237C	RH RHC YAW CMD C					

(1) Also SSID GNC-44.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V72K1245C	AFT RHC ROLL CMD A	(1)	h	None		
V72K1246C	AFT RHC PITCH CMD A					
V72K1247C	AFT RHC YAW CMD A					
V72K1255C	AFT RHC ROLL CMD B					
V72K1256C	AFT RHC PITCH CMD B					
V72K1257C	AFT RHC YAW CMD B					
V72K1265C	AFT RHC ROLL CMD C					
V72K1266C	AFT RHC PITCH CMD C					
V72K1267C	AFT RHC YAW CMD C					
V72K1530C	L RPTA CMD A		d	GNC-03		
V72K1531C	L RPTA CMD B					
V72K1532C	L RPTA CMD C					
V72K1540C	R RPTA CMD A					
V72K1541C	R RPTA CMD B					
V72K1542C	R RPTA CMD C					
V72K1585C	R SBTC CMD A		d	GNC-04		
V72K1587X	R SBTC TAKEOVER A					
V72K1588C	R SBTC CMD B					
V72K1590X	R SBTC TAKEOVER B					
V72K1591C	R SBTC CMD C					
V72K1593X	R SBTC TAKEOVER C					

(1) Mission dependent (all).

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
B79R1410C	SRGA 1 PITCH RATE		d	GNC-16		
B79R1411C	SRGA 1 YAW RATE					
B79R1412C	SRGA 3 PITCH RATE					
B79R1413C	SRGA 3 YAW RATE					
B79R2410C	SRGA 2 PITCH RATE					
B79R2411C	SRGA 2 YAW RATE					
B79R2412C	SRGA 4 PITCH RATE					
B79R2413C	SRGA 4 YAW RATE					
B79X1845X	SRGA 1 PITCH SMRD	GND (1)	d	GND-15		
B79X1846X	SRGA 3 PITCH SMRD					
B79X1848X	SRGA 1 YAW SMRD					
B79X1849X	SRGA 3 YAW SMRD					
B79X2845X	SRGA 2 PITCH SMRD					
B79X2846X	SRGA 4 PITCH SMRD					
B79X2848X	SRGA 2 YAW SMRD					
B79X2849X	SRGA 4 YAW SMRD					
V90X6748X	SRGA 1 FAIL		d	GNC-14		
V90X6749X	SRGA 2 FAIL					
V90X6750X	SRGA 3 FAIL					
V90X6751X	SRGA 4 FAIL					
V58H1150C	L SRB ROCK ACTR POSN	GND (1)	d	BTVC-11		(2)
B58H1151C	L SRB TILT ACTR POSN					
B58H2150C	R SRB ROCK ACTR POSN					
B58H2151C	R SRB TILT ACTR POSN					

(1) Applies to all measurements.
(2) Also SSID BTVC-15.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
B58P1311A	L SRB RK SEC DEL P A	GND (1)		BTVC-12		(2)
B58P1312A	L SRB RK SEC DEL P B					
B58P1313A	L SRB RK SEC DEL P C					
B58P1314A	L SRB RK SEC DEL P D					
B58P1315A	L SRB TL SEC DEL P A					
B58P1316A	L SRB TL SEC DEL P B					
B58P1317A	L SRB TL SEC DEL P C					
B58P1318A	L SRB TL SEC DEL P D					
B58P2311A	R SRB RK SEC DEL P A	GND (1)	d	BTVC-12		(2)
B58P2312A	R SRB RK SEC DEL P B					
B58P2313A	R SRB RK SEC DEL P C					
B58P2314A	R SRB RK SEC DEL P D					
B58P2315A	R SRB TL SEC DEL P A					
B58P2316A	R SRB TL SEC DEL P B					
B58P2317A	R SRB TL SEC DEL P C					
B58P2318A	R SRB TL SEC DEL P D					

(1) Applies to all measurements.
(2) Also SSID BTVC-14.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V79X5100X	L SRB ROCK ACT A FL		d	BTVC-13		
V79X5101X	L SRB TILT ACT A FL					
V79X5105X	L SRB ROCK ACT B FL					
V79X5106X	L SRB TILT ACT B FL					
V79X5110X	L SRB ROCK ACT C FL					
V79X5111X	L SRB TILT ACT C FL					
V79X5115X	L SRB ROCK ACT C FL					
V79X5116X	L SRB TILT ACT D FL					
V79X5150X	R SRB ROCK ACT A FL					
V79X5151X	R SRB TILT ACT A FL					
V79X5155X	R SRB ROCK ACT B FL					
V79X5156X	R SRB TILT ACT B FL					
V79X5160X	R SRB ROCK ACT C FL					
V79X5161X	R SRB TILT ACT C FL					
V79X5165X	R SRB ROCK ACT D FL					
V79X5166X	R SRB TILT ACT D FL					

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V73X3001X	L DDU 1 PWR SPLY A		d	GNC-85		
V73X3002X	L DDU 1 PWR SPLY B					
V73X3003X	L DDU 1 PWR SPLY C					
V73X3011X	R DDU 2 PWR SPLY A					
V73X3012X	R DDU 2 PWR SPLY B					
V73X3013X	R DDU 2 PWR SPLY C					
V73X3050X	L DDU BITE GOOD		d	None		
V73X3051X	R DDU BITE GOOD					
V73X3021X	A DDU 3 PWR SPLY A	(1)	d	None		
V73X3022X	A DDU 3 PWR SPLY B					
V73X3023X	A DDU 3 PWR SPLY C					
V73X3052X	A DDU 3 BITE GOOD	(1)	d	None		
V72K1315X	FWD THC +X CMD A		d	GNC-02		
V72K1335X	FWD THC +X CMD B					
V72K1355X	FWD THC +X CMD C					
V72K1316X	FWD THC -X CMD A					
V72K1336X	FWD THC -X CMD B					
V72K1356X	FWD THC -X CMD C					
V72K1320X	FWD THC +Y CMD A	2 of 3	d	GNC-02		
V72K1340X	FWD THC +Y CMD B					
V72K1360X	FWD THC +Y CMD C					
V72K1321X	FWD THC -Y CMD A	2 of 3	d	GNC-02		
V72K1341X	FWD THC -Y CMD B					
V72K1361X	FWD THC -Y CMD C					

(1) Mission dependent (all).

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V72K1325X	FWD THC +Z CMD A		d	GNC-02		
V72K1345X	FWD THC +Z CMD B					
V72K1365X	FWD THC +Z CMD C					
V72K1326X	FWD THC -Z CMD A					
V72K1346X	FWD THC -Z CMD B					
V72K1366X	FWD THC -Z CMD C					
V72K1435X	AFT THC +X CMD A	(1)	h			
V72K1436X	AFT THC -X CMD A					
V72K1440X	AFT THC +Y CMD A					
V72K1441X	AFT THC -Y CMD A					
V72K1445X	AFT THC +Z CMD A					
V72K1446X	AFT THC -Z CMD A					
V72K1451X	AFT THC +X CMD B					
V72K1455X	AFT THC -X CMD B					
V72K1460X	AFT THC +Y CMD B					
V72K1461X	AFT THC -Y CMD B					
V72K1465X	AFT THC +Z CMD B					
V72K1466X	AFT THC -Z CMD B					
V72K1475X	AFT THC +X CMD C					
V72K1476X	AFT THC -X CMD C					
V72K1480X	AFT THC +Y CMD C					
V72K1481X	AFT THC -Y CMD C					
V72K1485X	AFT THC +Z CMD C					
V72K1486X	AFT THC -Z CMD C					

(1) Mission dependent (all).

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V59X2600X	L ADP DEPLOY 1		d	AFM-12		
V59X2602X	L ADP DEPLOY 2					
V59X2604X	L ADP STOW 1	1 of 2	d	AFM-12		
V59X2606X	L ADP STOW 2					
V59X2700X	R ADP DEPLOY 1		d	AFM-12		
V59X2702X	R ADP DEPLOY 2					
V59X2704X	R ADP STOW 1	1 of 2	d	AFM-12		
V59X2706X	R ADP STOW 2					
V71X7023B	ADTA 1 HIGH TEST		d	GNC-73		
V71X7024B	ADTA 1 LOW TEST					
V71X7025B	ADTA 1 PAL XDCR GOOD					
V71X7026B	ADTA 1 PAU XDCR GOOD					
V71X7027B	ADTA 1 PAC XDCR GOOD					
V71X7028B	ADTA 1 PS XDCR GOOD					
V71X7029B	ADTA 1 A/D CONV GOOD					
V71X7030B	ADTA 1 ELECT GOOD					
V71X7032B	ADTA 1 SUM CHK GOOD					
V71X7033B	ADTA 1 PWR SPLY GOOD					
V71P7040B	ADTA 1 PS		d	GNC-74		
V71P7080B	ADTA 1 PAC					
V71P7120B	ADTA 1 PAL					
V71P7140B	ADTA 1 PAU					

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V71X7523B	ADTA 2 HIGH TEST		d	GNC-73		
V71X7524B	ADTA 2 LOW TEST					
V71X7525B	ADTA 2 PAL XDCR GOOD					
V71X7526B	ADTA 2 PAU XDCR GOOD					
V71X7527B	ADTA 2 PAC XDCR GOOD					
V71X7528B	ADTA 2 PS XDCR GOOD					
V71X7529B	ADTA 2 A/D CONV GOOD					
V71X7530B	ADTA 2 ELECT GOOD					
V71X7532B	ADTA 2 SUM CHK GOOD					
V71X7533B	ADTA 2 PWR SPLY GOOD					
V71P7540B	ADTA 2 PS		d	GNC-74		
V71P7580B	ADTA 2 PAC					
V71P7620B	ADTA 2 PAL					
V71P7640B	ADTA 2 PAU					
V71X8023B	ADTA 3 HIGH TEST		d	GNC-73		
V71X8024B	ADTA 3 LOW TEST					
V71X8025B	ADTA 3 PAL XDCR GOOD					
V71X8026B	ADTA 3 PAU XDCR GOOD					
V71X8027B	ADTA 3 PAC XDCR GOOD					
V71X8028B	ADTA 3 PS XDCR GOOD					
V71X8029B	ADTA 3 A/D CONV GOOD					
V71X8030B	ADTA 3 ELECT GOOD					
V71X8032B	ADTA 3 SUM CHK GOOD					
V71X8033B	ADTA 3 PWR SPLY GOOD					

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V71P8040B	ADTA 3 PS		d	GNC-74		
V71P8080B	ADTA 3 PAC					
V71P8120B	ADTA 3 PAL					
V71P8140B	ADTA 3 PAU					
V71X8523B	ADTA 4 HIGH TEST		d	GNC-73		
V71X8524B	ADTA 4 LOW TEST					
V71X8525B	ADTA 4 PAL XDCR GOOD					
V71X8526B	ADTA 4 PAU XDCR GOOD					
V71X8527B	ADTA 4 PAC XDCR GOOD					
V71X8528B	ADTA 4 PS XDCR GOOD					
V71X8529B	ADTA 4 A/D CONV GOOD					
V71X8530B	ADTA 4 ELECT GOOD					
V71X8532B	ADTA 4 SUM CHK GOO					
V71X8533B	ADTA 4 PWR SPLY GOOD					
V71P8540B	ADTA 4 PS		D	GNC-74		
V71P8580B	ADTA 4 PAC					
V71P8620B	ADTA 4 PAL					
V71P8640B	ADTA 4 PAU					
V71T7100B	ADTA 1 TOTAL TEMP	GND (1)	D	GNC-75		
V71T8100B	ADTA 3 TOTAL TEMP					
V71T7600B	ADTA 2 TOTAL TEMP					
V71T8600B	ADTA 4 TOTAL TEMP					

(1) Applies to all measurements.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V74H1012B	MLS 1 AZIMUTH DATA					
V74X1014B	MLS 1 AZIMUTH VAL					
V74M1030P	MLS 1 ELEVATION WORD					
V74H1032B	MLS 1 ELEV DATA					
V74X1034B	MLS 1 ELEV VAL					
V74M1050P	MLS 1 RANGE WORD					
V74H1052B	MLS 1 RANGE DATA					
V74X1054B	MLS 1 RANGE VAL					
V74M1110P	MLS 2 AZIMUTH WORD					
V74H1112B	MLS 2 AZIMUTH DATA					
V74X1114B	MLS 2 AZIMUTH VAL					
V74M1130P	MLS 2 ELEVATION WORD					
V74H1132B	MLS 2 ELEV DATA	2				
V74X1134B	MLS 2 ELEV VAL	of				
V74M1150P	MLS 2 RANGE WORD	3 (1)				
V74H1152B	MLS 2 RANGE DATA					
V74X1154B	MLS 2 RANGE VAL					
V74M1210P	MLS 3 AZIMUTH WORD					
V74H1212B	MLS 3 AZIMUTH DATA					
V74X1214B	MLS 3 AZIMUTH VAL					
V74M1230P	MLS 3 ELEVATION WORD					
V74H1232B	MLS 3 ELEV DATA					
V74X1234B	MLS 3 ELEV VAL					
V74M1250P	MLS 3 RANGE WORD					
V74H1252B	MLS 3 RANGE DATA					
V74X1254B	MLS 3 RANGE VAL					

(1) 3 of 3 if <2 RA (all data for a MLS are required).

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V74X0176X	RA 1 READY	1 of 2	d,h	CT-08		(1)
V74X0186X	RA 2 READY					
V74X0172X	RA 1 LOCKON	1 of 2	d,h			(1)
V74X0182X	RA 2 LOCKON					
V74M1801P	RA 1 PARENT WORD	1 of 2	d,h			(1)
V74H1804B	RA 1 ALTITUDE					
V74X1805B	RA 1 VALIDITY					
						(2)
V74M1851P	RA 2 PARENT WORD					
V74H1854B	RA 2 ALTITUDE					
V74X1855B	RA 2 VALIDITY					
V74X0071X	TACAN 1 PWR STATUS	2 of 3(3)	d	CT-01		(3)
V74X0081X	TACAN 2 PWR STATUS					
V74X0091X	TACAN 3 PWR STATUS					
V74J1552B	TACAN 1 RANGE VALID	2 of 3 (3)	d	CT-01		(3)
V74H1534B	TACAN 1 BRG VALID					
V74J1652B	TACAN 2 RANGE VALID					
V74H1634B	TACAN 2 BRG VALID					
V74J1752B	TACAN 3 RANGE VALID					
V74H1734B	TACAN 3 BRG VALID					
V74X0070X	TACAN 1 TST STAT MON	2 of 3(3)	d			(3)
V74X0080X	TACAN 2 TST STAT MON					
V74X0090X	TACAN 3 TST STAT MON					

(1) 2 of 2 if <3 MLS or planned night landing.
(2) All data for an RA are required.
(3) All data required for TACAN equipped vehicles; reference CT-01 for minimum functional TACAN requirements.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V74M1530P	TACAN 1 BEARING WD 1		d			(1)
V74M1531P	TACAN 1 BEARING WD 2					
V74M1549P	TACAN 1 RANGE WD 1					
V74U1553B	TACAN 1 RANGE					
V74M1630P	TACAN 2 BEARING WD 1	2 of 3 (1)				
V74M1631P	TACAN 2 BEARING WD 2					
V74M1649P	TACAN 2 RANGE WD 1					
V74U1653B	TACAN 2 RANGE					
V74M1730P	TACAN 3 BEARING WD 1					
V74M1731P	TACAN 3 BEARING WD 2					
V74M1749P	TACAN 3 RANGE WD 1					
V74U1753B	TACAN 3 RANGE					
V74V4518A	TACAN 1 AGC	2 of 3(1) (GND)	d			(1)
V74V4519A	TACAN 2 AGC					
V74V4520A	TACAN 3 AGC					

(1) All data required for TACAN equipped vehicles; reference CT-01 for minimum functional TACAN requirements.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V74X4463B	GPS1 RPU FAIL		d	CT-11 (1)		
V74X4922B	GPS1 DATA VALID					
V74U4466B	GPS1 FIGURE OF MERIT					(2)
V74W4452B	GPS1 SECONDS					
V74H4453B	GPS1 WGS84 ECEF POSX					
V74H4454B	GPS1 WGS84 ECEF POSY					
V74H4455B	GPS1 WGS84 ECEF POSZ					
V74L4456B	GPS1 WGS84 ECEF VELX					
V74L4457B	GPS1 WGS84 ECEF VELY					
V74L4458B	GPS1 WGS84 ECEF VELZ					
V74X1463B	GPS2 RPU FAIL			CT-01 (4)		
V74X1922B	GPS2 DATA VALID			CT-11 (1)		
V74U1466B	GPS2 FIGURE OF MERIT					
V74W1452B	GPS2 SECONDS	2				
V74H1453B	GPS2 WGS84 ECEF POSX	of				
V74H1454B	GPS2 WGS84 ECEF POSY	3 (3)				
V74H1455B	GPS2 WGS84 ECEF POSZ					
V74L1456B	GPS2 WGS84 ECEF VELX					
V74L1457B	GPS2 WGS84 ECEF VELY					
V74L1458B	GPS2 WGS84 ECEF VELZ					
V74X3463B	GPS3 RPU FAIL			CT-11 (1)		
V74X5922B	GPS3 DATA VALID					
V74U3466B	GPS3 FIGURE OF MERIT					
V74W3452B	GPS3 SECONDS					
V74H3453B	GPS3 WGS84 ECEF POSX					
V74H3454B	GPS3 WGS84 ECEF POSY					
V74H3455B	GPS3 WGS84 ECEF POSZ					
V74L3456B	GPS3 WGS84 ECEF VELX					
V74L3457B	GPS3 WGS84 ECEF VELY					
V74L3458B	GPS3 WGS84 ECEF VELZ					

(1) Applicable for 3-string GPS vehicles only
(2) All data are required for a GPS
(3) 3 of 3 if high speed C-Band is not scheduled for EOM
(4) Applicable for Single String GPS vehicles only

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V71M5020P	-Z STR TRKR STATUS		d			
V71X5026B	-Z STAR PRESENT					
V71Q5029B	-Z ST STAR INTENSITY	GND				
V71M5040P	-Z S TRK HORZ POS WD					
V71H5041B	-Z HORIZ POS					
V71M5060P	-Z S TRK VERT POS WD					
V71H5061B	-Z VERT POS					
V71M5520P	-Y STR TRKR STATUS					
V71Q5529B	-Y ST STAR INTENSITY	GND				
V71X5526B	-Y STAR PRESENT					
V71M5540P	-Y S TRK HORZ POS WD					
V71H5541B	-Y HORIZ POS					
V71M5560P	-Y S TRK VERT POS WD					
V71H5561B	-Y VERT POS					
V59X1055X	-Y S TRK DOOR OPEN 1	7 of 8	d	AFM-14		(1)
V59X1065X	-Y S TRK DOOR OPEN 2	(GND)				
V59X1005X	-Y S TRK DOOR CLSD 1					(2)
V59X1015X	-Y S TRK DOOR CLSD 2					
V59X1265X	-Z S TRK DOOR OPEN 1					
V59X1255X	-Z S TRK DOOR OPEN 2					
V59X1205X	-Z S TRK DOOR CLSD 1					
V59X1215X	-Z S TRK DOOR CLSD 2					

(1) Door must be closed for launch.
(2) Retain single-fault tolerance for the capability to open and close at least one door.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V71M2020P	IMU 1 MODE STAT		d			(1)
V71X2021B	IMU 1 GOOD		d	GNC-56		
V71X2022B	IMU I/O FAIL					
V71X2023B	IMU 1 A/D FAIL					
V71X2024B	IMU 1 PLATFORM FAIL					
V71X2025X	IMU 1 PWR CNTLR FAIL					
V71X2026B	IMU 1 DC/DC 1 FAIL					
V71X2027B	IMU 1 FILT/DC 2 FAIL					
V71X2028B	IMU 1 RX CURRNT FAIL					
V71X2029B	IMU 1 PWR COND O/TMP					
V71X2030B	IMU 1 TRANS WD1 FAIL		d	GNC-66		
V71X2031B	IMU 1 TRANS WD2 FAIL					
V71H2060B	IMU 1 THETA R 8X		d			(2)
V71H2080B	IMU 1 THETA X 1X					
V71H2100B	IMU 1 THETA X 8X					
V71H2120B	IMU 1 THETA Y 1X					
V71H2140B	IMU 1 THETA Y 8X					
V71H2160B	IMU 1 THETA Z 1X					
V71H2180B	IMU 1 THETA Z 8X					
V71L2200B	IMU 1 ACCUM VX		d			(3)
V71L2220B	IMU 1 ACCUM VY					
V71L2240B	IMU 1 ACCUM VZ					
V71X2403X	IMU 1 IN-OPER MODE		d			(4)

(1) Parent word for all H/W BITEs.
(2) IMU att data.
(3) IMU vel data.
(4) Used in IMU alignment process.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V71X2405X	IMU 1 PLAT TEMP SAFE		d	GNC-59		
V71X2407X	IMU 1 CAPRI TMP SAFE					
V71M3020P	IMU 2 MODE STAT		d			(1)
V71X3021B	IMU 2 GOOD		d	GNC-56		
V71X3022B	IMU 2 I/O FAIL					
V71X3023B	IMU 2 A/D FAIL					
V71X3024B	IMU 2 PLATFORM FAIL					
V71X3025B	IMU 2 PWR CNTLR FAIL					
V71X3026B	IMU 2 DC/DC 1 FAIL					
V71X3027B	IMU 2 FILT/DC 2 FAIL					
V71X3028B	IMU 2 RX CURRNT FAIL					
V71X3029B	IMU 2 PWR COND O/TMP					
V71X3030B	IMU 2 TRANS WD1 FAIL		d	GNC-66		
V71X3031B	IMU 2 TRANS WD2 FAIL					
V71H3060B	IMU 2 THETA R 8X		d			(2)
V71H3080B	IMU 2 THETA X 1X					
V71H3100B	IMU 2 THETA X 8X					
V71H3120B	IMU 2 THETA Y 1X					
V71H3140B	IMU 2 THETA Y 8X					
V71H3160B	IMU 2 THETA Z 1X					
V71H3180B	IMU 2 THETA Z 8X					
V71L3200B	IMU 2 ACCUM VX		d			(3)
V71L3220B	IMU 2 ACCUM VY					
V71L3240B	IMU 2 ACCUM VZ					

(1) Parent word for H/W BITEs.
(2) IMU att data.
(3) IMU vel data.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V71X3403X	IMU 2 IN-OPER MODE		d			(1)
V71X3405X	IMU 2 PLAT TEMP SAFE		d	GNC-59		
V71X3407X	IMU 2 CAPRI TMP SAFE					
V71M4020P	IMU 3 MODE STAT		d			(2)
V71X4021B	IMU 3 GOOD		d	GNC-56		
V71X4022B	IMU 3 I/O FAIL					
V71X4023B	IMU 3 A/D/FAIL					
V71X4024B	IMU 3 PLATFORM FAIL					
V71X4025B	IMU 3 PWR CNTLR FAIL					
V71X4026B	IMU 3 DC/DC 1 FAIL					
V71X4027B	IMU 3 FILT/DC 2 FAIL					
V71X4028B	IMU 3 RX CURRNT FAIL					
V71X4029B	IMU 3 PWR COND O/TMP					
V71X4030B	IMU 3 TRANS WD1 FAIL		d	GNC-66		
V71X4031B	IMU 3 TRANS WD2 FAIL					
V71H4060B	IMU 3 THETA R 8X		d			(3)
V71H4080B	IMU 3 THETA X 1X					
V71H4100B	IMU 3 THETA X 8X					
V71H4120B	IMU 3 THETA Y 1X					
V71H4140B	IMU 3 THETA Y 8X					
V71H4160B	IMU 3 THETA Z 1X					
V71H4180B	IMU 3 THETA Z 8X					

(1) Used in IMU alignment process.
(2) Parent word for H/W BITEs.
(3) IMU att data.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V71L4200B	IMU 3 ACCUM VX		d			(1)
V71L4220B	IMU 3 ACCUM VY					
V71L4240B	IMU 3 ACCUM VZ					
V71X4403X	IMU 3 IN-OPER MODE		d			(2)
V71X4405X	IMU 3 PLAT TEMP SAFE		d	GNC-59		
V71X4407X	IMU 3 CAPRI TMP SAFE					
V90X2601X	IMU 1 FAIL		d	GNC-60		
V90X2701X	IMU 2 FAIL					
V90X2801X	IMU 3 FAIL					
V95X0025X	IMU 1 TILT INIT FAIL		d	GNC-63		
V95X1025X	IMU 2 TILT INIT FAIL					
V95X2025X	IMU 3 TILT INIT FAIL					
V95X0030X	IMU 1 WD13 ECHO FAIL		d	GNC-61		(3)
V95X0031X	IMU 1 WD14 ECHO FAIL					
V95X0033X	IMU 1 REDUN RATE FL					
V95X0034X	IMU 1 IR NULL FAIL					
V95X0035X	IMU 1 VEL LIMIT FAIL					
V95X0037X	IMU 1 RSLVR LIMIT FL					
V95X0081X	IMU 1 ACC/CAPR SF FL					

(1) IMU vel data.
(2) Used in IMU alignment process.
(3) Software BITEs.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V95X1030X	IMU 2 WD13 ECHO FAIL		d	GNC-61		(1)
V95X1031X	IMU 2 WD14 ECHO FAIL					
V95X1033X	IMU 2 REDUN RATE FL					
V95X1034X	IMU 2 IR NULL FAIL					
V95X1035X	IMU 2 VEL LIMIT FAIL					
V95X1037X	IMU 2 RSLVR LIMIT FL					
V95X1081X	IMU 2 ACC/CAPR SF FL					
V95X2030X	IMU 3 WD13 ECHO FAIL		d	GNC-61		(1)
V95X2031X	IMU 3 WD14 ECHO FAIL					
V95X2033X	IMU 3 REDUN RATE FAI					
V95X2034X	IMU 3 IR NULL FAIL					
V95X2035X	IMU 3 VEL LIMIT FAIL					
V95X2037X	IMU 3 RSLVR LIMIT FL					
V95X2081X	IMU 3 ACC/CAPRI SF F					
V99U3262C	IMU 1/2 GYROCOMP FL		d	GNC-62		
V99U3263C	IMU 1/3 GYROCOMP FL					
V99U3264C	IMU 2/3 GYROCOMP FL					
V72K2077X	LH BODYFLAP UP A	4 of 4 of 4 of 4	d			(2)
V72K2078X	LH BODYFLAP UP B					
V72K2079X	LH BODYFLAP DOWN A					
V72K2080X	LH BODYFLAP DOWN B					
V72K2087X	RH BODYFLAP UP A					
V72K2088X	RH BODYFLAP UP B					
V72K2089X	RH BODYFLAP DOWN A					
V72K2090X	RH BODYFLAP DOWN B					

(1) Software BITEs.
(2) Maintain capability.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V72K2801X	FWD DAP SELECT A-A	2 of 3	h			(1)
V72K2802X	FWD DAP SELECT A-B					
V72K2805X	FWD DAP SELECT A-C	2 of 2				
V72K6430X	AFT DAP SELECT A-A					
V72K6431X	AFT DAP SELECT A-B					
V72K6419X	AFT DAP SELECT A-C					
V72K2803X	FWD DAP SELECT B-A	2 of 3	h			(1)
V72K2804X	FWD DAP SELECT B-B					
V72K2806X	FWD DAP SELECT B-C	2 of 2				
V72K6432X	AFT DAP SELECT B-A					
V72K6433X	AFT DAP SELECT B-B					
V72K6420X	AFT DAP SELECT B-C					
V72K2812X	FWD ROT ROLL DISC A	2 of 2 either switch	h			(2)
V72K2813X	FWD ROT ROLL DISC B					
V72K6440X	AFT ROT ROLL DISC A					
V72K6441X	AFT ROT ROLL DISC B					
V72K2816X	FWD ROT ROLL PULSE A	2 of 2 either switch	h			(2)
V72K2817X	FWD ROT ROLL PULSE B					
V72K6448X	AFT ROT ROLL PULSE A					
V72K6449X	AFT ROT ROLL PULSE B					
V72K2822X	FWD ROT PITCH DISC A	2 of 2 either switch	h			(2)
V72K2823X	FWD ROT PITCH DISC B					
V72K6460X	AFT ROT PITCH DISC A					
V72K6461X	AFT ROT PITCH DISC B					

(1) Maintain one-fault tolerance.
(2) Maintain capability.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V72K2826X	FWD ROT PIT PULSE A	2 of 2 either switch	h			(1)
V72K2827X	FWD ROT PIT PULSE B					
V72K6468X	AFT ROT PIT PULSE A					
V72K6469X	AFT ROT PIT PULSE B					
V72K2832X	FWD ROT YAW DISC A	2 of 2 either switch	h			(1)
V72K2833X	FWD ROT YAW DISC B					
V72K6480X	AFT ROT YAW DISC A					
V72K6481X	AFT ROT YAW DISC B					
V72K2836X	FWD ROT YAW PULSE A	2 of 2 either switch	h			(1)
V72K2837X	FWD ROT YAW PULSE B					
V72K6488X	AFT ROT YAW PULSE A					
V72K6489X	AFT ROT YAW PULSE B					
V72K2840X	FWD DAP CNTL AUTO A	2 of 3	2 of 2	h			(2)
V72K2841X	FWD DAP CNTL AUTO B					
V72K2842X	FWD DAP CNTL AUTO C					
V72K6490X	AFT DAP CNTL AUT0 A					
V72K6491X	AFT DAP CNTL AUT0 B					
V72K6492X	AFT DAP CNTL AUT0 C					
V72K2845X	FWD DAP CNTL MAN A	2 of 3 either switch	h			(3)
V72K2846X	FWD DAP CNTL MAN B					
V72K2847X	FWD DAP CNTL MAN C					
V72K6495X	AFT DAP CNTL MAN A					
V72K6496X	AFT DAP CNTL MAN B					
V72K6497X	AFT DAP CNTL MAN C					

(1) Maintain capability.
(2) Maintain one-fault tolerance.
(3) Maintain capability. Can downmode to MAN with RHC.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V72K2851X	FWD RCS JETS NORM A	2 of 3(1)	h			(2)
V72K2852X	FWD RCS JETS NORM B					
V72K2857X	FWD RCS JETS NORM C					
V72K6505X	AFT RCS JETS NORM A	2 of 3(1)	h			
V72K6506X	AFT RCS JETS NORM B					
V72K6500X	AFT RCS JETS NORM C					
V72K2853X	FWD RCS JETS VERN A	2 of 3	h			(2)
V72K2854X	FWD RCS JETS VERN B					
V72K2858X	FWD RCS JETS VERN C		2 of 2			
V72K6507X	AFT RCS JETS VERN A	2 of 3				
V72K6508X	AFT RCS JETS VERN B					
V72K6501X	AFT RCS JETS VERN C					
V72K2860X	FWD TRANSL X NORM A	2 of 2(3)	h			(4)
V72K2861X	FWD TRANSL X NORM B	either				
V72K6510X	AFT TRANSL X NORM A	switch				
V72K6511X	AFT TRANSL X NORM B					
V72K2862X	FWD TRANSL X PULSE A	2 of 2(3)	h			(4)
V72K2863X	FWD TRANSL X PULSE B	either				
V72K6513X	AFT TRANSL X PULSE A	switch				
V72K6514X	AFT TRANSL X PULSE B					
V72K2870X	FWD TRANSL Y NORM A	0 of 4(5)	h			
V72K2871X	FWD TRANSL Y NORM B					
V72K6520X	AFT TRANSL Y NORM A					
V72K6521X	AFT TRANSL Y NORM B					

(1) 6 of 6 Mission Dependent (prox ops).
(2) Maintain one-fault tolerance.
(3) 4 of 4 Mission Dep; maintain one-fault tolerance (rndz/prox ops).
(4) Maintain cap for backup to OMS.
(5) 4 of 4 Mission Dep; maintain one-fault tolerance.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V72K2872X	FWD TRANSL Y PULSE A	0 of 4(1)	h			
V72K2873X	FWD TRANSL Y PULSE B					
V72K6523X	AFT TRANSL Y PULSE A					
V72K6524X	AFT TRANSL Y PULSE B					
V72K2874X	FWD TRANSL LOW Z A	0 of 4(2)	h			
V72K2875X	FWD TRANSL LOW Z B					
V72K6527X	AFT TRANSL LOW Z A					
V72K6528X	AFT TRANSL LOW Z B					
V72K2880X	FWD TRANSL Z NORM A	2 of 2(3)	h			(5)
V72K2881X	FWD TRANSL Z NORM B	either				
V72K6530X	AFT TRANSL Z NORM A	switch				
V72K6531X	AFT TRANSL Z NORM B					
V72K2882X	FWD TRANSL Z PULSE A	2 of 2(3)	h			(5)
V72K2883X	FWD TRANSL Z PULSE B	either				
V72K6533X	AFT TRANSL Z PULSE A	switch				
V72K6534X	AFT TRANSL Z PULSE B					
V72K2884X	FWD TRANSL Z HIGH A	0 of 4(4)	h			
V72K2885X	FWD TRANSL Z HIGH B					
V72K6537X	AFT TRANSL Z HIGH A					
V72K6538X	AFT TRANSL Z HIGH B					

(1) 4 of 4 Mission Dep; maintain one-fault tolerance.
(2) 4 of 4 Mission Dep; maintain one-fault tolerance (rndz/prox ops, deply).
(3) 4 of 4 Mission Dep; maintain one-fault tolerance.
(4) 4 of 4 Mission Dep; maintain one-fault tolerance (rndz/prox ops).
(5) Maintain cap for backup to OMS.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V72K4893X	RH BODYFLAP A/M A	5 of 6	d			(1)
V72K4894X	RH BODYFLAP A/M B					
V72K4895X	RH BODYFLAP A/M C					
V72K4993X	LH BODYFLAP A/M A					
V72K4994X	LH BODYFLAP A/M B					
V72K4995X	LH BODYFLAP A/M C					
V72K5151X	RH PITCH AUTO MODE A	5 of 6	d			(1)
V72K5152X	RH PITCH AUTO MODE B					
V72K5153X	RH PITCH AUTO MODE C					
V72K5251X	LH PITCH AUTO MODE A					
V72K5252X	LH PITCH AUTO MODE B					
V72K5253X	LH PITCH AUTO MODE C					
V72K5165X	RH R/Y AUTO MODE A	5 of 6	d			(1)
V72K5166X	RH R/Y AUTO MODE B					
V72K5167X	RH R/Y AUTO MODE C					
V72K5265X	LH R/Y AUTO MODE A					
V72K5266X	LH R/Y AUTO MODE B					
V72K5267X	LH R/Y AUTO MODE C					
V72K5256X	L PITCH CSS MODE A	3 of 3 (2)	d			(3)
V72K5257X	L PITCH CSS MODE B					
V72K5258X	L PITCH CSS MODE C					
V72K5156X	R PITCH CSS MODE A	3 of 3 (2)	1 of 2			
V72K5157X	R PITCH CSS MODE B					
V72K5158X	R PITCH CSS MODE C					

(1) Maintain two-fault tolerance FR 8-60.
(2) For certain combinations of switch contact failures between L and R switches, this can be reduced to 2 of 3 and still maintain one-fault tolerance.
(3) Maintain one-fault tolerance.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V72K5270X	L R/Y CSS MODE A	3 of 3 (2) 1 of 2	d			(1)
V72K5271X	L R/Y CSS MODE B					
V72K5272X	L R/Y CSS MODE C					
V72K5170X	R R/Y CSS MODE A					
V72K5171X	R R/Y CSS MODE B					
V72K5172X	R R/Y CSS MODE C					
V72K1570X	L SB/TC AUTO/MAN A	3 of 3 (2) 1 of 2	d			(1)
V72K1571X	L SB/TC AUTO/MAN B					
V72K1572X	L SB/TC AUTO/MAN C					
V72K1600X	R SB/TC AUTO/MAN A					
V72K1601X	R SB/TC AUTO/MAN B					
V72K1602X	R SB/TC AUTO/MAN C					
V72K5180X	SENSE SW -X CON A	2 of 3(3)	h			(4)
V72K5181X	SENSE SW -X CON B					
V72K5182X	SENSE SW -X CON C					
V72K6314X	ENTRY MD LO GAIN A	2 of 4	d			(5)
V72K6315X	ENTRY MD LO GAIN B					
V72K6316X	ENTRY MD LO GAIN C					
V72K6317X	ENTRY MD LO GAIN D					
V72K6320X	ENTRY MODE NO Y JET	2 of 4	d			(6)
V72K6321X	ENTRY MODE NO Y JET					
V72K6322X	ENTRY MODE NO Y JET					
V72K6323X	ENTRY MODE NO Y JET					

(1) Maintain one-fault tolerance.
(2) For certain combinations of switch contact failures between L and R switches, this can be reduced to 2 of 3 and still maintain one-fault tolerance.
(3) 3 of 3 Mission dep (rndz/prox ops).
(4) Maintain capability.
(5) Maintain capability for backup to body bending filter.
(6) Maintain capability. No yaw jet mode reqd for dual reg fail.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V72K1150X	L RHC +PITCH TRIM A	2 of 2				(1)
V72K1165X	L RHC +PITCH TRIM B	either				
V72K1195X	R RHC +PITCH TRIM A	switch				
V72K1215X	R RHC +PITCH TRIM B					
V72K1151X	L RHC -PITCH TRIM A	2 of 2				(1)
V72K1166X	L RHC -PITCH TRIM B	either				
V72K1196X	R RHC -PITCH TRIM A	switch				
V72K1216X	R RHC -PITCH TRIM B					
V72K1152X	L RHC +ROLL TRIM A	2 of 2				(1)
V72K1167X	L RHC +ROLL TRIM B	either				
V72K1197X	R RHC +ROLL TRIM A	switch				
V72K1217X	R RHC +ROLL TRIM B					
V72K1153X	L RHC -ROLL TRIM A	2 of 2				(1)
V72K1168X	L RHC -ROLL TRIM B	either				
V72K1198X	R RHC -ROLL TRIM A	switch				
V72K1218X	R RHC -ROLL TRIM B					
V72K1160X	L RHC TRIM INHIBIT A		d			(2)
V72K1161X	L RHC TRIM INHIBIT B					
V72K1210X	R RHC TRIM INHIBIT A					(2)
V72K1211X	R RHC TRIM INHIBIT B					

(1) Maintain capability.
(2) Default is ENABLE, protects two-fault tolerance for RHC trim sw contact failures.

GUIDANCE, NAVIGATION AND CONTROL (GNC) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V72K1500X	L +PITCH TRIM A	2 of 2	d			(1)
V72K1501X	L +PITCH TRIM B	either				
V72K1512X	R +PITCH TRIM A	switch				
V72K1513X	R +PITCH TRIM B					
V72K1503X	L -PITCH TRIM A	2 of 2	d			(1)
V72K1504X	L -PITCH TRIM B	either				
V72K1515X	R -PITCH TRIM A	switch				
V72K1516X	R -PITCH TRIM B					
V72K1506X	L +ROLL TRIM A	2 of 2	d			(1)
V72K1507X	L +ROLL TRIM B	either				
V72K1518X	R +ROLL TRIM A	switch				
V72K1519X	R +ROLL TRIM B					
V72K1509X	L -ROLL TRIM A	2 of 2	d			(1)
V72K1510X	L -ROLL TRIM B	either				
V72K1521X	R -ROLL TRIM A	switch				
V72K1522X	R -ROLL TRIM B					
V72K1148X	L +YAW TRIM A	2 of 2	d			(1)
V72K1163X	L +YAW TRIM B	either				
V72K1193X	R +YAW TRIM A	switch				
V72K1213X	R +YAW TRIM B					
V72K1149X	L -YAW TRIM A	2 of 2	d			(1)
V72K1164X	L -YAW TRIM B	either				
V72K1194X	R -YAW TRIM A	switch				
V72K1214X	R -YAW TRIM B					

(1) Maintain capability.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V43P4121C	OMS L POD HE TANK P1	1 OF 2	a,b,g	OMS-01		(1)
V43P4122C	OMS L POD HE TANK P2	(BOTH)			FDA	
V43P5121C	OMS R POD HE TANK P1	1 OF 2	a,b,g	OMS-01		(1)
V43P5122C	OMS R POD HE TANK P2	(BOTH)			FDA	
V43X4152X	OMS L POD HE ISLN VLV A POS OP	GND (2)	a	OMS-02		(3)
V43X4154X	OMS L POD HE ISLN VLV B POS OP					
V43X5152X	OMS R POD HE ISLN VLV A POS OP	GND (2)	a	OMS-02		(3)
V43X5154X	OMS R POD HE ISLN VLV B POS OP					
V43X4156X	OMS L POD VAPOR ISLN VLV 1 OP	GND (2)	a	OMS-03		(3)
V43X4158X	OMS L POD VAPOR ISLN VLV 2 OP					
V43X5156X	OMS R POD VAPOR ISLN VLV 1 OP	GND (2)	a	OMS-03		(3)
V43X5158X	OMS L POD VAPOR ISLN VLV 2 OP					
V43T5641A	OMS R ENG OX VLV T	1 OF 3	a,g	OMS-04	FDA	(4)
V43T5216A	OMS R POD OX ENG INLET T	(BOTH)			FDA	
V43T5642A	OMS R ENG FU FDLN T				FDA	

(1) Requirement for leak detection and management.
(2) Applies to each measurement.
(3) GO for confirmed instrumentation failure.
(4) Required to ensure engine does not violate qual limit for start.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V43T4641A	OMS L ENG OX VLV T	1 OF 3	a,g	OMS-04	FDA	(1)
V43T4216A	OMS L POD OX ENG INLET T	(BOTH)			FDA	
V43T4642A	OMS L ENG FU FDLN T				FDA	
V43P4221C	OMS L POD OX TANK ULLAGE P	1 OF 2 (BOTH)	a,b,g	OMS-05	FDA/C&W	(2)
V43P4321C	OMS L POD FU TANK ULLAGE P					
V43P5221C	OMS R POD OX TANK ULLAGE P	1 OF 2 (BOTH)	a,b,g	OMS-05	FDA/C&W	(2)
V43P5321C	OMS R POD FU TANK ULLAGE P					
V43X4252X	OMS L POD OX ISLN VLV A POS OP	GND (4)	a	OMS-06		(3)
V43X4253X	OMS L POD OX ISLN VLV A POS CL					
V43X4254X	OMS L POD OX ISLN VLV B POS OP					
V43X4255X	OMS L POD OX ISLN VLV B POS CL					

(1) Required to ensure engine does not violate qual limit for start.
(2) Required for leak detection and system management.
(3) GO for confirmed instrumentation failure and valve functional.
(4) Applies to all measurements.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V43X4352X	OMS L POD FU ISLN VLV A POS OP	GND (1)	a	OMS-06		(2)
V43X4353X	OMS L POD FU ISLN VLV A POS CL					
V43X4354X	OMS L POD FU ISLN VLV B POS OP					
V43X4355X	OMS L POD FU ISLN VLV B POS CL					
V43X5252X	OMS R POD OX ISLN VLV A POS OP	GND (1)	a	OMS-06		(2)
V43X5253X	OMS R POD OX ISLN VLV A POS CL					
V43X5254X	OMS R POD OX ISLN VLV B POS OP					
V43X5255X	OMS R POD OX ISLN VLV B POS CL					
V43X5352X	OMS R POD FU ISLN VLV A POS OP	GND (1)	a	OMS-06		(2)
V43X5353X	OMS R POD FU ISLN VLV A POS CL					
V43X5354X	OMS R POD FU ISLN VLV B POS OP					
V43X5355X	OMS R POD FU ISLN VLV B POS CL					

(1) Applies to all measurements.
(2) GO for confirmed instrumentation failure and valve functional.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V43X4256X	OMS L POD OX XFD VLV A POS OP	GND (1)	a	OMS-07		(2)
V43X4257X	OMS L POD OX XFD VLV A POS CL					
V43X4258X	OMS L POD OX XFD VLV B POS OP					
V43X4259X	OMS L POD OX XFD VLV B POS CL					
V43X4356X	OMS L POD FU XFD VLV A POS OP	GND (1)	a	OMS-07		(2)
V43X4357X	OMS L POD FU XFD VLV A POS CL					
V43X4358X	OMS L POD FU XFD VLV B POS OP					
V43X4359X	OMS L POD FU XFD VLV B POS CL					
V43X5256X	OMS R POD OX XFD VLV A POS OP	GND (1)	a	OMS-07		(2)
V43X5257X	OMS R POD OX XFD VLV A POS CL					
V43X5258X	OMS R POD OX XFD VLV B POS OP					
V43X5259X	OMS R POD OX XFD VLV B POS CL					

(1) Applies to all measurements.
(2) GO for confirmed instrumentation failure and valve functional.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V43X5356X	OMS R POD FU XFD VLV A POS OP	GND (1)	a	OMS-07		(2)
V43X5357X	OMS R POD FU XFD VLV A POS CL					
V43X5358X	OMS R POD FU XFD VLV B POS OP					
V43X5359X	OMS R POD FU XFD VLV B POS CL					
V43P4547C	OMS L POD PNEU SPLY PRESS 1	1 OF 2 (BOTH)	a,g	OMS-08		(3)
V43P4548C	OMS L POD PNEU SPLY PRESS 2				FDA	
V43P5547C	OMS R POD PNEU SPLY PRESS 1	1 OF 2 (BOTH)				
V43P5548C	OMS R POD PNEU SPLY PRESS 2				FDA	
V43P4549C	OMS L ENG REG OUT P	BOTH (1)	a,c	OMS-09	FDA	(4)
V43P5549C	OMS R ENG REG OUT P				FDA	
V43X4552X	OMS L ENG PRESS VLV POSN OP	BOTH (1)	a	OMS-10		(2)
V43X5552X	OMS R ENG PRESS VLV POSN OP					

(1) Applies to each measurement.
(2) GO for confirmed instrumentation failure and valve functional.
(3) Required for leak detection and system management.
(4) GO for confirmed instrumentation failure.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V43X4558X	OMS L ENG PURGE VLV 1 POS OP	GND (1)	a	OMS-11		(2)
V43X4559X	OMS L ENG PURGE VLV 2 POS OP					
V43X5558X	OMS R ENG PURGE VLV 1 POS OP					
V43X5559X	OMS R ENG PURGE VLV 2 POS OP					
V43T4643A	L OMS ENG FU INJ T	BOTH (1)	a,b,c	OMS-12	FDA	(3)
V43T5643A	R OMS ENG FU INJ T					
V43P4645C	OMS L ENG OX INLET P	BOTH (1)	a,b	OMS-13		(4)
V43P4646C	OMS L ENG FU INLET P					
V43P5645C	OMS R ENG OX INLET P					
V43P5646C	OMS R ENG FU INLET P					
V43P4649C	OMS L ENG CHAMBER P	BOTH (1)	a,b,c	OMS-14	C&W	(5)
V43P5649C	OMS R ENG CHAMBER P				C&W	

(1) Applies to each measurement.
(2) GO for confirmed instrumentation failure with valve verified closed for launch.
(3) Required to ensure engine temp is within safe operating limits - FR 6-27.
(4) Required to distinguish OMS eng fail from propellant fail.
(5) Required to monitor OME performance FR 6-27.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V43H4655C	OMS L ENG BI-PROP VLV 1 POS	BOTH (1)	a,c	OMS-15		(2)
V43H4656C	OMS L ENG BI-PROP VLV 2 POS					
V43H5655C	OMS R ENG BI-PROP VLV 1 POS					
V43H5656C	OMS R ENG BI-PROP VLV 2 POS					
V43T5700A	OMS R POD RCS PNL T1	1 OF 2	a,g	OMS-16	FDA	(3)
V43T5710A	OMS R POD RCS PNL T2	(BOTH)			FDA	
V43T5702A	OMS R POD UPPER Y-WEB OTBD TEMP	1 OF 2 (BOTH)	a,g	OMS-16	FDA	(3)
V43T5703A	OMS R POD UPPER Y-WEB OTBD TEMP				FDA	
V43T5704A	OMS R POD OX DRAIN PNL TEMP 1	1 OF 2 (BOTH)	a,g	OMS-16	FDA	(3)
V43T5705A	OMS R POD OX DRAIN PNL TEMP 2				FDA	
V43T5708A	OMS R POD OX/HE TEST PORT TEMP 1	1 OF 2 (BOTH)	a,g	OMS-16	FDA	(3)
V43T5718A	OMS R POD OX/HE TEST PORT TEMP 2				FDA	

(1) Applies to each measurement.
(2) Required for system management.
(3) Required to monitor heater performance.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42T3304A	RCS R AFT THERM SW TEMP 1	1 OF 2 (BOTH)	a,g	OMS-16	FDA	(1)
V42T3305A	RCS R AFT THERM SW TEMP 2				FDA	
V43T5701A	OMS R POD RCS VERN CMPRTMNT T 1	1 OF 2 (BOTH)	a,g	OMS-16	FDA	(1)
V43T5711A	OMS R POD RCS VERN CMPRTMNT T 2				FDA	
V43T5706A	OMS R POD GSE SERV PNL TEMP	1 OF 1 (BOTH)	a	OMS-16	FDA	(1)
V43T5707A	OMS R POD ENG SERV PNL TEMP				FDA	
V43T5642A	OMS R POD ENG FUEL FEEDLINE TEMP	1 OF 3 (BOTH)	a,g	OMS-16	FDA	(1)
V43T5216A	OMS R POD ENG OX FEEDLINE TEMP				FDA	
V43T5720A	OMS R ENG COVER TEMP				FDA	
V43T4701A	OMS L POD RCS VERN CMPRTMNT TEMP 1	1 OF 2 (BOTH)	a,g	OMS-16	FDA	(1)
V43T4711A	OMS L POD RCS VERN CMPRTMNT TEMP 2				FDA	

(1) Required to monitor heater performance.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42T2304A	RCS L AFT THERM SW TEMP 1	1 OF 2 (BOTH)	a,g	OMS-16	FDA	(2)
V42T2305A	RCS L AFT THERM SW TEMP 2				FDA	
V43T4700A	OMS L POD RCS PNL TEMP 1	1 OF 2 (BOTH)	a,g	OMS-16	FDA	(2)
V43T4710A	OMS L POD RCS PNL TEMP 2				FDA	
V43T4702A	OMS L POD UPPER Y-WEB OTBD TEMP	BOTH (1)	a,g	OMS-16	FDA	(2)
V43T4703A	OMS L POD UPPER Y-WEB INBD TEMP				FDA	
V43T4704A	OMS L POD OX DRAIN PNL TEMP 1	1 OF 2 (BOTH)	a,g	OMS-16	FDA	(2)
V43T4705A	OMS L POD OX DRAIN PNL TEMP 2				FDA	
V43T4706A	OMS L POD GSE SERV PNL TEMP	BOTH (1)	a	OMS-16	FDA	(2)
V43T4707A	OMS L POD ENG SERV PNL TEMP				FDA	
V43T4708A	OMS L POD OX/HE TEST PORT T1	1 OF 2 (BOTH)	a,g	OMS-16	FDA	(2)
V43T4718A	OMS L POD OX/HE TEST PORT T2				FDA	

(1) Applies to each measurement.
(2) Required to monitor heater performance.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V43T4642A	OMS R POD ENG FU FEEDLINE TEMP	1 OF 3	a,g	OMS-16	FDA	(2)
V43T4216A	OMS R POD ENG OX TEMP				FDA	
V43T4720A	OMS R ENG COVER TEMP				FDA	
V43T6230A	OMS QD PNL OX HI PT BLD LN TEMP	BOTH (1,4)	g	OMS-17	FDA	(3)
V43T6234A	OMS FU HI PT BLEED LINE TEMP				FDA	
V43T6235A	OMS OX HI PT BLEED LINE TEMP				FDA	
V43T6238A	OMS AFT FU HI PT BLD LINE TEMP				FDA	
V43T6239A	OMS AFT OX HI PT BLD LINE TEMP				FDA	
V43T6236A	OMS AFT LOW PT OX DRN LINE TEMP-L				FDA	
V43T6237A	OMS AFT LOW PT OX DRN LINE TEMP-R				FDA	
V43T6218A	OMS AFT OX XFD L T	4 OF 5 (BOTH)	a,g	OMS-17	FDA	(5)
V43T6219A	OMS AFT OX XFD R T				FDA	
V43T6242A	OMS AFT XFD OX LN-CTR TEMP				FDA	
V43T6243A	OMS AFT FUS OX XFD LINE - LEFT TEMP				FDA	
V43T6244A	OMS AFT FUS OX XFD LINE - RIGHT TEMP				FDA	

(1) Applies to each measurement.
(2) Required to monitor heater performance.
(3) GO for confirmed instrumentation failure.
(4) Hi Pt Bld Line Temp measurements only applicable for Orbiters with OMS High Point Bleed Lines installed.
(5) Required to ensure propellant is within spec temperature limits for engine operation.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V43Q5332C	R POD FU AFT CMP QTY	1 OF 2	a,g	OMS-18	FDA	(1)
V43Q4332C	L POD FU AFT CMP QTY	(BOTH)			FDA	
V43S4570X	L OMS ARM/PRES CMD 1	1 OF 2	a,c	None		(2)
V43S4571X	L OMS ARM/PRES CMD 2	(GND)				
V43S5570X	R OMS ARM/PRES CMD 1	1 OF 2	a,c	None		(2)
V43S5571X	R OMS ARM/PRES CMD 2	(GND)				
V42T1100C	RCS FWD HE OX TK T 1	1 OF 2	a,g	RCS-01		(3)
V42T1104C	RCS FWD HE FU TK T 1	(BOTH)				
V42P1110C	RCS FWD HE OX TK P 1	1 OF 2	a,b,g	RCS-01		(4)
V42P1112C	RCS FWD HE OX TK P 2	(BOTH)			FDA	
V42P1113C	RCS FWD HE FU TK P 1	1 OF 2	a,b,g	RCS-01		(4)
V42P1114C	RCS FWD HE FU TK P 2	(BOTH)			FDA	
V42T2100C	RCS L AFT HE OX TANK TEMP 1	1 OF 2 (BOTH)	a,g	RCS-01		(3)
V42T2104C	RCS L AFT HE FU TANK TEMP 1					
V42P2110C	RCS L AFT HE OX TANK PRESS 1	1 OF 2 (BOTH)	a,b,g	RCS-01		(4)
V42P2112C	RCS L AFT HE OX TANK PRESS 2				FDA	

(1) Required for contingency dump software.
(2) Required for OMS engine operation.
(3) Required for RCS PVT gaging.
(4) Required for RCS PVT gaging and leak detection.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42P2113C	RCS L AFT HE FU TANK PRESS 1	1 OF 2 (BOTH)	a,b,g	RCS-01		(1)
V42P2114C	RCS L AFT HE FU TANK PRESS 2				FDA	
V42T3100C	RCS R AFT HE OX TANK TEMP 1	1 OF 2 (BOTH)	a,g	RCS-01		(2)
V42T3104C	RCS R AFT HE FU TANK TEMP 1					
V42P3110C	RCS R AFT HE OX TANK PRESS 1	1 OF 2 (BOTH)	a,b,g	RCS-01		(1)
V42P3112C	RCS R AFT HE OX TANK PRESS 2				FDA	
V42P3113C	RCS R AFT HE FU TANK PRESS 1	1 OF 2 (BOTH)	a,b,g	RCS-01		(1)
V42P3114C	RCS R AFT HE FU TANK PRESS 2				FDA	
V42P1115C	RCS FWD OX TK ULLAGE PRESS	1 OF 2 (BOTH)	a,b,g	RCS-02	FDA/C&W	(1)
V42P1210C	RCS FWD OX TANK OT P				FDA	
V42P1116C	RCS FWD FU TK ULLAGE PRESS	1 OF 2 (BOTH)	a,b,g	RCS-02	FDA/C&W	(1)
V42P1310C	RCS FWD FU TANK OT P				FDA	
V42T1200C	RCS FWD OX TANK T 1	1 OF 2 (BOTH)	a,g	RCS-02	FDA	(2)
V42T1300C	RCS FWD FU TANK T 1				FDA	

(1) Required for RCS PVT gaging and leak detection.
(2) Required for RCS PVT gaging.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42P2115C	RCS L AFT OX TANK ULLAGE PRESS	1 OF 2 (BOTH)	a,b,c,g	RCS-02	FDA/C&W	(2)
V42P2210C	RCS L AFT OX TK OT P				FDA	
V42P2116C	RCS L AFT FU TANK ULLAGE PRESS	1 OF 2 (BOTH)	a,b,c,g	RCS-02	FDA/C&W	(2)
V42P2310C	RCS L AFT FU TK OT P				FDA	
V42T2200C	RCS L AFT OX TANK T1	1 OF 2 (BOTH)	a,g	RCS-02	FDA	(3)
V42T2300C	RCS L AFT FU TANK T1				FDA	
V42P3115C	RCS R AFT OX TANK ULLAGE PRESS	1 OF 2 (BOTH)	a,b,c,g	RCS-02	FDA/C&W	(2)
V42P3210C	RCS R AFT OX TK OT P				FDA	
V42P3116C	RCS R AFT FU TANK ULLAGE PRESS	1 OF 2 (BOTH)	a,b,c,g	RCS-02	FDA/C&W	(2)
V42P3310C	RCS R AFT FU TK OT P				FDA	
V42T3200C	RCS R AFT OX TANK T1	1 OF 2 (BOTH)	a,g	RCS-02	FDA	(3)
V42T3300C	RCS R AFT FU TANK T1				FDA	
V42X1120X	RCS FWD HE OX PRESS VALVE A OP	BOTH (1)	a	RCS-03		(4)
V42X1122X	RCS FWD HE OX PRESS VALVE B OP					
V42X1124X	RCS FWD HE FU PRESS VALVE A OP					
V42X1126X	RCS FWD HE FU PRESS VALVE B OP					

(1) Applies to all measurements.
(2) Required for RCS PVT gaging and leak detection.
(3) Required for RCS PVT gaging.
(4) GO for confirmed instrumentation failure and valve functional.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42X2120X	RCS L AFT HE OX PRES VALVE A OP	BOTH (1)	a	RCS-03		(2)
V42X2122X	RCS L AFT HE OX PRES VALVE B OP					
V42X2124X	RCS L AFT HE FU PRES VALVE A OP					
V42X2126X	RCS L AFT HE FU PRES VALVE B OP					
V42X3120X	RCS R AFT HE OX PRES VALVE A OP	BOTH (1)	a	RCS-03		(2)
V42X3122X	RCS R AFT HE OX PRES VALVE B OP					
V42X3124X	RCS R AFT HE FU PRES VALVE A OP					
V42X3126X	RCS R AFT HE FU PRES VALVE B OP					
V42X1220X	RCS FWD OX TK ISLN VLV 1/2 OP	GND (1)	a	RCS-04		(2)
V42X1221X	RCS FWD OX TK ISLN VLV 1/2 CL					
V42X1222X	RCS FWD OX TK ISLN VLV 3/4/5 OP					
V42X1223X	RCS FWD OX TK ISLN VLV 3/4/5 CL					

(1) Applies to all measurements.
(2) GO for confirmed instrumentation failure and valve functional.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42X1320X	RCS FWD FU TK ISLN VLV 1/2 OP	GND (1)	a	RCS-04		(2)
V42X1321X	RCS FWD FU TK ISLN VLV 1/2 CL					
V42X1322X	RCS FWD FU TK ISLN VLV 3/4/5 OP					
V42X1323X	RCS FWD FU TK ISLN VLV 3/4/5 CL					
V42X2220X	RCS L OX TK ISLN VLV 1/2 OP	GND	a	RCS-04		(2)
V42X2221X	RCS L OX TK ISLN VLV 1/2 CL	GND				
V42X2222X	RCS L OX TK ISLN VLV 3/4/5A OP	BOTH				
V42X2223X	RCS L OX TK ISLN VLV 3/4/5A CL	BOTH				
V42X2224X	RCS L OX TK ISLN VLV 3/4/5B OP	BOTH				
V42X2225X	RCS L OX TK ISLN VLV 3/4/5B CL	BOTH				

(1) Applies to all measurements.
(2) GO for confirmed instrumentation failure and valve functional.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42X2320X	RCS L FU TK ISLN VLV 1/2 OP	GND	a	RCS-04		(1)
V42X2321X	RCS L FU TK ISLN VLV 1/2 CL	GND				
V42X2322X	RCS L FU TK ISLN VLV 3/4/5A OP	BOTH				
V42X2323X	RCS L FU TK ISLN VLV 3/4/5A CL	BOTH				
V42X2324X	RCS L FU TK ISLN VLV 3/4/5B OP	BOTH				
V42X2325X	RCS L FU TK ISLN VLV 3/4/5B CL	BOTH				
V42X3220X	RCS R OX TK ISLN VLV 1/2 OP	GND	a	RCS-04		(1)
V42X3221X	RCS R OX TK ISLN VLV 1/2 CL	GND				
V42X3222X	RCS R OX TK ISLN VLV 3/4/5A OP	BOTH				
V42X3223X	RCS R OX TK ISLN VLV 3/4/5A CL	BOTH				
V42X3224X	RCS R OX TK ISLN VLV 3/4/5B OP	BOTH				
V42X3225X	RCS R OX TK ISLN VLV 3/4/5B CL	BOTH				

(1) GO for confirmed instrumentation failure and valve functional.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42X3320X	RCS R FU TK ISLN VLV 1/2 OP	GND	a	RCS-04		(1)
V42X3321X	RCS R FU TK ISLN VLV 1/2 CL	GND				
V42X3322X	RCS R FU TK ISLN VLV 3/4/5A OP	BOTH				
V42X3323X	RCS R FU TK ISLN VLV 3/4/5A CL	BOTH				
V42X3324X	RCS R FU TK ISLN VLV 3/4/5B OP	BOTH				
V42X3325X	RCS R FU TK ISLN VLV 3/4/5B CL	BOTH				

(1) GO for confirmed instrumentation failure and valve functional.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42X1224X	RCS FWD OX MANF ISLN VLV 1 OP	BOTH (1)	a	RCS-05		(2)
V42X1225X	RCS FWD OX MANF ISLN VLV 1 CL					
V42X1226X	RCS FWD OX MANF ISLN VLV 2 OP					
V42X1227X	RCS FWD OX MANF ISLN VLV 2 CL					
V42X1228X	RCS FWD OX MANF ISLN VLV 3 OP					
V42X1229X	RCS FWD OX MANF ISLN VLV 3 CL					
V42X1230X	RCS FWD OX MANF ISLN VLV 4 OP					
V42X1231X	RCS FWD OX MANF ISLN VLV 4 CL					
V42X1232X	RCS FWD OX MANF ISLN VLV 5 OP					
V42X1233X	RCS FWD OX MANF ISLN VLV 5 CL					

(1) Applies to all measurements.
(2) GO for confirmed instrumentation failure and valve functional.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42X1324X	RCS FWD FU MANF ISLN VLV 1 OP	BOTH (1)	a	RCS-05		(2)
V42X1325X	RCS FWD FU MANF ISLN VLV 1 CL					
V42X1326X	RCS FWD FU MANF ISLN VLV 2 OP					
V42X1327X	RCS FWD FU MANF ISLN VLV 2 CL					
V42X1328X	RCS FWD FU MANF ISLN VLV 3 OP					
V42X1329X	RCS FWD FU MANF ISLN VLV 3 CL					
V42X1330X	RCS FWD FU MANF ISLN VLV 4 OP					
V42X1331X	RCS FWD FU MANF ISLN VLV 4 CL					
V42X1332X	RCS FWD FU MANF ISLN VLV 5 OP					
V42X1333X	RCS FWD FU MANF ISLN VLV 5 CL					

(1) Applies to all measurements.
(2) GO for confirmed instrumentation failure and valve functional.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42X2226X	RCS L AFT OX MANF ISLN VLV 1 OP	BOTH (1)	a	RCS-05		(2)
V42X2227X	RCS L AFT OX MANF ISLN VLV 1 CL					
V42X2228X	RCS L AFT OX MANF ISLN VLV 2 OP					
V42X2229X	RCS L AFT OX MANF ISLN VLV 2 CL					
V42X2230X	RCS L AFT OX MANF ISLN VLV 3 OP					
V42X2231X	RCS L AFT OX MANF ISLN VLV 3 CL					
V42X2232X	RCS L AFT OX MANF ISLN VLV 4 OP					
V42X2233X	RCS L AFT OX MANF ISLN VLV 4 CL					
V42X2234X	RCS L AFT OX MANF ISLN VLV 5 OP					
V42X2235X	RCS L AFT OX MANF ISLN VLV 5 CL					

(1) Applies to all measuruements.
(2) GO for confirmed instrumentation failure and valve functional.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42X2326X	RCS L AFT FU MANF ISLN VLV 1 OP	BOTH (1)	a	RCS-05		(2)
V42X2327X	RCS L AFT FU MANF ISLN VLV 1 CL					
V42X2328X	RCS L AFT FU MANF ISLN VLV 2 OP					
V42X2329X	RCS L AFT FU MANF ISLN VLV 2 CL					
V42X2330X	RCS L AFT FU MANF ISLN VLV 3 OP					
V42X2331X	RCS L AFT FU MANF ISLN VLV 3 CL					
V42X2332X	RCS L AFT FU MANF ISLN VLV 4 OP					
V42X2333X	RCS L AFT FU MANF ISLN VLV 4 CL					
V42X2334X	RCS L AFT FU MANF ISLN VLV 5 OP					
V42X2335X	RCS L AFT FU MANF ISLN VLV 5 CL					

(1) Applies to all measurements.
(2) GO for confirmed instrumentation failure and valve functional.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42X3226X	RCS R AFT OX MANF ISLN VLV 1 OP	BOTH (1)	a	RCS-05		(2)
V42X3227X	RCS R AFT OX MANF ISLN VLV 1 CL					
V42X3228X	RCS R AFT OX MANF ISLN VLV 2 OP					
V42X3229X	RCS R AFT OX MANF ISLN VLV 2 CL					
V42X3230X	RCS R AFT OX MANF ISLN VLV 3 OP					
V42X3231X	RCS R AFT OX MANF ISLN VLV 3 CL					
V42X3232X	RCS R AFT OX MANF ISLN VLV 4 OP					
V42X3233X	RCS R AFT OX MANF ISLN VLV 4 CL					
V42X3234X	RCS R AFT OX MANF ISLN VLV 5 OP					
V42X3235X	RCS R AFT OX MANF ISLN VLV 5 CL					

(1) Applies to all measurements.
(2) GO for confirmed instrumentation failure and valve functional.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42X3326X	RCS R AFT FU MANF ISLN VLV 1 OP	BOTH (1)	a	RCS-05		(2)
V42X3327X	RCS R AFT FU MANF ISLN VLV 1 CL					
V42X3328X	RCS R AFT FU MANF ISLN VLV 2 OP					
V42X3329X	RCS R AFT FU MANF ISLN VLV 2 CL					
V42X3330X	RCS R AFT FU MANF ISLN VLV 3 OP					
V42X3331X	RCS R AFT FU MANF ISLN VLV 3 CL					
V42X3332X	RCS R AFT FU MANF ISLN VLV 4 OP					
V42X3333X	RCS R AFT FU MANF ISLN VLV 4 CL					
V42X3334X	RCS R AFT FU MANF ISLN VLV 5 OP					
V42X3335X	RCS R AFT FU MANF ISLN VLV 5 CL					
V42T2501C	RCS L OX THRUST INJ TEMP L1A	3 OF 4 (GND)	a,d	RCS-06	FDA	(3)
V42T2502C	RCS L FU THRUST INJ TEMP L1A				FDA	
V42T2503C	RCS L OX THRUST INJ TEMP L3A				FDA	
V42T2504C	RCS L FU THRUST INJ TEMP L3A				FDA	

(1) Applies to all measurements.
(2) GO for confirmed instrumentation failure and valve functional.
(3) Instrumentation required for RCS RM leak detection. Failed XDCR requires prelaunch read/write.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42T3501C	RCS R OX THRUST INJ TEMP R1A	3 OF 4 (GND)	a,d	RCS-06	FDA	(1)
V42T3502C	RCS R FU THRUST INJ TEMP R1A				FDA	
V42T3503C	RCS R OX THRUST INJ TEMP R3A				FDA	
V42T3504C	RCS R FU THRUST INJ TEMP R3A				FDA	
V42T1501C	RCS FWD OX THRUST INJ TEMP F1F	5 OF 6 (GND)	d	RCS-06	FDA	(1)
V42T1502C	RCS FWD FU THRUST INJ TEMP F1F				FDA	
V42T1503C	RCS FWD OX THRUST INJ TEMP F2F				FDA	
V42T1504C	RCS FWD FU THRUST INJ TEMP F2F				FDA	
V42T1505C	RCS FWD OX THRUST INJ TEMP F3F				FDA	
V42T1506C	RCS FWD FU THRUST INJ TEMP F3F				FDA	

(1) Instrumentation required for RCS RM leak detection. Failed XDCR requires prelaunch read/write.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42T1515C	RCS FWD OX THRUST INJ TEMP F1U	5 OF 6 (GND)	d	RCS-06	FDA	(1)
V42T1516C	RCS FWD FU THRUST INJ TEMP F1U				FDA	
V42T1517C	RCS FWD OX THRUST INJ TEMP F2U				FDA	
V42T1518C	RCS FWD FU THRUST INJ TEMP F2U				FDA	
V42T1519C	RCS FWD OX THRUST INJ TEMP F3U				FDA	
V42T1520C	RCS FWD FU THRUST INJ TEMP F3U				FDA	
V42T2513C	RCS L OX THRUST INJ TEMP L1U	5 OF 6 (GND)	a,d	RCS-06	FDA	(1)
V42T2514C	RCS L FU THRUST INJ TEMP L1U				FDA	
V42T2515C	RCS L OX THRUST INJ TEMP L2U				FDA	
V42T2516C	RCS L FU THRUST INJ TEMP L2U				FDA	
V42T2517C	RCS L OX THRUST INJ TEMP L4U				FDA	
V42T2518C	RCS L FU THRUST INJ TEMP L4U				FDA	

(1) Instrumentation required for RCS RM leak detection. Failed XDCR requires prelaunch read/write.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42T3513C	RCS R OX THRUST INJ TEMP R1U	5 OF 6 (GND)	a,d	RCS-06	FDA	(1)
V42T3514C	RCS R FU THRUST INJ TEMP R1U				FDA	
V42T3515C	RCS R OX THRUST INJ TEMP R2U				FDA	
V42T3516C	RCS R FU THRUST INJ TEMP R2U				FDA	
V42T3517C	RCS R OX THRUST INJ TEMP R4U				FDA	
V42T3518C	RCS R FU THRUST INJ TEMP R4U				FDA	
V42T1507C	RCS FWD OX THRUST INJ TEMP F1L	3 OF 4 (GND)	a,d	RCS-06	FDA	(1)
V42T1508C	RCS FWD FU THRUST INJ TEMP F1L				FDA	
V42T1511C	RCS FWD OX THRUST INJ TEMP F3L				FDA	
V42T1512C	RCS FWD FU THRUST INJ TEMP F3L				FDA	
V42T1509C	RCS FWD OX THRUST INJ TEMP F2R	3 OF 4 (GND)	a,d	RCS-06	FDA	(1)
V42T1510C	RCS FWD FU THRUST INJ TEMP F2R				FDA	
V42T1513C	RCS FWD OX THRUST INJ TEMP F4R				FDA	
V42T1514C	RCS FWD FU THRUST INJ TEMP F4R				FDA	

(1) Instrumentation required for RCS RM leak detection. Failed XDCR requires prelaunch read/write.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42T2505C	RCS L OX THRUST INJ TEMP L1L	7 OF 8 (GND)	a,d	RCS-06	FDA	(1)
V42T2506C	RCS L FU THRUST INJ TEMP L1L				FDA	
V42T2507C	RCS L OX THRUST INJ TEMP L2L				FDA	
V42T2508C	RCS L FU THRUST INJ TEMP L2L				FDA	
V42T2509C	RCS L OX THRUST INJ TEMP L3L				FDA	
V42T2510C	RCS L FU THRUST INJ TEMP L3L				FDA	
V42T2511C	RCS L OX THRUST INJ TEMP L4L				FDA	
V42T2512C	RCS L FU THRUST INJ TEMP L4L				FDA	

(1) Instrumentation required for RCS RM leak detection. Failed XDCR requires prelaunch read/write.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42T3505C	RCS R OX THRUST INJ TEMP R1R	7 OF 8 (GND)	a,d	RCS-06	FDA	(1)
V42T3506C	RCS R FU THRUST INJ TEMP R1R				FDA	
V42T3507C	RCS R OX THRUST INJ TEMP R2R				FDA	
V42T3508C	RCS R FU THRUST INJ TEMP R2R				FDA	
V42T3509C	RCS R OX THRUST INJ TEMP R3R				FDA	
V42T3510C	RCS R FU THRUST INJ TEMP R3R				FDA	
V42T3511C	RCS R OX THRUST INJ TEMP R4R				FDA	
V42T3512C	RCS R FU THRUST INJ TEMP R4R				FDA	

(1) Instrumentation required for RCS RM leak detection. Failed XDCR requires prelaunch read/write.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42T1521C	RCS FWD OX THRUST INJ TEMP F1D	7 OF 8 (GND)	a,d	RCS-06	FDA	(1)
V42T1522C	RCS FWD FU THRUST INJ TEMP F1D				FDA	
V42T1523C	RCS FWD OX THRUST INJ TEMP F2D				FDA	
V42T1524C	RCS FWD FU THRUST INJ TEMP F2D				FDA	
V42T1525C	RCS FWD OX THRUST INJ TEMP F3D				FDA	
V42T1526C	RCS FWD FU THRUST INJ TEMP F3D				FDA	
V42T1527C	RCS FWD OX THRUST INJ TEMP F4D				FDA	
V42T1528C	RCS FWD FU THRUST INJ TEMP F4D				FDA	
V42T2519C	RCS L OX THRUST INJ TEMP L2D	5 OF 6 (GND)	a,d	RCS-06	FDA	(1)
V42T2520C	RCS L FU THRUST INJ TEMP L2D				FDA	
V42T2521C	RCS L OX THRUST INJ TEMP L3D				FDA	
V42T2522C	RCS L FU THRUST INJ TEMP L3D				FDA	
V42T2523C	RCS L OX THRUST INJ TEMP L4D				FDA	
V42T2524C	RCS L FU THRUST INJ TEMP L4D				FDA	

(1) Instrumentation required for RCS RM leak detection. Failed XDCR requires prelaunch read/write.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42T3519C	RCS R OX THRUST INJ TEMP R2D	5 OF 6 (GND)	a,d	RCS-06	FDA	(1)
V42T3520C	RCS R FU THRUST INJ TEMP R2D				FDA	
V42T3521C	RCS R OX THRUST INJ TEMP R3D				FDA	
V42T3522C	RCS R FU THRUST INJ TEMP R3D				FDA	
V42T3523C	RCS R OX THRUST INJ TEMP R4D				FDA	
V42T3524C	RCS R FU THRUST INJ TEMP R4D				FDA	
V42T1529C	RCS FWD OX THRUST INJ TEMP F5L	1 OF 2 (GND)	a,h	RCS-07	FDA	(2)
V42T1530C	RCS FWD FU THRUST INJ TEMP F5L					
V42T1531C	RCS FWD OX THRUST INJ TEMP F5R	1 OF 2 (GND)	a,h	RCS-07	FDA	(2)
V42T1532C	RCS FWD FU THRUST INJ TEMP F5R					
V42T2525C	RCS L OX THRUST INJ TEMP L5D	1 OF 2 (GND)	a,h	RCS-07	FDA	(2)
V42T2526C	RCS L FU THRUST INJ TEMP L5D					

(1) Instrumentation required for RCS RM leak detection. Failed XDCR requires prelaunch read/write.
(2) Instrumentation required for leak detection.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42T2527C	RCS L OX THRUST INJ TEMP L5L	1 OF 2 (GND)	a,h	RCS-07	FDA	(1)
V42T2528C	RCS L FU THRUST INJ TEMP L5L					
V42T3525C	RCS R OX THRUST INJ TEMP R5D	1 OF 2 (GND)	a,h	RCS-07	FDA	(1)
V42T3526C	RCS R FU THRUST INJ TEMP R5D					
V42T3527C	RCS R OX THRUST INJ TEMP R5R	1 OF 2 (GND)	a,h	RCS-07	FDA	(1)
V42T3528C	RCS R FU THRUST INJ TEMP R5R					
V42P1551A	RCS FWD THRUST CHMBR PRESS F1D	3 OF 4 (GND)	a,d	RCS-08	FDA	(2)
V42P1552A	RCS FWD THRUST CHMBR PRESS F2D				FDA	
V42P1553A	RCS FWD THRUST CHMBR PRESS F3D				FDA	
V42P1554A	RCS FWD THRUST CHMBR PRESS F4D				FDA	
V42P2550A	RCS L AFT THRUST CHMBR PRESS L2D	2 OF 3 (GND)	a,d	RCS-08	FDA	(2)
V42P2551A	RCS L AFT THRUST CHMBR PRESS L3D				FDA	
V42P2552A	RCS L AFT THRUST CHMBR PRESS L4D				FDA	

(1) Instrumentation required for leak detection.
(2) Instrumentation required for fail off detection. Failed XDCR requires prelaunch read/write.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42P3550A	RCS R AFT THRUST CHMBR PRESS R2D	2 OF 3 (GND)	a,d	RCS-08	FDA	(2)
V42P3551A	RCS R AFT THRUST CHMBR PRESS R3D				FDA	
V42P3552A	RCS R AFT THRUST CHMBR PRESS R4D				FDA	
V42P2547A	RCS L AFT THRUST CHMBR PRESS L1U	2 OF 3 (GND)	a,d	RCS-08	FDA	(2)
V42P2548A	RCS L AFT THRUST CHMBR PRESS L2U				FDA	
V42P2549A	RCS L AFT THRUST CHMBR PRESS L4U				FDA	
V42P3547A	RCS R AFT THRUST CHMBR PRESS R1U	2 OF 3 (GND)	a,d	RCS-08	FDA	(2)
V42P3548A	RCS R AFT THRUST CHMBR PRESS R2U				FDA	
V42P3549A	RCS R AFT THRUST CHMBR PRESS R4U				FDA	
V42P1548A	RCS FWD THRUST CHMBR PRESS F1U	GND (1)	d	RCS-08	FDA	(3)
V42P1549A	RCS FWD THRUST CHMBR PRESS F2U				FDA	
V42P1550A	RCS FWD THRUST CHMBR PRESS F3U				FDA	

(1) Applies to all measurements.
(2) Instrumentation required for fail off detection. Failed XDCR requires prelaunch read/write.
(3) Instrumentation required for fail off detection. Prelaunch read/write will be performed for failed xducer if time permits.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42P1544A	RCS FWD THRUST CHMBR PRESS F1L	1 OF 2 (GND)	a,d	RCS-08	FDA	(1)
V42P1546A	RCS FWD THRUST CHMBR PRESS F3L				FDA	
V42P1545A	RCS FWD THRUST CHMBR PRESS F2R	1 OF 2 (GND)	a,d	RCS-08	FDA	(1)
V42P1547A	RCS FWD THRUST CHMBR PRESS F4R				FDA	
V42P2543A	RCS L AFT THRUST CHMBR PRESS L1L	3 OF 4 (GND)	a,d	RCS-08	FDA	(1)
V42P2544A	RCS L AFT THRUST CHMBR PRESS L2L				FDA	
V42P2545A	RCS L AFT THRUST CHMBR PRESS L3L				FDA	
V42P2546A	RCS L AFT THRUST CHMBR PRESS L4L				FDA	
V42P3543A	RCS R AFT THRUST CHMBR PRESS R1R	3 OF 4 (GND)	a,d	RCS-08	FDA	(1)
V42P3544A	RCS R AFT THRUST CHMBR PRESS R2R				FDA	
V42P3545A	RCS R AFT THRUST CHMBR PRESS R3R				FDA	
V42P3546A	RCS R AFT THRUST CHMBR PRESS R4R				FDA	

(1) Instrumentation required for fail off detection. Failed XDCR requires prelaunch read/write.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42P2541A	RCS L AFT THRUST CHMBR PRESS L1A	1 OF 2 (GND)	a,d	RCS-08	FDA	(2)
V42P2542A	RCS L AFT THRUST CHMBR PRESS L3A				FDA	
V42P3541A	RCS R AFT THRUST CHMBR PRESS R1A	1 OF 2 (GND)	a,d	RCS-08	FDA	(2)
V42P3542A	RCS R AFT THRUST CHMBR PRESS R3A				FDA	
V42P1541A	RCS FWD THRUST CHMBR PRESS F1F	GND (1)	d	RCS-08	FDA	(3)
V42P1542A	RCS FWD THRUST CHMBR PRESS F2F				FDA	
V42P1543A	RCS FWD THRUST CHMBR PRESS F3F				FDA	
V42P2212C	RCS L AFT OX MANF P1	1 OF 2 (BOTH)	a,b,g	RCS-09		(4)
V42P2214C	RCS L AFT OX MANF P2					
V42P2216C	RCS L AFT OX MANF P3	1 OF 2 (BOTH)	a,b,g	RCS-09		(4)
V42P2218C	RCS L AFT OX MANF P4					
V42P2312C	RCS L AFT FU MANF P1	1 OF 2 (BOTH)	a,b,g	RCS-09		(4)
V42P2314C	RCS L AFT FU MANF P2					
V42P2316C	RCS L AFT FU MANF P3	1 OF 2 (BOTH)	a,b,g	RCS-09		(4)
V42P2318C	RCS L AFT FU MANF P4					

(1) Applies to all measurements.
(2) Instrumentation required for fail off detection. Failed XDCR requires prelaunch read/write.
(3) Instrumentation required for fail off detection. Prelaunch read/write will be performed for failed xducer if time permits.
(4) Instrumentation required for in-flight leak isolation.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42P3212C V42P3214C	RCS R AFT OX MANF P1 RCS R AFT OX MANF P2	1 OF 2 (BOTH)	a,b,g	RCS-09		(1)
V42P3216C V42P3218C	RCS R AFT OX MANF P3 RCS R AFT OX MANF P4	1 OF 2 (BOTH)	a,b,g	RCS-09		(1)
V42P3312C V42P3314C	RCS R AFT FU MANF P1 RCS R AFT FU MANF P2	1 OF 2 (BOTH)	a,b,g	RCS-09		(1)
V42P3316C V42P3318C	RCS R AFT FU MANF P3 RCS R AFT FU MANF P4	1 OF 2 (BOTH)	a,b,g	RCS-09		(1)
V42P1212C V42P1214C	RCS FWD OX MANF P1 RCS FWD OX MANF P2	1 OF 2 (BOTH)	a,c,g	RCS-09		(1)
V42P1216C V42P1218C	RCS FWD OX MANF P3 RCS FWD OX MANF P4	1 OF 2 (BOTH)	a,c,g	RCS-09		(1)
V42P1312C V42P1314C	RCS FWD FU MANF P1 RCS FWD FU MANF P2	1 OF 2 (BOTH)	a,c,g	RCS-09		(1)
V42P1316C V42P1318C	RCS FWD FU MANF P3 RCS FWD FU MANF P4	1 OF 2 (BOTH)	a,c,g	RCS-09		(1)

(1) Instrumentation required for in-flight leak isolation.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42X2236X	RCS L AFT OX XFD VLV 1/2 OP	GND (1)	a	RCS-10		(2)
V42X2237X	RCS L AFT OX XFD VLV 1/2 CL					
V42X2238X	RCS L AFT OX XFD VLV 3/4/5 OP					
V42X2239X	RCS L AFT OX XFD VLV 3/4/5 CL					
V42X2336X	RCS L AFT FU XFD VLV 1/2 OP	GND (1)	a	RCS-10		(2)
V42X2337X	RCS L AFT FU XFD VLV 1/2 CL					
V42X2338X	RCS L AFT FU XFD VLV 3/4/5 OP					
V42X2339X	RCS L AFT FU XFD VLV 3/4/5 CL					
V42X3236X	RCS R AFT OX XFD VLV 1/2 OP	GND (1)	a	RCS-10		(2)
V42X3237X	RCS R AFT OX XFD VLV 1/2 CL					
V42X3238X	RCS R AFT OX XFD VLV 3/4/5 OP					
V42X3239X	RCS R AFT OX XFD VLV 3/4/5 CL					

(1) Applies to all measurements.
(2) GO for confirmed instrumentation failure and valve functional.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V42X3336X	RCS R AFT FU XFD VLV 1/2 OP	GND (1)	a	RCS-10		(2)
V42X3337X	RCS R AFT FU XFD VLV 1/2 CL					
V42X3338X	RCS R AFT FU XFD VLV 3/4/5 OP					
V42X3339X	RCS R AFT FU XFD VLV 3/4/5 CL					
V79X2704X	RJDF 1 JET F1D CHMBR PRESS IND	3 OF 4 (GND)	a,d	GNC-45		(3)
V79X2708X	RJDF 1 JET F2D CHMBR PRESS IND					
V79X2712X	RJDF 2 JET F3D CHMBR PRESS IND					
V79X2714X	RJDF 2 JET F4D CHMBR PRESS IND					
V79X2722X	RJDA 1 JET L2D CHMBR PRESS IND	2 OF 3 (GND)	a,d	GNC-45		(3)
V79X2725X	RJDA 2 JET L3D CHMBR PRESS IND					
V79X2728X	RJDA 2 JET L4D CHMBR PRESS IND					

(1) Applies to all measurements.
(2) GO for confirmed instrumentation failure and valve functional.
(3) Instrumentation required for fail off detection. Failed measurement requires prelaunch read/write.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V79X2736X	RJDA 1 JET R2D CHMBR PRESS IND	2 OF 3 (GND)	a,d	GNC-45		(1)
V79X2739X	RJDA 2 JET R3D CHMBR PRESS IND					
V79X2742X	RJDA 2 JET R4D CHMBR PRESS IND					
V79X2702X	RJDF 1 JET F1L CHMBR PRESS IND	1 OF 2 (GND)	a,d	GNC-45		(1)
V79X2710X	RJDF 2 JET F3L CHMBR PRESS IND					
V79X2706X	RJDF 1 JET F2R CHMBR PRESS IND	1 OF 2 (GND)	a,d	GNC-45		(1)
V79X2713X	RJDF 2 JET F4R CHMBR PRESS IND					
V79X2718X	RJDA 1 JET L1L CHMBR PRESS IND	3 OF 4 (GND)	a,d	GNC-45		(1)
V79X2720X	RJDA 1 JET L2L CHMBR PRESS IND					
V79X2724X	RJDA 2 JET L3L CHMBR PRESS IND					
V79X2726X	RJDA 2 JET L4L CHMBR PRESS IND					

(1) Instrumentation required for fail off detection. Failed measurement requires prelaunch read/write.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V79X2732X	RJDA 1 JET R1R CHMBR PRESS IND	3 OF 4 (GND)	a,d	GNC-45		(2)
V79X2734X	RJDA 1 JET R2R CHMBR PRESS IND					
V79X2738X	RJDA 2 JET R3R CHMBR PRESS IND					
V79X2740X	RJDA 2 JET R4R CHMBR PRESS IND					
V79X2703X	RJDF 1 JET F1U CHMBR PRESS IND	GND (1)	d	GNC-45		(2)
V79X2707X	RJDF 1 JET F2U CHMBR PRESS IND					
V79X2711X	RJDF 2 JET F3U CHMBR PRESS IND					
V79X2719X	RJDA 1 JET L1U CHMBR PRESS IND	2 OF 3 (GND)	a,d	GNC-45		(2)
V79X2721X	RJDA 2 JET L2U CHMBR PRESS IND					
V79X2727X	RJDA 2 JET L4U CHMBR PRESS IND					
V79X2733X	RJDA 1 JET R1U CHMBR PRESS IND	2 OF 3 (GND)	a,d	GNC-45		(2)
V79X2735X	RJDA 2 JET R2U CHMBR PRESS IND					
V79X2741X	RJDA 2 JET R4U CHMBR PRESS IND					

(1) Applies to all measurements.
(2) Instrumentation required for fail off detection. Failed measurement requires prelaunch read/write.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V79X2717X	RJDA 1 JET L1A CHMBR PRESS IND	1 OF 2 (GND)	a,d	GNC-45		(2)
V79X2723X	RJDA 2 JET L3A CHMBR PRESS IND					
V79X2731X	RJDA 1 JET R1A CHMBR PRESS IND	1 OF 2 (GND)	a,d	GNC-45		(2)
V79X2737X	RJDA 2 JET R3A CHMBR PRESS IND					
V79X2701X	RJDF 1 JET F1F CHMBR PRESS IND	GND (1)	d	GNC-45		(3)
V79X2705X	RJDF 1 JET F2F CHMBR PRESS IND					
V79X2709X	RJDF 2 JET F3F CHMBR PRESS IND					
V79X2615X	RJDF JET DRIVER F5L	GND (1)	b,h	GNC-46		(4)
V79X2616X	RJDF JET DRIVER F5R					
V79X2629X	RJDF JET DRIVER L5D					
V79X2630X	RJDF JET DRIVER L5L					
V79X2643X	RJDF JET DRIVER R5R					
V79X2644X	RJDF JET DRIVER R5D					
V76X3257E	RJDF 2 MANF 4,5 LOGIC RPC C ON	GND (1)	d	GNC-47		(5)
V76X4237E	PCA FC RJDA 2 LOGIC 3 RPC B ON					
V76X4221E	PCA FC RJDA 1 LOGIC 1 RPC A ON					

(1) Applies to all measurements.
(2) Instrumentation required for fail off detection. Failed measurement requires prelaunch read/write.
(3) Instrumentation required for fail off detection. Prelaunch read/write will be performed for failed measurement if time permits.
(4) Required for verniers. May be waived if verniers not required.
(5) GO if instrumentation failure confirmed using LCC troubleshooting procedure.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V76X3252E	RJDF 1 MANF 1 DR RPC A ON	GND (1)	d	GNC-48		(2)
V76X3254E	RJDF 1 MANF 2 DR RPC B ON					
V76X3256E	RJDF 2 MANF 3 DR RPC C ON					
V76X3260E	RJDF 2 MANF 3 DR RPC A ON					
V76X3258E	RJDF 2 MANF 4 DR RPC C ON					
V76X4233E	PCA FC RJDA 1 RCS 2 RPC A ON	7 OF 8 (GND)	d	GNC-48		(2)
V76X4234E	PCA FC RJDA 1 RCS 2 RPC C ON					
V76X4224E	PCA FC RJDA 1 RCS 1 RPC B ON					
V76X4223E	PCA FC RJDA 1 RCS 1 RPC A ON					
V76X4244E	PCA FC RJDA 2 RCS 4 RPC C ON					
V76X4243E	PCA FC RJDA 2 RCS 4 RPC A ON					
V76X4239E	PCA FC RJDA 2 RCS 3 RPC B ON					
V76X4240E	PCA FC RJDA 2 RCS 3 RPC C ON					

(1) Applies to all measurements.
(2) GO if instrumentation failure confirmed using LCC troubleshooting procedure.

OMS/RCS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V79X2345X	RJDF 1 TRICKLE CUR CONT 1	GND (1)	d	GNC-49		(2)
V79X2347X	RJDF 1 TRICKLE CUR CONT 2					
V79X2355X	RJDF 2 TRICKLE CUR CONT 4,5					
V79X2357X	RJDF 2 TRICKLE CUR CONT 3					
V79X2365X	RJDA 1 TRICKLE CUR CONT 1,5L					
V79X2367X	RJDA 1 TRICKLE CUR CONT 2					
V79X2375X	RJDA 2 TRICKLE CUR CONT 3,5L					
V79X2377X	RJDA 2 TRICKLE CUR CONT 4					
V72K4515X	MASTER XFD FROM RT-1	2 of 3 (GND)	a			(3)
V72K4516X	MASTER XFD FROM RT-2					
V72K4517X	MASTER XFD FROM RT-3					
V72K4510X	MASTER XFD FROM LT-1	2 of 3 (GND)				
V72K4511X	MASTER XFD FROM LT-2					
V72K4512X	MASTER XFD FROM LT-3					

(1) Applies to all measurements.
(2) GO for confirmed instrumentation failure.
(3) GO as long as two contacts are not failed high - two failed high contacts results in auto crossfeed.

BOOSTER MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
SOLID ROCKET BOOSTER						
B47P1300C	L SRM CHAMBER P A	GND (1)	a,e	SRM-04	NONE	(2)
B47P1301C	L SRM CHAMBER P B					
B47P1302C	L SRM CHAMBER P C					
B47P2300C	R SRM CHAMBER P A					
B47P2301C	R SRM CHAMBER P B					
B47P2302C	R SRM CHAMBER P C					
EXTERNAL TANK						
T41P1700C	GH2 ULL PRESS 1	BOTH	a,c,g	ET-05	CLASS 3	(3)
T41P1701C	GH2 ULL PRESS 2	BOTH			BFS ALERT	
T41P1702C	GH2 ULL PRESS 3	BOTH				
(SPARE)	GH2 ULL PRESS 4					
T41P1750C	GO2 ULL PRESS 1	BOTH	c,e	ET-06	CLASS 3	(4)
T41P1751C	GO2 ULL PRESS 2	BOTH			BFS ALERT	
T41P1752C	GO2 ULL PRESS 3	BOTH				
(SPARE)	GO2 ULL PRESS 4					

(1) Applies to each measurement.
(2) Required to maintain single-fault tolerance. Required for SRB sep sequence.
(3) 3 of 3 required to maintain single-fault tolerance. 2 of 3 transducers are required to operate the flow control valves and to maintain engine inlet pressure. Required for the Net Positive Suction Pressure (NPSP) comp which is used to make manual throttle calls for low NPSP. Supports FR: 5-49, 50, 51.
(4) 3 of 3 required to maintain single-fault tolerance. 2 of 3 transducers are required to operate the flow control valves and to maintain LO2 tank structural integrity.

BOOSTER MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
T41X1730X	LH2 C/O SENSOR 1	GND (1)	a-d	MPS-22	NONE	(2)
T41X1731X	LH2 C/O SENSOR 2					
T41X1732X	LH2 C/O SENSOR 3					
T41X1733X	LH2 C/O SENSOR 4					
MAIN PROPULSION SYSTEM						
V41X1555X	LO2 LEFT C/O SEN 1	GND (1)	a-d	MPS-21	NONE	(2)
V41X1556X	LO2 LEFT C/O SEN 2					
V41X1557X	LO2 RGHT C/O SEN 2					
V41X1558X	LO2 RGHT C/O SEN 1					
V41P1150C	C HELIUM TANK P	BOTH (1)	a,b,g	MPS-01	CLASS 2 BFS ALERT; CLASS 3 BFS ALERT	(3)
V41P1250C	L HELIUM TANK P					
V41P1350C	R HELIUM TANK P					
V41P1600A	PNEU HELIUM TANK P	BOTH	a,b,g	MPS-01	NONE	(4)

(1) Applies to each measurement.
(2) 4 of 4 required to maintain two-fault tolerance. If three fail dry early MECO will result (SSME OPS sequence). Supports FR: 5-52.
(3) Required for MCC helium time of depletion comp and abort determination intelligence. Required for crew procedure implementation. Support FR: 5-28, 48.
(4) Required for MCC helium time of depletion comp and abort determination intelligence. Support FR: 5-47.

BOOSTER MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V41P1154A	C HELIUM REG P A	BOTH (1)	a,b,d,g	MPS-03	CLASS 2 BFS ALERT	(2)
V41P1153A	C HELIUM REG P B				CLASS 3 BFS ALERT	
V41P1254A	L HELIUM REG P A	BOTH (1)	a,b,d,g	MPS-03	CLASS 2 BFS ALERT	(2)
V41P1253A	L HELIUM REG P B				CLASS 3 BFS ALERT	
V41P1354A	R HELIUM REG P A	BOTH (1)	a,b,d,g	MPS-03	CLASS 2 BFS ALERT	(2)
V41P1353A	R HELIUM REG P B				CLASS 3 BFS ALERT	
V41P1650A	PNEU HELIUM ACCUM	GROUND	a,c,g	MPS-03	NONE	(3)
V41P1605A	PNEU HELIUM REG P	BOTH				
V41X1158E	C HE ISO A OP PWR	GND (1)	a,g	MPS-38	NONE	(4)
V41X1159E	C HE ISO B OP PWR					

(1) Applies to each measurement.
(2) MCC is GO for loss of TLM only on one transducer provided reg is verified operational. Supports FR: 5-47, 48.
(3) One of two required for insight into helium available for prevalve closure at MECO (engine shutdown). Supports FR: 5-45.
(4) Required for insight into crew leak isolation procedures. Supports FR: 5-47.

BOOSTER MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V41X1258E V41X1259E	L HE ISO A OP PWR L HE ISO B OP PWR	GND (1)	a,g	MPS-38	NONE	(2)
V41X1358E V41X1359E	R HE ISO A OP PWR R HE ISO B OP PWR	GND (1)	a,g	MPS-38	NONE	(2)
V41X1164E V41X1170E	C HE INCN IN OP PWR C HE INCN OUT OP PWR	GND (1)	a,g	MPS-40	NONE	(3)
V41X1264E V41X1270E	L HE INCN IN OP PWR L HE INCN OUT OP PWR	GND (1)	a,g	MPS-40	NONE	(3)
V41X1364E V41X1370E	R HE INCN IN OP PWR R HE INCN OUT OP PWR	GND (1)	a,g	MPS-40	NONE	(3)

(1) Applies to each measurement.
(2) Required for insight into crew leak isolation procedures. Supports FR: 5-47.
(3) Required for insight into crew interconnect procedures. Supports FR: 5-45, 46, 48.

BOOSTER MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V41X1430X V41X1434X	LH2 17" DSC CL IND A LH2 17" DSC CL IND B	GND (1)	a,g	MPS-16	ET SEP INHIBIT MESSAGE	(2)
V41X1530X V41X1534X	LO2 17" DSC CL IND A LO2 17" DSC CL IND B	GND (1)	a,g	MPS-15	ET SEP INHIBIT MESSAGE	(2)
V41X1410X V41X1405E V41X1406E	LH2 IB F/D VL CL IND LH2 IB F/D VL CL PWR LH2 IB F/D VL OP PWR		a,g	MPS-04	NONE	(3)
V41X1389X V41X1385E V41X1386E	LH2 OB F/D VL CL IND LH2 OB F/D VL CL PWR LH2 OB F/D VL OP PWR		a,g	MPS-05	NONE	(3)
V41X1509X V41X1505E V41X1506E	LO2 IB F/D VL CL IND LO2 IB F/D VL CL PWR LO2 IB F/D VL OP PWR		a,g	MPS-07	NONE	(3)
V41X1514X V41X1507E V41X1508E	LO2 OB F/D VL CL IND LO2 OB F/D VL CL PWR LO2 OB F/D VL OP PRW		a,g	MPS-08	NONE	(3)

(1) Applies to each measurement.
(2) One of two closed indications are required for automatic ET sep to occur (ET sep sequence). Both required for redundancy. Supports FR: 5-60.
(3) Required for abort dumps and inerting insight.

BOOSTER MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V41X1919X V41X1929X	LH2 RTLS O/B VL CL LH2 RTLS I/B VL CL		a,g	MPS-20	NONE	(2)
V41X1542E V41X1442E	LO2 FDLN RLF SOV CL LO2 FDLN RLF SOV CL	GND (1)	a,C	MPS-19	NONE	(3)
SPACE SHUTTLE MAIN ENGINE						
First 32 words of SSME controller vehicle data table for center (1) left (2) and right (3) engines	Primary and secondary data paths	GND (5)		SSME CONTROLLER MONITORED LCC	ENGINE STATUS LIGHTS AND FAULT MESSAGES	(4)

(1) Applies to each measurement.
(2) Required in MPS dump sequence.
(3) Required for manifold relief capability post-MECO.
(4) Vehicle Data Table is required by the GPC software and MCC for SSME performance insight. The MCC also requires this data for abort determination intelligence. Note that the following SSME parameters are the only ones not on low data rate: ID word 2, HPFT Dschg P, FPB Chamber P, Hydraulic P. Supports FR: 5-28, 35.
(5) Vehicle Data Table word six (MCC Pc average) is required by the crew to monitor acceptance of throttle commands and to implement the manual throttling procedure for low LH2 NPSP. Supports FR:5-50.

BOOSTER MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
ORBITER						
V72K0071X	ENG LIMIT AUTO A	GND (1)	a,g	SSME-37	NONE	(2)
V72K0072X	ENG LIMIT AUTO B					
V72K0073X	ENG LIMIT AUTO C					
V90X7570X	SRB SEP AUTO ENA	BOTH	a,g	BSEP-06	NONE	(3)
V90X7551X	SEL ME-1 SHTDN CMD	GND (1)	a	SSME-36	FDA	(4)
V90X7552X	SEL ME-2 SHTDN CMD					
V90X7553X	SEL ME-2 SHTDN CMD					

(1) Applies to each measurement.
(2) Required for inflight redline protection insight. Supports FR: 5-27, 28.
(3) Required for ground and crew insight into separation mode.
(4) Required for ground and crew insight into state of SSME shutdown switch.

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ELECTRICAL POWER DISTRIBUTION AND CONTROL MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
FUEL CELLS						
V45C0101A	FUEL CELL 1 CURRENT	2 of 3	b	FCP-01	FDA	(1)
V45C0201A	FUEL CELL 2 CURRENT					
V45C0301A	FUEL CELL 3 CURRENT					
V45T0120A	FC 1 STACK COOL T	1 of 2	b	FCP-02	C&W, FDA	(2)
V45T0130A	FC 1 CNDSR EXIT T				FDA	
V45T0220A	FC 2 STACK COOL T	1 of 2			C&W, FDA	
V45T0230A	FC 2 CNDSR EXIT T				FDA	
V45T0320A	FC 3 STACK COOL T	1 of 2			C&W, FDA	
V45T0330A	FC 3 CNDSR EXIT T				FDA	
V45X0143E	FC 1 COOL PMP STATUS		c	FCP-04	C&W, FDA	(3)
V45X0243E	FC 2 COOL PMP STATUS					
V45X0343E	FC 3 COOL PMP STATUS					

(1) Supports FLT Rules 9-1A, -1F, -1J, -11A, -16, -20, -23, -31, Plus MALFS.
(2) Supports FLT Rules 9-1B, -1C, -1F, -14D plus MALFS and Pocket Checklist Procedures.
(3) Supports FLT Rules 9-1B, -14C, -21 Plus MALFS and Pocket Checklist Procedures.

ELECTRICAL POWER DISTRIBUTION AND CONTROL MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V45V0102A	FC 1 SUBSTACK 1 DELTA VOLTS		c	FCP-03	FDA	(1)
V45V0103A	FC 1 SUBSTACK 2 DELTA VOLTS				FDA	
V45V0104A	FC 1 SUBSTACK 3 DELTA VOLTS				FDA	
V45V0202A	FC 2 SUBSTACK 1 DELTA VOLTS				FDA	
V45V0203A	FC 2 SUBSTACK 2 DELTA VOLTS				FDA	
V45V0204A	FC 2 SUBSTACK 3 DELTA VOLTS				FDA	
V45V0302A	FC 3 SUBSTACK 1 DELTA VOLTS				FDA	
V45V0303A	FC 3 SUBSTACK 2 DELTA VOLTS				FDA	
V45V0304A	FC 3 SUBSTACK 3 DELTA VOLTS				FDA	
V45X0410E	FC 1 H2O COND	3 of 4	c	FCP-05	FDA	(2)
V45X0420E	FC 2 H2O COND				FDA	
V45X0430E	FC 3 H2O COND				FDA	
V45X0462E	FC H2O CONDUCTIVITY					
V45T0182A	FC 1 ALT H20 LN T	2 of 3 (GND)	b	FCP-06		(3)
V45T0282A	FC 2 ALT H2O LN T					
V45T0382A	FC 3 ALT H20 LN T					

(1) Supports FLT Rules 9-1L, -14K, -17 Plus MALF and Pocket Checklists.
(2) Supports FLT Rules 9-1I, -14G, -14H, -17 Plus MALF and Pocket Checklists.
(3) Supports FLT Rules 9-1E, -241 (EECOM GO/NO-GO CHART).

ELECTRICAL POWER DISTRIBUTION AND CONTROL MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V62Q0595A	SMOKE DET CONCEN - CAB HX	2 of 3		ECL-30	C&W	(1)
V62Q0590A	SMOKE DET CONCEN - L FLT DK				C&W	
V62Q0591A	SMOKE DET CONCEN - R FLT DK				C&W	
V62Q0618A	SMOKE DET A CONCEN - AV BAY 1	1 of 2	c	ECL-32	C&W	(1)
V62Q0619A	SMOKE DET B CONCEN - AV BAY 1				C&W	
V62Q0608A	SMOKE DET A CONCEN - AV BAY 2	1 of 2	c	ECL-32	C&W	(1)
V62Q0609A	SMOKE DET B CONCEN - AV BAY 2				C&W	
V62Q0628A	SMOKE DET A CONCEN - AV BAY 3A	1 of 2	c	ECL-32	C&W	(1)
V62Q0629A	SMOKE DET B CONCEN - AV BAY 3A				C&W	

(1) Required for Fire/Smoke Detection.

ELECTRICAL POWER DISTRIBUTION AND CONTROL MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
ELECTRICAL BUSSES						
V76V0100A	MAIN BUS A VOLTS	1 of 2	b,c	FCP-01	C&W, FDA	(1)
V45V0100A	FC 1 VOLTS			EPDC-01	FDA	
V76V0200A	MAIN BUS B VOLTS	1 of 2			C&W, FDA	
V45V0200A	FC 2 VOLTS				FDA	
V76V0300A	MAIN BUS C VOLTS	1 of 2			C&W, FDA	
V45V0300A	FC 3 VOLTS				FDA	
V76V1500A	AC BUS 1 PH A VOLT	1 of 2	b,c	EPDC-03	C&W, FDA	(2)
V76C1540A	AC BUS 1 PH A CUR			EPDC-04		
V76V1501A	AC BUS 1 PH B VOLT	1 of 2			C&W, FDA	
V76C1541A	AC BUS 1 PH B CUR					
V76V1502A	AC BUS 1 PH C VOLT	1 of 2			C&W, FDA	
V76C1542A	AC BUS 1 PH C CUR					
V76V1600A	AC BUS 2 PH A VOLT	1 of 2			C&W, FDA	
V76C1640A	AC BUS 2 PH A CUR					
V76V1601A	AC BUS 2 PH B VOLT	1 of 2			C&W, FDA	
V76C1641A	AC BUS 2 PH B CUR					
V76V1602A	AC BUS 2 PH C VOLT	1 of 2			C&W, FDA	
V76C1642A	AC BUS 2 PH C CUR					

(1) Supports Flight Rules 9-2A, -11A, -11C, -14A, -14I, -15A, -16, -22B, -36A Plus MALFS and Pocket Checklist Procedures.
(2) Supports Flight Rules 9-2F, -31, -50, -52, -56 plus MALFS and Pocket Checklists.

ELECTRICAL POWER DISTRIBUTION AND CONTROL MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V76V1700A	AC BUS 3 PH A VOLT	1 of 2	b,c	EPDC-03	C&W, FDA	(1)
V76C1740A	AC BUS 3 PH A CUR			EPDC-04		
V76V1701A	AC BUS 3 PH B VOLT	1 of 2			C&W, FDA	
V76C1741A	AC BUS 3 PH B CUR					
V76V1702A	AC BUS 3 PH C VOLT	1 of 2			C&W, FDA	
V76C1742A	AC BUS 3 PH C CUR					
V76X6775E	L SRB BUS A B/U PWR ON	1 of 2	c	EPDC-05		(2)
B76V1600C	LH VOLTS OPS BUS A			BEI-01		
V76X6776E	R SRB BUS A B/U PWR ON	1 of 2				
B76V1601C	RH VOLTS OPS BUS A					
V76X6777E	L SRB BUS B B/U PWR ON	1 of 2				
B76V2600C	LH VOLTS OPS BUS B					
V76X6778E	R SRB BUS B B/U PWR ON	1 of 2				
B76V2601C	RH VOLTS OPS BUS B					

(1) Supports Flight Rules 9-2F, -31, -50, -52, -56 Plus MALFS and Pocket Checklists.
(2) SRB BUS Status (Prelaunch Only).

ELECTRICAL POWER DISTRIBUTION AND CONTROL MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY		GDLINE REF.	SSID	C&W/FDA	NOTES
V76V0120A	CNTL BUS AB1 VOLTS			b	EPDC-02	FDA	(1)
			1				
V76X0124E	MN A TO CNTRL BUS	1	of				
	AB1/CA1 RPC ON	of	2				
V76X0224E	MN B TO CNTRL BUS	2					
	AB1/BC1 RPC ON						
V76V0121A	CNTL BUS AB2 VOLTS			b	EPDC-02	FDA	(1)
			1				
V76X0125E	MN A TO CNTRL BUS	1	of				
	AB2/CA2 RPC ON	of	2				
V76X0225E	MN B TO CNTRL BUS	2					
	AB2/BC2 RPC ON						
V76V0122A	CNTL BUS AB3 VOLTS			b	EPDC-02	FDA	(1)
			1				
V76X0126E	MN A TO CNTRL BUS	1	of				
	AB3/CA3 RPC ON	of	2				
V76X0226E	MN B TO CNTRL BUS	2					
	AB3/BC3 RPC ON						
V76V0220A	CNTL BUS BC1 VOLTS			b	EPDC-02	FDA	(1)
			1				
V76X0224E	MN B TO CNTRL BUS	1	of				
	AB1/BC1 RPC ON	of	2				
V76X0324E	MN C TO CNTRL BUS	2					
	BC1/CA1 RPC ON						

(1) Supports FLT Rules 9-2E, -12E, -12G, -241 (EECOM GO/NO-GO CHART) Plus MALF and Pocket Checklist.

ELECTRICAL POWER DISTRIBUTION AND CONTROL MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V76V0221A	CNTL BUS BC2 VOLTS		b	EPDC-02	FDA	(1)
V76X0225E	MN B TO CNTRL BUS AB2/BC2 RPC ON	1 of 2				
V76X0325E	MN C TO CNTRL BUS BC2/CA2 RPC ON					
V76V0222A	CNTL BUS BC3 VOLTS		b	EPDC-02	FDA	(1)
V76X0226E	MN B TO CNTRL BUS AB3/BC3 RPC ON	1 of 2				
V76X0326E	MN C TO CNTRL BUS BC3/CA3 RPC ON					
V76V0320A	CNTL BUS CA1 VOLTS		b	EPDC-02	FDA	(1)
V76X0124E	MN A TO CNTRL BUS AB1/CA1 RPC ON	1 of 2				
V76X0324E	MN C TO CNTRL BUS BC1/CA1 RPC ON					
V76V0321A	CNTL BUS CA2 VOLTS		b	EPDC-02	FDA	(1)
V76X0125E	MN A TO CNTRL BUS AB2/CA2 RPC ON	1 of 2				
V76X0325E	MN C TO CNTRL BUS BC2/CA2 RPC ON					

(1) Supports FLT Rules 9-2E, -12E, -12G, -241 (EECOM GO/NO-GO CHART), Plus MALF and Pocket Checklist.

ELECTRICAL POWER DISTRIBUTION AND CONTROL MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V76V0322A	CNTL BUS CA3 VOLTS	1 of 2	b	EPDC-02	FDA	(1)
V76X0126E	MN A TO CNTRL BUS AB3/CA3 RPC ON					
V76X0326E	MN C TO CNTRL BUS BC3/CA3 RPC ON					

(1) Supports FLT Rules 9-2E, -12E, -12G, -241 (EECOM GO/NO-GO CHART), Plus MALF and Pocket Checklists.

LIFE SUPPORT SYSTEMS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
ARPCS						
V61R2401A	CABIN dP/dT	1 of 2	a,b	ECL-04	KLAXON	(1),
V61P2405A	CABIN PRESS	(BOTH)	a,b,f		C&W/FDA	(2)
V61P2405A	CABIN PRESS	BOTH	a,b,f,h		C&W/FDA	(3)
V61P2511A	PPO2 A	2 of 3	a,b,f	ECL-06	C&W	(4),
V61P2513A	PPO2 B	(BOTH)	a,b,f		C&W	(5)
V61P2515A	PPO2 C		a,b			

(1) Supports LK detection; supports flt rule 9-110, 9-241D (EECOM GO/NO-GO Chart), plus MALF and Pocket Checklist procedures (APCL, OPCL and EPCL).
(2) The cabin pressure measurement is used by the BFS to calculate the backup dP/dt.
(3) Mandatory for scheduled EVA flights since cabin cannot be depressed to 10.2 psia without it (FR 9-144A).
(4) Two of three sensors are required because of the temperature changes.
(5) Instrumentation supports the requirement to provide a habit-crew environment and to avoid a max 02 concentration problem (fire hazard). Also supports Flt Rules 9-112, 9-123, 9-135, 9-136, 9-144B, 9-241D (EECOM GO/NO-GO Chart), plus MALF and Pocket Checklist procedures.

LIFE SUPPORT SYSTEMS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V61P2301A	SYS 1 N2 SUPPLY P	1 of 2	b	ECL-02	FDA (1)	(2)
V61P2309A	SYS 2 N2 SUPPLY P	(GND)			FDA (1)	
V61T2406A	SYS 1 N2 TANK 1 T				FDA (1)	
V61T2407A	SYS 1 N2 TANK 2 T	1 of 4			FDA (1)	
V61T2408A	SYS 2 N2 TANK 1 T	(GND)			FDA (1)	
V61T2409A	SYS 2 N2 TANK 2 T				FDA (1)	
V61P2540A	CABIN CO2 PARTIAL PRESSURE	1 of 2	b,e		FDA	(3)
V61P2921A	EDO CO2 RCRS PARTIAL PRESSURE					

(1) Onboard N2 QTY comp is lost for loss of any instrumentation; the FDA is on the comp.
(2) Supports leak detection and consumables management; supports Flt Rules 9-111B, 9-113, 9-144C, 9-230, 9-241D (EECOM GO/NO-GO Chart), plus MALFS.
(3) Requirement applies only for missions with RCRS and for which the number of LiOH canisters loaded is less than the number required to complete the planned mission plus extension.

LIFE SUPPORT SYSTEMS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
WATER SYSTEM						
V62Q0410A	POT H2O TANK A QTY	1 of 2	b	ECL-20	FDA	(1)
V62Q0420A	SPLY H2O TANK B QTY	(BOTH)	b		FDA	
V62Q0548A	SPLY H2O TANK C QTY	1 of 2	b		FDA	
V62Q0544A	SPLY H2O TANK D QTY	(BOTH)	b		FDA	
V62T0520A	WASTE H20 DUMP NOZ TEMP A	1 of 2 (BOTH)	b	ECL-22	FDA	(2)
V62T0519A	WASTE H20 DUMP NOZ TEMP B		b		FDA	
V62T0440A	SUPPLY H2O DUMP NOZ TEMP A	1 of 2 (BOTH)	b,h	ECL-23	FDA	(3)
V62T0439A	SUPPLY H2O DUMP NOZ TEMP B		b,h		FDA	

(1) Supports leak detection and consumable management. Supports Flt Rules 9-180, 9-199, 9-232, 9-241F (EECOM GO/NO-GO Chart), plus MALF and Pocket Checklist procedure (OPCL).
(2) One nozzle temp is required to be able to dump waste water overboard through the dump nozzle. Supports Flt Rules 9-184D, 9-205, 9-241F, (EECOM GO/NO-GO Chart), plus MALFS.
(3) One nozzle temp is required to be able to dump supply water overboard through the dump nozzle. Supports Flt Rules 9-181D, 9-182, 9-194, plus MALFS. However, this is dependent on whether the FES is constrained or not for a particular flight.

LIFE SUPPORT SYSTEMS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
CRYOGENIC O2 AND H2						
V45P1110A	O2 TK 1 HTR CTR P	1 of 2	a,b,f	PRSD-01	C&W	(1)
V45P1100A	O2 TK 1 P	(BOTH)	a,b		FDA	
V45P1210A	O2 TK 2 HTR CTR P	1 of 2	a,b,f		C&W	
V45P1200A	O2 TK 2 P	(BOTH)	a,b		FDA	
V45P1310A	O2 TK 3 HTR CTR P	1 of 2	a,b,f,h		C&W	
V45P1300A	O2 TK 3 P	(BOTH)	a,b,h		FDA	(2)
V45P1410A	O2 TK 4/5 HTR CTR P	1 of 2	a,b,f,h		C&W	
V45P1400A	O2 TK 4 P	(BOTH)	a,b,h		FDA	
V45P1410A	O2 TK 4/5 HTR CTR P	1 of 3	a,b,f,h		C&W	
V45P1400A	O2 TK 4 P	(BOTH)	a,b,h		FDA	
V45P1500A	O2 TK 5 P		a,b,h		FDA	
V45P2110A	H2 TK 1 HTR CTR P	1 of 2	a,b,f	PRSD-06	C&W	(1)
V45P2100A	H2 TK 1 P	(BOTH)	a,b		FDA	
V45P2210A	H2 TK 2 HTR CTR P	1 of 2	a,b,f		C&W	
V45P2200A	H2 TK 2 P	(BOTH)	a,b		FDA	
V45P2310A	H2 TK 3 HTR CTR P	1 of 2	a,b,f,h		C&W	
V45P2300A	H2 TK 3 P	(BOTH)	a,b,h		FDA	(2)
V45P2410A	H2 TK 4/5 HTR CTR P	1 of 2	a,b,f,h		C&W	
V45P2400A	H2 TK 4 P	(BOTH)	a,b,h		FDA	

(1) Supports LK detection. Supports Flt Rules 9-150, 9-151, 9-168, 9-169, 9-241E (EECOM GO/NO-GO Chart), plus MALFS and Pocket Checklist procedures (APCL, OPCL, EPCL).
(2) TKS 3,4,5 applicable when flown.

LIFE SUPPORT SYSTEMS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V45P2410A	H2 TK 4/5 HTR CTR P	1 of 3	a,b,f,h		C&W	
V45P2400A	H2 TK 4 P	(BOTH)	a,b,h		FDA	
V45P2500A	H2 TK 5 P		a,b,h		FDA	
V45Q1105A	O2 TK 1 QTY	2 of X(1)	b	PRSD-07	FDA	(2)
V45Q1205A	O2 TK 2 QTY	(BOTH)			FDA	
V45Q1305A	O2 TK 3 QTY				FDA	
V45Q1405A	O2 TK 4 QTY				FDA	
V45Q1505A	O2 TK 5 QTY				FDA	
V45Q2105A	H2 TK 1 QTY	2 of X(1)	b	PRSD-08	FDA	(2)
V45Q2205A	H2 TK 2 QTY	(BOTH)			FDA	
V45Q2305A	H2 TK 3 QTY				FDA	
V45Q2405A	H2 TK 4 QTY				FDA	
V45Q2505A	H2 TK 5 QTY				FDA	

(1) Two of the flown tank quantities required, one of which must be tank 1 or 2.
(2) Supports Consumables Management. Supports Flt Rules 9-164, 9-167, 9-231, 9-241E (EECOM GO/NO-GO Chart).

LIFE SUPPORT SYSTEMS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
FREON COOLANT LOOPS/FLASH EVAPORATOR SYSTEM						
V63Q1130A V63P1108A	FCL 1 ACCUM QTY FCL 1 PUMP IN P	(BOTH) 1 (GND) of 2	b	ECL-41	FDA	(1)
V63Q1330A V63P1308A	FCL 2 ACCUM QTY FCL 2 PUMP IN P	(BOTH) 1 (GND) of 2			FDA	
V63R1100A V63R1105A V63R1103A	FCL 1 ICH FLOW RATE FCL 1 AFT CP FLOW FCL 1 PL HX FLOW	2 of 3 (BOTH)	b	ECL-40	C&W FDA FDA	(2)
V63R1300A V63R1305A V63R1303A	FCL 2 ICH FLOW RATE FCL 2 AFT CP FLOW FCL 2 PL HX FLOW	2 of 3 (BOTH)	b		C&W FDA FDA	
V63R1100A V63R1300A	FCL 1 ICH FLOW RATE FCL 2 ICH FLOW RATE	1 of 2 (BOTH)	a		C&W C&W	
V63T1207A V63T1407A	EVAP OUT T FCL 1 EVAP OUT T FCL 2	1 OF 2 (BOTH)	b, c	ECL-43	C&W C&W	(3)

(1) Supports FCL Leak Detection. Supports Flt Rules 9-70, 9-82, 9-241 (EECOM GO/NO-GO Chart), plus MALF procedures.
(2) Supports degraded FCL Detection. Supports Flt Rules 9-70, 9-241 (EECOM GO/NO-GO Chart), plus MALF and Pocket Checklist procedures.
(3) Supports FES/ABS Malf Detection. Supports Flt Rules 9-71, 9-72, 9-73, 9-74, 9-241 (EECOM GO/NO-GO Chart), plus MALF and Pocket Checklist procedures.

LIFE SUPPORT SYSTEMS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
AMMONIA BOILER SYSTEM						
V63P1196A	NH3 SYS A TK P	1 of 2	a,b	ECL-42		(2)
V63T1180A	NH3 SYS A TK T	1(1) of 2 (GND)				
V63P1197A	NH3 SYS B TK P	1 of 2				
V63T1188A	NH3 SYS B TK T					
WATER LOOPS						
V61P2700A	LOOP 2 PUMP OUT P	1 of 3 (BOTH)	b,c	ECL-09	C&W	(3)
V61R2722A	LOOP 2 ICH FLOW				FDA	
V61P2705A	LOOP 2 PUMP DELTA P				FDA	
V61P2600A	LOOP 1 PUMP OUT P	1 of 2 (BOTH)	b,c	ECL-08	C&W	(4)
V61P2610A	LOOP 1 ACCUM QTY				FDA	
V61P2700A	LOOP 2 PUMP OUT P	1 of 2 (BOTH)			C&W	
V61P2710A	LOOP 2 ACCUM QTY				FDA	

(1) One measurement (P or T) per TK and one must be pressure.
(2) Must verify at least one of two NH3 systems for ascent aborts.
(3) Supports water loop system performance evaluation. Supports FLT rules 9-90, 9-241 (EECOM GO/NO-GO Chart), plus MALFS and all Pocket Checklist procedures.
(4) Support water loop LK detection. Supports FLT rules 9-90, 9-100, 9-241, (EECOM GO/NO-GO Chart), plus MALFS.

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APU/HYD, MECHANICAL, RMS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
APU						
V46P0100A	APU 1 FUEL TANK P	1 of 2	b	APU-01	(1)	(2)
V46P0105A	APU 1 FUEL OUT P					
V46P0200A	APU 2 FUEL TANK P	1 of 2			(1)	
V46P0205A	APU 2 FUEL OUT P					
V46P0300A	APU 3 FUEL TANK P	1 of 2			(1)	
V46P0305A	APU 3 FUEL OUT P					
V46T0161A	APU 1 GBX BRG TEMP 1	1 of 2	a,b	APU-12	FDA	
V46T0162A	APU 1 GBX BRG TEMP 2					
V46T0261A	APU 2 GBX BRG TEMP 1	1 of 2			FDA	
V46T0262A	APU 2 GBX BRG TEMP 2					
V46T0361A	APU 3 GBX BRG TEMP 1	1 of 2			FDA	
V46T0362A	APU 3 GBX BRG TEMP 2					

(1) Used in Tank Quantity Comp which is on FDA.
(2) Supports APU Leak Detection/Isolation plus malfunction procedures.

APU/HYD, MECHANICAL, RMS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V46T0183A	APU 1 FU TEST LN T1	1 of 2	b,e	APU-14	FDA	(1)
V46T0184A	APU 1 FU SERV LN T				FDA	
V46T0283A	APU 2 FU TEST LN T1	1 of 2			FDA	
V46T0284A	APU 2 FU SERV LN T				FDA	
V46T0383A	APU 3 FU TEST LN T1	1 of 2			FDA	
V46T0384A	APU 3 FU SERV LN T				FDA	

(1) Supports detection of failed on heater which can result in N2H4 detonation and failed off htr which can result in N2H4 leakage during entry; supports MALF procedures.

APU/HYD, MECHANICAL, RMS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V46T0104A	APU 1 FU LN T2	1 of 2	b,e	APU-02	FDA	(1)
V46T0108A	APU 1 FU LN T1				FDA	
V46T0204A	APU 2 FU LN T2	1 of 2			FDA	
V46T0208A	APU 2 FU LN T1				FDA	
V46T0304A	APU 3 FU LN T2	1 of 2			FDA	
V46T0308A	APU 3 FU LN T1				FDA	
V46T0128A	APU 1 FU LN T3	1 of 2	b,e	APU-05	FDA	(1)
V46T1171A	APU 1 GG SPLY LN T				FDA	
V46T0228A	APU 2 FU LN T3	1 of 2			FDA	
V46T1271A	APU 2 GG SPLY LN T				FDA	
V46T0328A	APU 3 FU LN T3	1 of 2			FDA	
V46T1371A	APU 3 GG SPLY LN T				FDA	
V46T0112A	APU 1 FU PMP DISCH T	1 of 3	a,b,e	APU-18	FDA	(2)
V46T1172A	APU 1 GGVM HTSK T			APU-22		
V46T0192A	APU 1 FU PMP T				FDA	
V46T0212A	APU 2 FU PMP DISCH T	1 of 3			FDA	
V46T1272A	APU 2 GGVM HTSK T					
V46T0292A	APU 2 FU PMP T				FDA	
V46T0312A	APU 3 FU PMP DISCH T	1 of 3			FDA	
V46T1372A	APU 3 GGVM HTSK T					
V46T0392A	APU 3 FU PMP T				FDA	

(1) Supports detection of failed on heater which can result in N2H4 detonation and failed off htr which can result in N2H4 leakage during entry; supports MALF procedures.
(2) Supports leak detection and isolation plus MALF procedures.

APU/HYD, MECHANICAL, RMS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V46T0170A	APU1 FU PMP DR LN T2	1 of 2	b,e	APU-15	FDA	(1)
V46T0186A	APU1 FU PMP DR LN T1				FDA	
V46T0270A	APU2 FU PMP DR LN T2	1 of 2			FDA	
V46T0286A	APU2 FU PMP DR LN T1				FDA	
V46T0370A	APU3 FU PMP DR LN T2	1 of 2			FDA	
V46T0386A	APU3 FU PMP DR LN T1				FDA	
V46T0150A	APU 1 LUBE OIL RTN T	1 of 2	a,b,e	APU-08	C&W	(2)
V46T0154A	APU 1 LUBE OIL OUT T			APU-09	FDA	
V46T0250A	APU 2 LUBE OIL RTN T	1 of 2			C&W	
V46T0254A	APU 2 LUBE OIL OUT T				FDA	
V46T0350A	APU 3 LUBE OIL RTN T	1 of 2			C&W	
V46T0354A	APU 3 LUBE OIL OUT T				FDA	
V46T0122A	APU 1 GG BED T	1 of 2	a,b,e	APU-04	FDA	(3)
V46T0174A	APU 1 INJ T					
V46T0222A	APU 2 GG BED T	1 of 2			FDA	
V46T0274A	APU 2 INJ T					
V46T0322A	APU 3 GG BED T	1 of 2			FDA	
V46T0374A	APU 3 INJ T					

(1) Supports detection of failed on heater which can result in N2H4 detonation and failed off htr which can result in N2H4 leakage during entry; supports MALF procedures.
(2) Supports WSB performance eval; FRs, MALF, PCL and Cue Card procedures.
(3) Supports MALF, and Cue Card procedures.

APU/HYD, MECHANICAL, RMS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V46P0120A	APU 1 GG CHMBR P	GRND	a,b	APU-03		
V46P0220A	APU 2 GG CHMBR P	GRND				
V46P0320A	APU 3 GG CHMBR P	GRND				
V46P0151A	APU 1 GBOX GN2 P		a,b	APU-10 APU-11	FDA	(1)
V46P0251A	APU 2 GBOX GN2 P				FDA	
V46P0351A	APU 3 GBOX GN2 P				FDA	
V46P0190A V46P0191A	APU1 FU PMP DR LN P1 APU1 FU PMP DR LN P2	1 of 2	a,b	APU-16	FDA	(2)
V46P0290A V46P0291A	APU2 FU PMP DR LN P1 APU2 FU PMP DR LN P2	1 of 2			FDA	
V46P0390A V46P0391A	APU3 FU PMP DR LN P1 APU3 FU PMP DR LN P2	1 of 2			FDA	
V46P0110A	APU 1 FP INLET PR			APU-25		
V46P0210A	APU 2 FP INLET PR			APU-25		(3)
V46P0310A	APU 3 FP INLET PR			APU-25		

(1) Used to detect gearbox leaks after APU start. Causes repress if failed low.
(2) Supports APU leak detection and isolation plus PCL and Cue Card procedures.
(3) Supports detection of fuel leak and verify fuel pump inlet pressure is above lower pressure constraint for opening fuel isolation valve.

APU/HYD, MECHANICAL, RMS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
HYD						
V58P0115A	HYD 1 MN PMP P B	1 of 2	a,b	HYD-02	FDA	(1)
V58P0116C	HYD 1 MN PMP P C					
V58P0215A	HYD 2 MN PMP P B	1 of 2			FDA	
V58P0216C	HYD 2 MN PMP P C					
V58P0315A	HYD 3 MN PMP P B	1 of 2			FDA	
V58P0316C	HYD 3 MN PMP P C					
V76X4020E	PCA HYD PMP 1 RPC A	GRND		HYD-09		(2)
V76X4021E	PCA HYD PMP 1 RPC B	GRND				
V76X4024E	PCA HYD PMP 2 RPC B	GRND				
V76X4025E	PCA HYD PMP 2 RPC C	GRND				
V76X4027E	PCA HYD PMP 3 RPC C	GRND				
V76X4028E	PCA HYD PMP 3 RPC A	GRND				
V58X0199E	HYD 1 LG/NWS ISLN CL		a,b	HYD-08		(3)
V58Q0102A	HYD 1 RSVR QTY	ONBD	a,b	HYD-01	FDA	(4)
V58Q0202A	HYD 2 RSVR QTY	ONBD			FDA	
V58Q0302A	HYD 3 RSVR QTY	ONBD			FDA	

(1) Supports PCL and Cue Cards procedure. Used in priority rate limiting software.
(2) Prelaunch mandatory to insure ability to start APU on-orbit.
(3) Also referred to as LDG EXTEND ISOL VALVE.
(4) Supports MALF, PCL and Cue Card procedures.

APU/HYD, MECHANICAL, RMS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V58P0131A	HYD 1 RSVR P	1 of 2	b	HYD-07		(1)
V58P0167A	HYD 1 GN2 ACCUM P				FDA	
V58P0231A	HYD 2 RSVR P	1 of 2				
V58P0267A	HYD 2 GN2 ACCUM P				FDA	
V58P0331A	HYD 3 RSVR P	1 of 2				
V58P0367A	HYD 3 GN2 ACCUM P				FDA	
V58P0137A	HYD 1 CIRC PMP P		b	HYD-03	FDA	(2)
V58P0237A	HYD 2 CIRC PMP P				FDA	
V58P0337A	HYD 3 CIRC PMP P				FDA	
V58P0147A	HYD 1 WSB GN2 TK P	1 of 2	b	HYD-04		
V58T0105A	HYD 1 WSB GN2 TK T					
V58P0247A	HYD 2 WSB GN2 TK P	1 of 2				
V58T0205A	HYD 2 WSB GN2 TK T					
V58P0347A	HYD 3 WSB GN2 TK P	1 of 2				
V58T0305A	HYD 3 WSB GN2 TK T					
V58X0182E	HYD 1 WSB OK		b	HYD-10		(3)
V58X0282E	HYD 2 WSB OK					
V58X0383E	HYD 3 WSB OK					

(1) Supports MALF, PCL and Cue Card procedures.
(2) Detection of check valve failure.
(3) Detects GN2 Valve failure.

APU/HYD, MECHANICAL, RMS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V58T0165A	HYD 1 WSB VENT T 1	1 of 2	b	HYD-10		
V58T0166A	HYD 1 WSB VENT T 2					
V58T0265A	HYD 2 WSB VENT T 1	1 of 2				
V58T0266A	HYD 2 WSB VENT T 2					
V58T0365A	HYD 3 WSB VENT T 1	1 of 2				
V58T0366A	HYD 3 WSB VENT T 2					
V58T0162A	HYD 1 WSB BLR T 1	1 of 2	b	HYD-05		
V58T0163A	HYD 1 WSB BLR T 2					
V58T0262A	HYD 2 WSB BLR T 1	1 of 2				
V58T0263A	HYD 2 WSB BLR T 2					
V58T0362A	HYD 3 WSB BLR T 1	1 of 2				
V58T0363A	HYD 3 WSB BLR T 2					

APU/HYD, MECHANICAL, RMS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
LANDING GEAR						
V58X1725E	LMG STRUT ACTUATOR SHUTTLE VLV GR DN READY		c	AFM-11		
V58X1775E	RMG STRUT ACTUATOR SHUTTLE VLV GR DN READY					
V58X1825E	NLG STRUT ACTUATOR SHUTTLE VLV GR DN READY					
V51V0550C	NW POSN A IND	2 of 3		GNC-84		(1)
V51V0551C	NW POSN B IND					
V51V0552C	NW POSN C IND					
V51X0645E	NWS FAIL IND			GNC-83		(2)
V51X0100X	LMG UP	3 of 4	b,c	AFM-10		
V51X0115E	LMG DR UP					
V51X0200X	RMG UP					
V51X0215E	RMG DR UP					
V51X0300X	NLG UP		b,c	AFM-10		
V51X0315E	NLG DR UP					

(1) Used during OPS 8 FCS check procedure to assess health of NWS feedback protection.
(2) GO for confirmed instrumentation loss.

APU/HYD, MECHANICAL, RMS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V51P0724A	LOB BRAKE PRESS 4A		c	GNC-79		
V51P0726A	LIB BRAKE PRESS 3A					
V51P0744A	ROB BRAKE PRESS 4A					
V51P0746A	RIB BRAKE PRESS 3A					
V51X0430E	LOB SKID TEST FAIL-A	GRND	b,c	GNC-81		
V51X0431E	LOB SKID TEST FAIL-B	GRND				
V51X0432E	LIB SKID TEST FAIL-B	GRND				
V51X0433E	LIB SKID TEST FAIL-A	GRND				
V51X0440E	RIB SKID TEST FAIL-B	GRND				
V51X0441E	RIB SKID TEST FAIL-A	GRND				
V51X0442E	ROB SKID TEST FAIL-A	GRND				
V51X0443E	ROB SKID TEST FAIL-B	GRND				
V51X0410E	LIB SELF TEST FAIL-B	GRND				
V51X0411E	LOB SELF TEST FAIL-B	GRND				
V51X0412E	LIB SKID TEST FAIL-A	GRND				
V51X0413E	LOB SKID TEST FAIL-A	GRND				
V51X0414E	RIB SKID TEST FAIL-B	GRND				
V51X0415E	ROB SKID TEST FAIL-B	GRND				
V51X0416E	RIB SKID TEST FAIL-A	GRND				
V51X0417E	ROB SKID TEST FAIL-A	GRND				

APU/HYD, MECHANICAL, RMS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V51P0370A	NLG LH TIRE P 1	0 of 2				
V51P0372A	NLG LH TIRE P 2					
V51P0371A	NLG RH TIRE P 1	0 of 2				
V51X0373A	NLG RH TIRE P 2					
V51P0470A	ROB TIRE P 1	0 of 2				
V51P0472A	ROB TIRE P 2					
V51P0471A	RIB TIRE P 1	0 of 2				
V51X0473A	RIB TIRE P 2					
V51P0570A	LOB TIRE P 1	0 of 2				
V51P0572A	LOB TIRE P 2					
V51P0571A	LOB TIRE P 1	0 of 2				
V51X0573A	LOB TIRE P 2					

APU/HYD, MECHANICAL, RMS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V56X3550X	L ET DR LTCH IND 1	1 of 2	a,c	AFM-01		(1)
V56X3560X	L ET DR LTCH IND 2			AFM-02		
				AFM-03		
V56X4550X	R ET DR LTCH IND 1	1 of 2				
V56X4560X	R DT DR LTCH IND 2					
V56X1255X	ET DR CL LCH 1 DPY 1	1 of 2				
V56X1265X	ET DR CL LCH 1 DPY 2					
V56X1355X	ET DR CL LCH 2 DPY 1	1 of 2				
V56X1365X	ET DR CL LCH 2 DPY 2					
V56X3110X	L ET DR CLS IND 1	1 of 2				
V56X3115X	L ET DR CLS IND 2					
V56X4110X	R ET DR CLS IND 1	1 of 2				
V56X4115X	R DT DR CLS IND 2					
V98X3307X	PBD RIGHT OPEN 1	1 of 2	a,b	AFM-06		(2)
V98X3327X	PBD RIGHT OPEN 2					
V98X3367X	PBD LEFT OPEN 1	1 of 2				
V98X3347X	PBD LEFT OPEN 2					

(1) Ensures doors are locked open for ascent and are closed and latched for entry.
(2) Functional capability must be assured. Loss of instrumentation results in loss of auto mode.

APU/HYD, MECHANICAL, RMS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V98X3343X	PBD LF BH LCH REL 1	1 of 2	a,b	AFM-07		(1)
V98X3363X	PBD LF BH LCH REL 2					
V98X3344X	PBD LF BH LCH-LAT 1	1 of 2				
V98X3364X	PBD LF BH LCH-LAT 2					
V98X3345X	PBD LA BH LCH-LAT 1	1 of 2				
V98X3365X	PBD LA BH LCH-LAT 2					
V98X3346X	PBD LA BH LCH LAT 1	1 of 2				
V98X3366X	PBD LA BH LCH REL 2					
V98X3303X	PBD RF BH LCH-REL 1	1 of 2				
V98X3323X	PBD RF BH LCH-REL 2					
V98X3304X	PBD RF BH LCH-LAT 1	1 of 2				
V98X3324X	PBD RF BH LCH-LAT 2					
V98X3325X	PBD RA BH LCH-REL 1	1 of 2				
V98X3305X	PBD RA BH LCH-REL 2					
V98X3326X	PBD RA BH LCH-LAT 1	1 of 2				
V98X3306X	PBD RA BH LCH-LAT 2					
V98X3383X	PBD CL LCH 1-4 REL 1	1 of 2	a,b	AFM-09		
V98X3403X	PBD CL LCH 1-4 REL 2					
V98X3384X	PBD CL LCH 1-4 LAT 1	1 of 2				
V98X3404X	PBD CL LCH 1-4 LAT 2					

(1) Functional capability must be assured.

APU/HYD, MECHANICAL, RMS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V98X3385X	PBD CL LCH 5-8 REL 1	1 of 2	a,b	AFM-09		
V98X3405X	PBD CL LCH 5-8 REL 2					
V98X3386X	PBD CL LCH 5-8 LAT 1	1 of 2				
V98X3406X	PBD CL LCH 5-8 LAT 2					
V98X3387X	PBD CL LCH 9-12 REL1	1 of 2				
V98X3407X	PBD CL LCH 9-12 REL2					
V98X3388X	PBD CL LCH 9-12 LAT1	1 of 2				
V98X3408X	PBD CL LCH 9-12 LAT2					
V98X3409X	PBD CL LCH13-16 REL1	1 of 2				
V98X3389X	PBD CL LCH13-16 REL2					
V98X3410X	PBD CL LCH13-16 LAT1	1 of 2				
V98X3390X	PBD CL LCH13-16 LAT2					

APU/HYD, MECHANICAL, RMS MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V37X3545X	S/RAD LCH 1-6 REL 1	1 of 2	b,c	AFM-05		
V37X3550X	S/RAD LCH 1-6 REL 2					
V37X3548X	S/RAD LCH 1-6 LAT 1	1 of 2				
V37X3553X	S/RAD LCH 1-6 LAT 2					
V37X3555X	S/RAD LCH 7-12 REL 1	1 of 2				
V37X3560X	S/RAD LCH 7-12 REL 2					
V37X3558X	S/RAD LCH 7-12 LAT 1	1 of 2				
V37X3563X	S/RAD LCH 7-12 LAT 2					
V37X3525X	P/RAD LCH 1-6 REL 1	1 of 2				
V37X3530X	P/RAD LCH 1-6 REL 2					
V37X3528X	P/RAD LCH 1-6 LAT 1	1 of 2				
V37X3533X	P/RAD LCH 1-6 LAT 2					
V37X3535X	P/RAD LCH 7-12 REL 1	1 of 2				
V37X3540X	P/RAD LCH 7-12 REL 2					
V37X3538X	P/RAD LCH 7-12 LAT 1	1 of 2				
V37X3543X	P/RAD LCH 7-12 LAT 2					

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DATA PROCESSING SYSTEM MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
N/A	GNC DOWNLIST	GND		N/A	N/A	(1)
N/A	BFS DOWNLIST	GND		N/A	N/A	(1) (2)

(1) Applies to failures that cause loss of entire downlist and not necessarily individual parameters.
(2) All detailed troubleshooting and immediate failure recognition is dependent upon presence of the downlist.

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COMMUNICATIONS AND INSTRUMENTATION (INCO) MANDATORY INSTRUMENTATION LIST

MSID	MEASUREMENT NAME	MANDATORY CATEGORY	GDLINE REF.	SSID	C&W/FDA	NOTES
V74T2965A	KU-BND A AXIS GMBL T		h		FDA	
V74T2969A	KU-BND B AXIS GMBL T				FDA	
V74T2967A	KU-BAND GYRO T				FDA	

(1) Measurement requirements are mission dependent and are contingent upon the KU-Band requirements as noted in the Minimum Equipment List (see Appendix H). Applies to all these measurements.
(2) Measurements are available in fixed TFL 129 (but not in ascent soft TFL) and circuit breaker KU-BAND ANT HTR must be closed.

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APPENDIX J

WAIVERS/DEVIATIONS

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PRCBD	DATE SIGNED	DESCRIPTION
S94984	07/27/88	STS-26R-FRF/OV-103. DOCUMENTS CHANGE REQUEST S94984 TO SHOW THE RANGE SAFETY BATTERY TEMPERATURE AS NOT APPLICABLE TO THE WET COUNTDOWN DEMONSTRATION TEST (WCDDT) NOR THE FLIGHT READINESS FIRING (FRF).
S61304D	08/03/88	STS-26R-FRF/OV-103. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-002. LW-002 AUTHORIZED DELETION OF THE MINIMUM LIMIT (PRE AND POST APU START) FOR THE ORBITER HYDRAULIC SYSTEM 2 GN2 ACCUMULATOR PRESSURE.
S61304E	08/03/88	STS-26R-FRF/OV-103. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-003. LW-003 AUTHORIZED REVISION OF THE MINIMUM LIMIT (PRE AND POST APU START) FOR THE ORBITER HYDRAULIC SYSTEM 3 RESERVOIR FLUID VOLUME. PRCBD S61304F SUPERSEDED THIS WAIVER AND REVISED THE MINIMUM LIMIT FOR ALL ORBITER HYDRAULIC SYSTEMS RESERVOIR FLUID VOLUMES.
S71304E	12/23/88	STS-26R/OV-103. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-004. LW-004 AUTHORIZED WAIVER OF SECTION 1.4, PARA. 1.4.4 (REFERENCE NSTS 08211 LAUNCH SYSTEMS EVALUATION ADVISORY TEAM (LSEAT)). THIS WAIVER CLEARED THE ORBITER FOR LAUNCH WITH WING LEADING EDGE INDICATORS: WLE 14L=102.7 and 14R=102.0.
S41544	09/27/88	STS-26R/OV-103. DOCUMENTS CHANGE REQUEST S41544 TO REFLECT WAIVING THE REQUIREMENT FOR MASTER EVENTS CONTROLLER #1 (CORE B) TO PASS THE SIMULATED CAPACITOR VOLTAGE TEST AS REQUIRED BY THE OPERATIONS AND MAINTENANCE REQUIREMENTS AND SPECIFICATIONS DOCUMENT, AND MOVING THE PRE-FLIGHT BITE READ FOR MASTER EVENTS CONTROLLER #1 AND MASTER EVENTS CONTROLLER #2 FROM "LAUNCH MINUS 50 SECONDS" TO "PRIOR TO T-9 MINUTES. BYPASS IN GROUND LAUNCH SEQUENCER AND PERFORM MANUAL COMPARISON OF 18 WORDS WITH MATRIX IN NSTS 16007, TABLE 6.9.7-1."
S71304D	09-28-88	STS-26R/OV-103. DOCUMENTS CHANGE REQUEST S71304D TO REPLACE "IF SHIFT IS NOT OBSERVED, HOLD AT NEXT AVAILABLE POINT (T-2.55). COMMAND AFFECTED ENGINE TO PSN3, DELAY 10 SECONDS, THEN COMMAND PSN4. MONITOR FOR POSITION SHIFT ON ALL VALVES ON AFFECTED ENGINES. IF DOWN SHIFT IS OBSERVED, CONTINUE COUNTDOWN." TO "RESOLVE ANOMALY BEFORE LAUNCH."

PRCBD	DATE SIGNED	DESCRIPTION
S81304B	12/01/88	STS-27R/OV-104. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-005. LW-005 AUTHORIZED REVISION OF FUEL CELL 1,2 AND 3 H2 PUMP MOTOR CONDITION UPPER LIMIT FROM 0.65 VOLTS TO 0.75 VOLTS.
S81304C	12/02/88	STS-27R/OV-104. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-006. LW-006 AUTHORIZED REVISION OF THE GROUND UMBILICAL CARRIER PLATE (GUCP) H2 CONCENTRATION MAXIMUM LIMIT FROM 34K PPM TO 50K PPM (POST FAST FILL).
S81304D	12/02/88	STS-27R/OV-104. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-007. LW-007 AUTHORIZED REVISION OF THE ET NOSE CONE MINIMUM TEMPERATURE FROM 45 DEG. F. TO 40 DEG. F.
S81304E	12/02/88	STS-27R/OV-104. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-008. LW-008 AUTHORIZED THE START OF APU #2 WITHOUT AN ORBITER HYDRAULIC SYSTEM 2 H2O BOILER OK "ON" INDICATION PRESENT.
S81304F	12/23/88	STS-27R/OV-104. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-009. LW-009 AUTHORIZED WAIVER OF SECTION 1.4, PARA 1.4.4 (REFERENCE NSTS 08211 LAUNCH SYSTEMS EVALUATION ADVISORY TEAM (LSEAT)). THIS WAIVER CLEARED THE ORBITER FOR LAUNCH WITH LOAD INDICATOR A-18 AT MACH 1.14 AT 101 EXCEEDANCE.
S41757K	04/03/89	STS-29R/OV-103. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-010. LW-010 AUTHORIZED WAIVER OF SECTION 1.4, PARA. 1.4.4 (REFERENCE NSTS 08211 LAUNCH SYSTEMS EVALUATION ADVISORY TEAM (LSEAT)). THIS WAIVER CLEARED THE ORBITER FOR LAUNCH WITH YAW 2 TRAJECTORY, L-70 WIND SQUATCHELOID EXCEEDANCE. THE VIOLATION ON THE ET IS 1% AT MACH 1.35.
S41757Y	06/14/89	STS-30R-2/OV-104. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-011. LW-011 ALLOWED THE ORBITER HYDRAULIC WATER SPRAY BOILER (WSB) STEAM VENT TEMPERATURES (2 PER WSB), TO TREND BELOW THE MINIMUM OF 123 DEG. F. IF THE SLOPE IS SHALLOW ENOUGH TO DEMONSTRATE FUNCTIONAL HEATERS.

PRCBD	DATE SIGNED	DESCRIPTION
S50957B	11/03/89	STS-34/OV-104. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-013. LW-013 AUTHORIZED DELETION OF THE REQUIREMENT FOR MTU PCM IRIG B. THIS FUNCTION IS MISSION DEPENDENT AND NOT REQUIRED FOR STS-34.
S50957C	11/03/89	STS-34/OV-104. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-014. LW-014 AUTHORIZED REVISION OF THE MAXIMUM FREON COOLANT LOOP (FCL) EVAPORATOR OUTLET TEMPERATURE (BOTH LOOPS) FROM 50 DEG. F. TO 55 DEG. F. A COUNTDOWN HOLD AFTER T-2 MINUTES UNTIL T-31 SECONDS WOULD BE REQUIRED TO ESTABLISH TEMPERATURE CONTROL IF EXCURSIONS OCCURRED ABOVE 55 DEG. F.
S50957D	11/03/89	STS-34-2/OV-104. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-015. LD-015 AUTHORIZED THE INCLUSION OF THE OPERATIONAL TELEVISION (OTV) AS AN ALTERNATE SOURCE TO CONFIRM LO2 LEAKAGE EMANATING FROM AN SSME NOZZLE.
S072379LM	02/13/95	STS-32R-1/OV-102. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-016. LW-016 AUTHORIZED ALLOWANCE OF LOCALIZED ICE FORMATION ON THE GOX VENT ARM (GVA) NORTH VENT DUCT. THE PREVAILING WINDS (FROM THE SOUTH) WOULD PRECLUDE ANY FALLING ICE FROM IMPACTING THE SHUTTLE AT LIFT-OFF.
S060957	02/16/90	STS-36-1/OV-104. DOCUMENTS CHANGE REQUEST S060957 TO CHANGE MEASUREMENT NUMBERS AND NOMENCLATURE IN LCC SECTION 3.2 PAGES 3.2 - 23 AND 3.4 - 24 TO COMPLY WITH THE SHUTTLE GSE FUNCTIONAL DESIGNATOR LIST.
S60957Q	03/09/90	STS-36-1/OV-104. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-017. LD-017 AUTHORIZED ALLOWANCE OF THE FUEL SYSTEM MODULE (FSM) BOTTLE PRESSURE (LEFT AND RIGHT SRB SYSTEMS A AND B) TO INCREASE ABOVE THE MAXIMUM REDLINE OF 415 PSIA (PRIOR TO HPU START) TO 425 PSIA. THIS IS THE RESULT OF AN INCREASE IN THE AFT SKIRT PURGE TEMPERATURE TO MAINTAIN THE NOZZLE TO CASE JOINT TEMPERATURE ABOVE 75 DEG. F.
S60957Y	03/12/90	STS-36-2/OV-104. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-018. LW-018 AUTHORIZED ALLOWANCE OF TWO MINOR ICE ACCUMULATIONS ON THE NORTH GOX VENT DUCT OUTLET.

PRCBD	DATE SIGNED	DESCRIPTION
S60957T	03/12/90	STS-36-2/OV-104. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-019. LW-019 AUTHORIZED AN INCREASE IN SURFACE WINDS (FROM ANY AZIMUTH), FROM 24 KNOTS TO 26 KNOTS, PEAK.
S60957U	03/09/90	STS-36-3/OV-104. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-020. LW-020 AUTHORIZED ALLOWANCE OF MINOR ICE ACCUMULATION ON THE NORTH GOX VENT DUCT.
S70957L	05/09/90	STS-31-2/OV-103. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-021. LW-021 AUTHORIZED ALLOWANCE OF A LOW DENSITY ICE FORMATION ON THE ET LH2 17-INCH FEED-LINE NEAR THE DISCONNECT ACTUATION HOUSING.
S052271D	10/10/90	STS-41-1/OV-103. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-023. LW-023 AUTHORIZED ALLOWANCE OF A LOW DENSITY ICE FORMATION ON THE ET LH2 17-INCH FEEDLINE NEAR THE DISCONNECT ACTUATION HOUSING.
S083024DR2	11-15-90	STS-38/OV-104. DOCUMENTS CHANGE REQUEST S083024DR2 TO RESTORE THE ET RANGE SAFETY SYSTEM BATTERY A AND BATTERY B AND THE LH AND RH SRB RANGE SAFETY BATTERY NO.1 VOLTAGES TO 27.5 MINIUMUM AND 29.0 MAXIMUM FOR STS-38 ONLY.
S052379A	05/15/91	STS-39-2/OV-103. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-024. LW-024 AUTHORIZED REVISION OF APPENDIX F, ICE CRITERIA (SSID ICE-01), TO ALLOW MINOR ICE ACCUMULATION ON THE SOUTH GASEOUS OXYGEN (GOX) VENT.
S052501C	10/01/91	STS-48/OV-103. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-025. LW-025 AUTHORIZED REVISION OF SSID ECL-34 TO ALLOW MSID V62X0612E TO GO UNMONITORED THROUGH T-31 AND SSID ECL-33 TO ALLOW MSIDS V62X0621E AND V62X0630E TO GO UNMONITORED THROUGH T-10 SECONDS. THIS WAS THE RESULT OF HAVING OPENED CIRCUIT BREAKER 1B/3A ON PANEL 015 TO PRECLUDE A POSSIBLY SPURIOUS "ON" INDICATION FROM THE SMOKE DETECTORS IN AVIONICS BAYS 1 OR 3A DURING THE TERMINAL COUNTDOWN.

PRCBD	DATE SIGNED	DESCRIPTION
S052501W	01/31/92	STS-42/OV-103. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-026. LW-026 AUTHORIZED REVISION OF SSID FCP-04 TO ALLOW MSID V45V0214A (FUEL CELL NUMBER 2 H2 PUMP MOTOR CONDITION) TO SPIKE TO 1.48 VOLTS FOR APPROXIMATELY 5 SECONDS. ALL OTHER FUEL CELL NUMBER 2 PARAMETERS READ NOMINALLY. THE H2 PUMP MOTOR VOLTAGE WAS NOMINAL (0.52 TO 0.56 VOLTS DIRECT CURRENT) FROM FUEL CELL NUMBER 2 ACTIVATION UNTIL THE VOLTAGE SPIKE AND WAS NOMINAL (0.56 TO 0.60 VOLTS DIRECT CURRENT) AFTER THE SPIKE. DATA RETRIEVALS OF THE FUEL CELL NUMBER 2 BUS CURRENTS SHOWED THAT DURING THE VOLTAGE SPIKE, PHASE A CURRENT WAS A CONSTANT 5.35 AMPERES, PHASE B CURRENT INCREASED FROM 5.35 TO 5.51 AMPERES AND PHASE C CURRENT DROPPED FROM 5.35 TO 5.19 AMPERES. THERE WAS NO VOLTAGE CHANGE. THE FUEL CELL NUMBER 2 PHASE C CIRCUIT BREAKER WAS CYCLED OPEN AND CLOSED TO CLEAN ANY POSSIBLE OXIDATION OFF THE CIRCUIT BREAKER CONTACTS. THE RATIONALE FOR THE ACCEPTANCE OF THIS WAIVER/DEVIATION IS THE FUEL CELL PUMP MOTOR WILL OPERATE NORMALLY ON 2 PHASE ALTERNATING CURRENT POWER.
S072379C	07/14/92	STS-49/OV-105. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-027. LW-027 AUTHORIZED REVISION OF THE MINIMUM LCC REDLINE FOR MEASUREMENT V46T0384A APU 3 FUEL TEST LINE TEMP 2 FROM 48 DEGREES F TO 42 DEGREES F. (REFERENCE LCC SSID APU-14.) THE REQUIREMENT VERIFIES THE HEATER FUNCTION AND PROTECTS THE HYDRAZINE PROPELLANT AGAINST FREEZING. ALTHOUGH THE TEMPERATURE DROPPED TO 47.2 DEGREES F, HEATER CYCLING WAS OCCURING. FOR THIS CONDITION, HEATER FUNCTION WAS VERIFIED AND THE REDUCED REDLINE OF 42 DEGREES F PROVIDED ENOUGH MARGIN (FOR INSTRUMENTATION AND LOCATION UNCERTAINTY) TO PROTECT AGAINST FREEZING.
S072379D	08/05/92	STS-49/OV-105. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-028. LW-028 AUTHORIZED ALLOWANCE OF THE ONE TIME FAILURE OF THE MASTER EVENTS CONTROLLER NUMBER 2 BITE WORD 10, BIT 9, F2/F3 FAIL INDICATOR. THE INDICATION WAS '1' AND IT SHOULD HAVE BEEN '0' (REFER- ENCE EPDC-09, TABLE 26-01). THE MEC PREFLIGHT BITE TEST WAS PERFORMED THREE TIMES AFTER THE INITIAL FAILURE. THE FAILURE COULD NOT BE REPEATED. A REOCCURENCE WOULD RESULT IN THE FAILURE TO ISSUE A F2/F3 COMMAND IN ONE CORE OF MASTER EVENTS CONTROLLER NUMBER 2. REDUNDANT COMMAND CAPABILITY WAS AVAILABLE IN THE OTHER CORE OF MEC NUMBER 2 AND IN BOTH CORES OF MEC NUMBER 1.

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S072379Z	10/08/92	STS-47/OV-105. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-030. LW-030 AUTHORIZED WAIVER OF SSID HAZ-04, TO CHANGE THE AFT FUSELAGE HYDROGEN CONCENTRATION LIMIT OF 500 PPM TO 560 PPM, THE PEAK CONCENTRATION OBSERVED DURING LH2 FAST FILL. ANALYSIS INDICATED THAT ANY LEAKAGE CONTRIBUTING TO THIS CONDITION WAS FROM THE LOW PRESSURE PART OF THE LH2 SYSTEM. FLIGHT PRESSURES IN THIS AREA ARE BASICALLY THE SAME AS DURING LH2 FAST FILL. LW-030 ALSO WAIVED THE SSID HAZ-05A TO CHANGE THE OV-105 REQUIREMENT TO REFLECT THE NOTE FOUR VALUE OF 600 PPM IF H2 CONCENTRATION LEVELS EXCEEDED 300 PPM AFTER LH2 PREPRESS. INCREASED LIMIT IS WITHIN THE EXPERIENCE BASE FOR OV-102, WHOSE CURRENT LIMIT IS THE FLEET LEADER AT 600 PPM.
S072379AA	10/16/92	STS-47/OV-105. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-029. LW-029 AUTHORIZED WAIVER OF SSID APU-14 TO CHANGE THE APU NUMBER THREE FUEL TEST LINE TEMPERATURE NUMBER TWO LOWER LIMIT FROM 48 DEGREES FAHRENHEIT TO 42 DEGREES FAHRENHEIT. THE INTENT OF THIS REQUIREMENT IS TO VERIFY HEATER FUNCTION. THE ACTUAL LOW TEMPERATURE OBSERVED WAS 46.2 DEGREES FAHRENHEIT. ACCEPTANCE OF THIS WAIVER WAS BASED ON A NOMINAL LOW READING OF 53.2 DEGREES FAHRENHEIT FROM APU FUEL TEST LINE TEMPERATURE ONE AND FROM ANALYSIS OF EMPERICAL DATA. THE NEW LOWER LIMIT OF 42 DEGREES PROVIDES ADEQUATE PROTECTION AGAINST N2H4 FREEZING, WHICH OCCURS AT 35 DEGREES FAHRENHEIT.
S072379BE	12/21/92	STS-53/OV-103. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-031. LW-031 AUTHORIZED WAIVER OF SSID MPS-03 TO CHANGE THE ACCEPTABLE MPS ENGINE 750 HELIUM REGULATOR OUTLET PRESSURE FROM 785 PSIA MAXIMUM TO 788 PSIA MAXIMUM.
S072379DA	05/05/93	STS-56/OV-103. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-032. LD-032 AUTHORIZED WAIVER OF SSID SSME-04 TO ACCEPT THE OUT-OF-SPEC AFV SKIN TEMPERATURE 1 & 2 INDICATIONS AND AUTHORIZED A PROCEDURE DEVIATION WHICH ALLOWED FOR THE MONITORING OF THE AFV SKIN TEMPERATURE 1 & 2 INDICATORS ALONG WITH THE ME1 GOX INTERFACE TEMPERATURE VIA RPS STRIP CHARTS TO DETERMINE SYSTEM HEALTH AND FLIGHT READINESS.

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S072379DB	05/05/93	STS-56/OV-103. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-033. LD-033 AUTHORIZED WAIVER OF SSID MPS-12 FOR THE FIRST LAUNCH ATTEMPT OF STS-56. THIS LCC VIOLATION OCCURRED WHEN THE VALVE POSITION INDICATOR FOR THE MPS LH2 HIGH POINT BLEED VALVE (PV22) FAILED OFF AND RESULTED IN A LAUNCH SCRUB AT T-11 SECONDS. LD-033 ALSO AUTHORIZED A REVISION TO SSID MPS-12 WHICH RESULTED IN THE PERFORMANCE OF A FUNCTIONAL VERIFICATION OF PV22 DURING LH2 FAST FILL AND MASKED MSID V41X1469E1 IN THE GLS FOR THE SECOND LAUNCH ATTEMPT OF STS-56 ONLY.
S072379DH	05/05/93	STS-55-3/OV-102. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-034. LD-034 AUTHORIZED DEVIATION OF SSID FCP-02 TO CHANGE THE MAXIMUM ALLOWABLE TEMPERATURE FOR FUEL CELL #1 CONDENSOR EXIT TEMP (V45T0130A), FROM 160 DEGREES F. TO 164 DEGREES F.
S072379DJ	05/21/93	STS-55-3/OV-102. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-035. LW-035 AUTHORIZED WAIVER OF SSID ECL-48 TO ALLOW THE ORBITER FLASH EVAPORATOR SYSTEM WATER FEEDLINE HEATER TEMPERATURE MEASUREMENT V63T1877A1 TO CYCLE BELOW THE REDLINE OF 56 DEGREES F. AS LONG AS THE HEATER COULD BE VERIFIED FUNCTIONAL BY MONITORING THE HEATER CYCLE DATA.
S072379EA	07/08/93	STS-57/OV-105. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-036. LW-036 AUTHORIZED REVISION OF THE MINIMUM SSME HELIUM REGULATOR OUTLET PRESSURE FOR SSME 2 FROM 730 PSIA TO 724 PSIA IN ORDER TO ACCOUNT FOR THE KNOWN BIAS OF 11 PSIA IN TRANSDUCER P/N ME449-0177-2179, S/N 0000714, WHICH WAS USED TO MONITOR SSID MPS-03, MEASUREMENT NUMBER V41P1253A1.
S072379HN	10/26/93	STS-58/OV-102. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-037. LD-037 AUTHORIZED DEVIATION OF SSID FCP-02 TO CHANGE THE MAXIMUM ALLOWABLE TEMPERATURE FOR FUEL CELL #1 CONDENSOR EXIT TEMP (V45T0130A), FROM 160 DEGREES F. TO 164 DEGREES F.

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S072379HP	10/26/93	STS-58/OV-102. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-038. LD-038 AUTHORIZED DEVIATION OF SSID HAZ-07 TO CHANGE THE TIME END OF THE TIME PERIOD EFFECTIVITY OF MEASUREMENT GGDR2161T (OXYGEN CONCENTRATION #2 ET INTERTANK HIGH RANGE), FROM T-31 SECONDS TO T-75 SECONDS TO ACCEPT AIR INTRUSION AFTER ET/IT GN2 PURGE TERMINATION.
S072379JD	12/03/93	STS-61/OV-105. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-039. LD-039 AUTHORIZED DEVIATION FROM THE REQUIREMENT IN SSID PAY-01 TO CONTINUOUSLY MONITOR PAYLOAD SELECT LATCH 1, 2 AND 3 FROM T-6 HOURS TO T-9 MINUTES. THIS DEVIATION WAS REQUIRED DUE TO A CONFLICT BETWEEN THE LAUNCH COMMIT CRITERIA AND THE ASCENT SWITCH LIST WHICH REQUIRED THE PAYLOAD SELECT SWITCH TO BE IN THE "PLD SEL 1" POSITION. THIS PREVENTED VISIBILITY INTO THE STATUS OF THE PAYLOAD SELECT LATCH 2 AND 3 STATUS. THE PAYLOAD SELECT SWITCH WAS PUT IN THE "MONITOR" POSITION TEMPORARILY AND THE LATCH 2 AND LATCH 3 STATUS WAS CONFIRMED. THE SWITCH WAS RETURNED TO ITS ASCENT POSITION PRIOR TO LAUNCH. (REFERENCE IPR 61V-0145).
S072379KA	04/07/94	STS-59/OV-105. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-040. LW-040 ELIMINATED THE REQUIREMENT TO MONITOR THE H2O LOOP 2 ACCUMULATOR QUANTITY MEASUREMENT, (V61Q2710A) AND AUTHORIZED THE USE OF OTHER SYSTEM PARAMETERS (PUMP OUT PRESSURE, PUMP DELTA PRESSURE, INTERCHANGER FLOW AND PUMP OUT TEMPERATURE), TO MONITOR WCL SYSTEM STATUS DUE TO A CONSISTANTLY LOW READING ON LOOP 2.

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S072379LJ	11/16/94	STS-66/OV-104. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-041. LW-041 WAIVED THE OMS-13 REQUIREMENT FOR MAINTAINING OMS ENGINE INLET PRESSURE WITHIN 17 PSIA OF THE OXIDIZER SUPPLY TANK ULLAGE PRESSURE AS CORRECTED FOR HEAD PRESSURE. THIS WAIVER/DEVIATION ALSO WAIVED THE REQUIREMENT WHICH RESTRICTS THE INLET/ ULLAGE DELTA P TO A SHIFT OF TWO DATA BITS. THIS REQUIREMENT WAS FAILED WHEN THE RIGHT OMS OXIDIZER INLET PRESSURE (V43P5645C1) SHIFTED FROM 280 TO 286 PSIA (SEVEN DATA BITS), IN APPROXIMATELY 20 SECONDS AND NO CORRESPONDING CHANGE IN SUPPLY TANK ULLAGE PRESSURE WAS NOTED. EXTENSIVE ANALYSIS OF THE RIGHT OMS ENGINE PROPELLANT SYSTEM'S MAINTENANCE HISTORY CONCLUDED THAT THE LIKELIHOOD OF ANY CONTAMINANT HAVING BEEN INTRODUCED INTO THE OXIDIZER LINE WAS LOW. THE RESULTS OF FLOW PATH REDUNDANCY CHECKS PERFORMED DURING PROPELLANT SERVICING SUPPORTED THIS CONCLUSION. ANY FAILURE OF THE RIGHT OMS ENGINE OCCURING DURING A LAUNCH ABORT WAS TO HAVE BEEN ATTRIBUTED TO THE ENGINE AND NOT TO PROPELLANT SYSTEM BLOCKAGE.
S072379LZ	02/13/95	STS-63/OV-103. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-042. LD-042 AUTHORIZED REVISION OF THE TIME PERIOD EFFECTIVITY OF LPS-08 AND LPS-15 FROM T-31 SECONDS TO T-9 MINUTES. THE PREPLANNED CONTINGENCY PROCEDURES FOR THESE CONSOLES (C5 AND C12) WERE REVISED TO SPECIFY THAT IF A CONSOLE FAILURE OCCURRED AFTER L-14 MINUTES THE RECOVERY OF THE CONSOLE, (RELOADED AND PROGRAM ACTIVATION IN THE SPARE CONSOLE) WAS NOT MANDATORY PROVIDED THE SYSTEM ENGINEERS WERE IN PLACE PER S0007, VOLUME V DOCUMENTATION AT THE MASTER AND/OR BACKUP CONSOLE. LD-042 REVISED THE TIME PERIOD EFFECTIVITY OF LPS-17 FROM T-10 SECONDS TO T-9 MINUTES AND THE EFFECTIVITIES OF LPS-18 THRU LPS-21 AND LPS-25 FROM T-0 TO T-9 MINUTES. THE PREPLANNED CONTINGENCY PROCEDURES FOR THESE SSID'S WERE CHANGED TO COMMIT THESE FRONT END PROCESSORS TO REDUNDANCY AT L-14 MINUTES. LD-042 ALSO CHANGED THE TIME PERIOD EFFECTIVITY OF SSIDS LPS-04, LPS-05, LPS-09 THRU LPS-14 AND LPS-23 FROM T-5 MINUTES TO T-9 MINUTES. THE PREPLANNED CONTINGENCY PROCEDURE FOR THESE SSIDS WAS REVISED TO SPECIFY THAT RECOVERY OF A FAILED CONSOLE AFTER L-14 MINUTES WAS NOT MANDATORY. IF A PDR FAILURE OCCURRED (LPS-23) AFTER L-14 MINUTES, THE SPA SUBSYSTEM WOULD HAVE PERFORMED THE PDR FUNCTIONS.

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S072379FE	03/09/95	STS-67/OV-105. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-043. LD-043 AUTHORIZED DEVIATION OF SSID TRSS-05 TO CHANGE THE LOWER LIMIT FOR THE ET RSS BATTERIES A AND B (T55V1735A & T55V1736A) FROM 27.5 VDC TO 27.15 VDC. THIS WAS DONE AFTER REVIEW OF THE ET RSS SERIES REGULATOR BUILD PAPER SHOWED THAT THE REGULATOR WAS SET LOWER THAN NOMINAL, AND AFTER REVIEW OF THE PREINSTALLATION BENCH TEST DATA SHOWED THAT THE OUTPUT HAD NOT CHANGED SINCE INSTALLATION. THE MINIMUM OPERATING VOLTAGE FOR THE ET RSS IS 24 VDC, SO ITS FUNCTIONALITY WAS NOT COMPROMISED IN ANY WAY BY THIS CHANGE.
S072379FN	03/09/95	STS-67/OV-105. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-044. LD-044 AUTHORIZED DEVIATION OF SSID ECL-41 TO CHANGE THE UPPER LIMIT FOR FCL 2 ACCUMULATOR QUANTITY (V63Q1330A1) FROM 39% TO 45% BASED ON A 100 PSIA INLET PRESSURE (96 PSIA ACTUAL), VERSUS THE 117 PSIA INLET PRESSURE ON WHICH THE LCC LIMIT WAS BASED.
S072379FU	05/09/95	STS-67/OV-105. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-045. LW-045 AUTHORIZED WAIVER OF THE REQUIREMENT IN SSID ECL-48 TO VERIFY THAT A COMPLETE HEATER STRING IS ACTIVE ON THE FES ACCUMULATOR WATER FEEDLINE. AT APPROXIMATELY T-9 MINUTES THE B SUPPLY FES ACCUMULATOR H2O FEEDLINE TEMPERATURE (V63T1894A1) APPROACHED ITS LOWER LIMIT. WHEN ITS TEMPERATURE REACHED 57 DEGREES F., THE B HEATER STRING WAS SWITCHED FROM STRING 2 TO STRING 1 AND THE TEMPERATURE INCREASED TO 59 DEGREES F. ALL ZONAL TEMPERATURES WERE NOT VERIFIED TO BE INCREASING PRIOR TO LAUNCH. THEREFORE, A COMPLETE FEEDLINE STRING WAS NOT VERIFIED TO BE FUNCTIONAL. THIS CONDITION WAS ACCEPTED BY THE LAUNCH TEAM AND THE MMT OVER THE OIS NET PRIOR TO LAUNCH.

PRCBD	DATE SIGNED	DESCRIPTION
S072379GQR1	10/20/95	STS-73/OV-102. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-046. LD-046 AUTHORIZED THE REVISION OF THE HYDRAULIC SYSTEM 1 RESERVOIR FLUID VOLUME SPECIFIED IN SSID HYD-01. THE MINIMUM OF 51% FLUID VOLUME FROM CIRCULATION PUMP START TO APU START WAS CHANGED TO 47%. THE VALUE FROM APU START TO T-31 SECONDS WAS CHANGED FROM 46% TO 42%. THESE CHANGES WERE NECESSITATED BY A KNOWN LOW HYDRAULIC SYSTEM FLUID VOLUME CONDITION. (NOTE: THIS DEVIATION WAS NOT INVOKED FOR THE SECOND LAUNCH ATTEMPT OF STS-73. AN ATTEMPT TO EQUALIZE HYDRAULIC FLUID VOLUME ACROSS THE THREE SYSTEMS RESULTED IN THE TRANSFER OF THE LOW VOLUME CONDITION FROM SYSTEM 1 TO SYSTEM 2. REFERENCE LD-048.)
S072379GT	10/20/95	STS-73-3/OV-102. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LW-047. LW-047 AUTHORIZED ACCEPTING CONFIRMED INSTRUMENTATION FAILURE OF FCP #3 SUBSTACK 1 DELTA VOLTAGE. THE INSTRUMENTATION INDICATED FULL SCALE (500MV) WHERE THE DELTA VOLTAGE (V45V0302A1) REQUIREMENT DOES NOT ALLOW EXCEEDING 150MV. MEASUREMENT V45V0302A1 WAS MASKED IN THE GROUND LAUNCH SEQUENCER AND FUEL CELL VOLTAGE/CURRENT WAS MONITORED PER FCP-01.
S072379GU	10/20/95	STS-73-3/OV-102. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-048. LD-048 AUTHORIZED THE REVISION OF THE HYDRAULIC SYSTEM 2 RESERVOIR VOLUME SPECIFIED IN SSID HYD-01. THE MINIMUM OF 51% FLUID VOLUME FROM CIRC PUMP START TO APU START WAS CHANGED TO 47%. THE VALUE FROM APU START TO T-31 SECONDS WAS CHANGED FROM 46% TO 42%. THESE CHANGES WERE NECESSITATED BY A KNOWN LOW HYDRAULIC SYSTEM FLUID VOLUME CONDITION.

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S072379PP	01/13/97	STS-81/OV-104, FLT 18. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-049. LD-049 WAIVED THE REQUIREMENT FOR THE LEFT OMS ENGINE PITCH ACTUATOR'S ACTIVE AND STANDBY POSITION INDICATORS TO REMAIN WITHIN 0.25 DEGREES OF ONE ANOTHER, WAIVED THE MAXIMUM INDICATION LIMITS, ESTABLISHED 0.25 DEGREES AS THE MAXIMUM ALLOWABLE DELTA BETWEEN THE LEFT PITCH ACTUATOR STANDBY POSITION INDICATION AND THE STOW STANDBY POSITION INDICATION, AND 0.50 DEGREES AS THE MAXIMUM ALLOWABLE DELTA BETWEEN THE LEFT PITCH ACTIVE POSITION INDICATION AND THE STOW COMMAND.
CAR S072379QK	05/09/97	DIRECTIVE S072379QK AND LCC DEVIATION LD-050 ARE WITHDRAWN.
S072379QP	05/01/97	STS-84/0V-104, FLT 19. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-051. LD-051 DELETED THE MAXIMUM AND MINIMUM LIMITS FOR THE LEFT ACTIVE PITCH INDICATION ON THE LEFT OME. IT ALSO DELETED THE MAXIMUM LIMIT FOR THE LEFT STANDBY PITCH INDICATION. THE REQUIREMENT FOR THE ACTIVE AND STANDBY INDICATIONS TO TRACK WITHIN 0.25 DEGREES OF ONE ANOTHER WAS DELETED. A REQUIREMENT THAT THE STANDBY INDICATION NOT CHANGE MORE THAN 0.25 DEGREES FOLLOWING OME GIMBAL PROFILE WAS ADDED. THIS CHANGE WAS DEEMED ACCEPTABLE BECAUSE THE KNOWN CONDITION OF A GAIN SHIFT IN THE LEFT OMS TVC ACTIVE CONTROLLER HAD BEEN STABLE SINCE ITS INITIAL SHIFT AND WAS NOT EXPECTED TO SHIFT FARTHER. A FLIGHT SOFTWARE PATCH WHICH WOULD DISABLE THE LEFT PITCH REPOSITIONING SOFTWARE SHOULD THE GAIN SHIFT INCREASE DURING ASCENT WAS IMPLEMENTED. THIS DEVIATION COMPENSATED FOR THE KNOWN GAIN SHIFT IN THE OMS ACTIVE CONTROLLER AND MAINTAINED THE FUNCTIONAL INTENT OF THE LCC, GNC-43.

PRCBD	DATE SIGNED	DESCRIPTION
S072379TA	07/02/97	STS-94/OV-102, FLT 23. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-052. LD-052 ADDED A NEW REQUIREMENT TO THE BASIC MAXIMUM AND MINIMUM GAS GENERATOR PEAK CHAMBER PRESSURE FOR APU 2 (V46P0220A1) WHICH REQUIRES A RANGE OF BETWEEN 725 AND 1450 PSIA. THE NEW REQUIREMENT IN SSID APU-03 STATED "THE GAS GENERATOR CHAMBER PRESSURE LIMIT AT THE LOW POINT OF PULSE MUST REMAIN BELOW 100 PSIA." LD-052 ALSO ADDED PREPLANNED CONTINGENCY PROCEDURES TO BE FOLLOWED IN THE EVENT OF AN EXCEDENCE OF THE NEW REQUIREMENT. THESE CONTINGENCY PROCEDURES CALLED FOR A HOLD AT T-31 SECONDS, RUNNING APU 2 AT HIGH SPEED FOR ONE MINUTE AND THE CONTINUED MONITORING OF THE LOW POINT OF THE PULSE. IF THE LOW POINT OF THE PULSE REMAINED BELOW 100 PSIA, THEN THE HOLD WOULD CONTINUE AS INTERNAL LEAKAGE IN THE GGVM WAS INDICATED. IF THE PRESSURE ROSE ABOVE 100 PSIA DURING HIGH SPEED OPERATION OF APU 2, THEN THE COUNT WOULD PROCEED AS A SHIFT IN THE GAS GENERATOR PRESSURE TRANSDUCER WAS INDICATED. APU 2 WAS TO BE RETURNED TO NORMAL SPEED PRIOR TO LAUNCH. THIS DEVIATION WAS DEVELOPED IN RESPONSE TO TWO INSTANCES OF NEW GGVMS LEAKING DURING VENDOR TESTING. APU 2 WAS EQUIPPED WITH A NEW TYPE GGVM WHILE APUS 1 AND 3 WERE EQUIPPED WITH THE OLD.
S072379TK	10/06/97	STS-86/OV-104, FLT 20. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-053. LD-053 DELETED THE MAXIMUM AND MINIMUM LIMITS FOR THE LEFT ACTIVE PITCH INDICATION ON THE LEFT OME. IT ALSO DELETED THE MAXIMUM LIMIT FOR THE LEFT STANDBY PITCH INDICATION. THE REQUIREMENT FOR THE ACTIVE AND STANDBY INDICATIONS TO TRACK WITHIN 0.25 DEGREES OF ONE ANOTHER WAS DELETED. A REQUIREMENT THAT THE STANDBY INDICATION NOT CHANGE MORE THAN 0.25 DEGREES FOLLOWING OME GIMBAL PROFILE WAS ADDED. THIS CHANGE WAS DEEMED ACCEPTABLE BECAUSE THE KNOWN CONDITION OF A GAIN SHIFT IN THE LEFT OMS TVC ACTIVE CONTROLLER HAD BEEN STABLE SINCE ITS INITIAL SHIFT AND WAS NOT EXPECTED TO SHIFT FARTHER. A FLIGHT SOFTWARE PATCH WHICH WOULD DISABLE THE LEFT PITCH REPOSITIONING SOFTWARE SHOULD THE GAIN SHIFT INCREASE DURING ASCENT WAS IMPLEMENTED. THIS DEVIATION COMPENSATED FOR THE KNOWN GAIN SHIFT IN THE OMS ACTIVE CONTROLLER AND MAINTAINED THE FUNCTIONAL INTENT OF THE LCC, GNC-43.

PRCBD	DATE SIGNED	DESCRIPTION
S072379TQ	12/02/97	STS-87/OV-102, FLT 24. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-054. LD-054 ADDED A NEW REQUIREMENT TO THE BASIC MAXIMUM AND MINIMUM GAS GENERATOR PEAK CHAMBER PRESSURE FOR APU 2 (V46P0220A1) WHICH REQUIRES A RANGE OF BETWEEN 725 AND 1450 PSIA. THE NEW REQUIREMENT IN SSID APU-3 STATED "THE GAS GENERATOR CHAMBER PRESSURE LIMIT AT THE LOW POINT OF THE PULSE MUST REMAIN BELOW 100 PSID." LD-054 ALSO ADDED PREPLANNED CONTINGENCY PROCEDURES TO BE FOLLOWED IN THE EVENT OF AN EXCEEDANCE OF THE NEW REQUIREMENT. THESE CONTINGENCY PROCEDURES CALLED FOR A HOLD AT T-31 SECONDS, RUNNING APU-2 AT HIGH SPEED FOR ONE MINUTE AND THE CONTINUED MONITORING OF THE LOW POINT OF THE PULSE. IF THE LOW POINT OF THE PULSE REMAINED BELOW 100 PSID THEN THE HOLD WOULD CONTINUE AS INTERNAL LEAKAGE IN THE GGVM WAS INDICATED. IF THE PRESSURE ROSE ABOVE 100 PSID DURING HIGH SPEED OPERATION OF APU 2, THEN THE COUNT WOULD PROCEED AS A SHIFT IN THE GAS GENERATOR PRESSURE TRANSDUCER WAS INDICATED. APU 2 WAS TO BE RETURNED TO NORMAL SPEED PRIOR TO LAUNCH. THIS DEVIATION WAS DEVELOPED IN RESPONSE TO TWO INSTANCES OF NEW GGVMS LEAKING DURING VENDOR TESTING. APU 2 WAS EQUIPPED WITH A NEW TYPE GGVM WHILE APUS 1 AND 3 WERE EQUIPPED WITH THE OLD.
S072379TZ	02/05/98	STS-89/OV-105, FLT 12. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-055. LD-055 CHANGED THE FUEL CELL #1 (S/N 114) SUBSTACK 2 DELTA VOLTAGE ALLOWABLE MAXIMUM LIMIT FROM 150 MV TO 200 MV FOR STS-89. THE INTENT OF THE NORMAL 150 MV LIMIT IS TO PROTECT AGAINST A SINGLE CELL DEGRADING TO A POINT OF POTENTIAL CATASTROPHIC FAILURE (REACTANT CROSSOVER). VENDOR TESTING INDICATES A 300 MV SHIFT IN PERFORMANCE OF A SINGLE CELL REPRESENTS IMMINENT CELL FAILURE. IN FUEL CELL #1 (S/N 114) THE ELEVATED SUBSTACK VOLTAGE IS A RESULT OF CELL GROUPING RATHER THAN THE DEGRADATION OF A SINGLE CELL. THE REQUESTED LIMIT OF 200 MV WILL ALLOW MARGIN FOR CONTINUED INCREASE IN SUBSTACK DELTA VOLTAGE OVER THE NEXT FLIGHT. RECENTLY ADDED REQUIREMENTS RELATED TO SUBSTACK DELTA VOLTAGE SENSITIVITY AND STABILITY PERFORMANCE HAVE BEEN REVIEWED AGAINST DATA FROM THE PREVIOUS FIVE FLIGHTS AND ARE NOT AFFECTED.

PRCBD	DATE SIGNED	DESCRIPTION
S072379UA	02/05/98	STS-89/OV-105, FLT 12. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-056. LD-056 ADDED A NEW REQUIREMENT FOR APU 2 (S/N 203) IN SSID APU-03 WHICH STATED "THE GAS GENERATOR CHAMBER PRESSURE AT THE LOWEST POINT BETWEEN PULSES MUST REMAIN BELOW 100 PSID." LD-056 ALSO ADDED PREPLANNED CONTINGENCY PROCEDURES TO BE FOLLOWED IN THE EVENT OF AN EXCEEDANCE OF THE NEW REQUIREMENT. THESE CONTINGENCY PROCEDURES CALLED FOR A HOLD AT T-31 SECONDS, RUNNING APU 2 AT HIGH SPEED FOR ONE MINUTE AND THE CONTINUED MONITORING OF THE LOW POINT OF THE PULSE. IF GG CHAMBER PRESSURE AT THE LOWEST POINT BETWEEN PULSES RETURNS TO OPERATING TRANSDUCER BIAS LEVEL (I.E., DROPS BY >= 100 PSI) LEAKAGE AND INDICATING EXCESSIVE PULSE CONTROL VALVE OUTLET LEAKAGE TO THE GG, HOLD AND EVALUATE. OR, IF GG CHAMBER PRESSURE AT THE LOWEST POINT BETWEEN PULSES REMAINS WITHIN 100 PSID (I.E., DROPS BY < 100 PSI), TRANSDUCER HAS SHIFTED. CONTINUE. THIS DEVIATION WAS DEVELOPED IN RESPONSE TO EVALUATION OF LEAKAGE DISCOVERED IN SEVERAL PRODUCTION PHASE VALVES OF THE NEW DESIGN WHILE UNDERGOING TESTS AT THE VENDOR.
S072379UB	02/05/98	STS-89/OV-105, FLT 12. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-057. LD-057 REPLACED THE REQUIREMENTS FOR 2 OF 2 ABORT LIGHT COMMAND PATHS TO T-5 MINUTES AND 1 OF 2 ABORT LIGHT COMMAND PATHS TO T-10 SECONDS WITH THE REQUIREMENT FOR 1 OF 2 ABORT LIGHT COMMAND PATHS FROM ET CRYO LOAD (T-6 HOURS) TO T-10 SECONDS.
S072379UJ	04/09/98	STS-90/OV-102, FLT 25. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-058. LD-058 DIRECTED THE GROUND ACTIVATION OF APU WATER LINE HEATERS 3A AND 3B IN THE EVENT OF A CONFIRMED INSTRUMENTATION FAILURE IN THE APU H2O LINE TEMPERATURE #3 MEASUREMENT, (V46T0503A). THIS ACTION PROTECTED AGAINST AN UNDETECTABLE FAILED OFF HEATER. LD-058 ALSO CORRECTED THE SWITCH CALLOUTS IN THE PREPLANNED CONTINGENCY PROCEDURE SECTION OF SSID APU-19 FOR A FAILED ON HEATER FROM "PANEL A12 TANK/FUEL LINE/H2O SYS 2A AND 2B" TO "PANEL A12 TANK/ FUEL LINE/H2O SYS 3A AND 3B".

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S072379UT	06/04/98	STS-91/OV-103, FLT 24. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-059. LD-059 MADE PRSD O2 HEATER CURRENT SENSOR MEASUREMENTS V45X1485E, V45X1486E, V45X1487E, AND V45X1488E APPLICABLE TO TANK SET FIVE AS INSTALLED ON OV-103. THESE MEASUREMENTS AS DOCUMENTED IN SSID PRSD-04 WERE ONLY APPLICABLE TO OV-104 AND OV-105. THE SSID WAS NOT UPDATED WHEN OV-103 RECEIVED THE TANK SET FIVE MOD.
S072379UV	06/15/98	STS-91/OV-103, FLT 24. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-061. LD-061 CHANGED THE ORBITER ACCESS ARM ACCUMULATOR GN2 UPPER PRESSURE LIMIT PER SSID GSE-10 FROM 2800 PSI TO "NO HIGH" IN THE GLS. THE PRESSURE HAD BEEN INCREASING PROPORTIONATELY WITH THE AMBIENT TEMPERATURE. S0007, VOLUME 5, SEQUENCE 100-001 WAS TO BE USED FOR ACCUMULATOR RECHARGE SHOULD TWO OF FOUR ACCUMULATOR NORMAL SWITCHES NOT BE OBTAINED.
S072379UU	07/01/98	STS-91/OV-103, FLT 24. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-060. LD-060 PERMITTED LAUNCH WITH ALL O2 TANK 5 SENSORS (BOTH SETS) TRIPPED ON IF THE SENSORS COULD NOT BE RESET BY T-31 SECONDS. THE MEASUREMENTS COULD BE MASKED BY GLS AND THE COUNT RESUMED WITH A MASK OF THE AFFECTED FD'S (V45X1585/ 1586/1587/1588E).
S072379VW	11/25/98	STS-88/OV-105, FLT 13. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-062. LD-062 CHANGED THE FUEL CELL #1 SUBSTACK 2 DELTA VOLTAGE ALLOWABLE MAXIMUM LIMIT PER SSID FCP-03 FROM 150 MV TO 200 MV FROM START OF ET CYRO TANKING TO "GO" FOR RSLS START. FUEL CELL #1 SUBSTACK 2 DELTA VOLTAGE HAD BEEN STEADILY INCREASING OVER THE PAST EIGHT FLIGHTS FROM A VALUE OF APPROXIMATELY 62 MV (STS-32) TO APPROXIMATELY 136 MV (STS-89). MAXIMUM PRELAUNCH VALUES HAVE BEEN 98, 102, 108, 118, 132, 136 MV FOR THE PAST 6 MISSIONS (STS-48, 42, 53, 76, 79, 89). THIS FUEL CELL HAS APPROXIMATELY 2026 HOURS STACK RUNTIME (LIFE LIMITS IS 2600 HOURS). THE REQUESTED LIMITS OF 200 MV ALLOWED MARGIN FOR CONTINUED INCREASE IN SUBSTACK DELTA VOLTAGE.

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S072379WA	12/14/98	STS-88/OV-105, FLT 13. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-063. LD-063 ADDED DRSD TO SECTION 5.2.2.1 OF SSID ETR-01 WHICH MADE THE RANGE SAFETY DISPLAY 2 OF 3 MANDATORY INSTEAD OF 2 OF 2. LD-063 ALSO MADE AN ADMINISTRATIVE CLARIFICATION IN SECTION 5.2.2.2, AND ELIMINATED THE 1 OF 1 MANDATORY FOR THE CAPE HIGH POWER COMMAND DESTRUCT BY ADOPTING A NEW CONFIGURATION WHICH INCLUDED THE JDMTA IN SECTION 5.2.3.2.
S072379WU	05/25/99	STS-96/OV-103, FLT 26. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-064. LD-064 ADDS THE DEBRIS DATABASE AS AN ADDITIONAL RESOURCE FOR ASSESSING ICING CONDITIONS IDENTIFIED BY THE ICE TEAM.
S072379YG	07/27/99	STS-93/OV-102, FLT 26. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-065. LD-065 CHANGED THE PAY-01, PAYLOAD LATCH ANOMALY, 2 OF 2 PLD SEL 1 LATCH 3A AND 3B LATCHED AND RELEASED INDICATIONS, FOR CONFIRMED INSTRUMENTATION FAILURE, IF DUAL MOTOR FUNCTION IS VERIFIED, CONTINUE. THE REQUIREMENT WAS CHANGED TO 1 OF 2 PLD SEL 1 LATCH 3A AND 3B LATCHED AND RELEASED INDICATIONS, FOR CONFIRMED INSTRUMENTATION FAILURE, CONTINUE. THERE IS NO PLANNED OPERATION OF THE KEEL LATCH FOR THIS MISSION. THEREFORE, MOTOR FUNCTION IS NOT REQUIRED AND LOSS OF INSTRUMENTATION IS ACCEPTABLE.
S072379YH	08/11/99	STS-93/OV-102, FLT 26. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-066. LD-066 CHANGED THE V61P2642A, AVIONICS BAY 1 FAN DELTA PRESSURE UPPER LIMIT FROM 4.30 INCHES OF WATER TO 4.40 INCHES OF WATER. THE INCREASED PRESSURE HAS NO NEGATIVE EFFECTS ON THE FANS OPERATION AND COOLING CAPABILITY. A LIMIT OF 4.40 INCHES OF WATER WILL STILL PROTECT THE INTENT OF THE LCC UPPER LIMIT.
S072379ZB	11/17/99	STS-103/OV-103, FLT 27. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-067. LD-067 MODIFIED THE MINIMUM SRM FIELD JOINT TEMPERATURE REDLINES. THIS CHANGE WAS REQUESTED DUE TO NON UNIFORM HEATING AROUND THE CIRCUMFERENCE OF THE RSRM FIELD JOINTS. THE CHANGE PROVIDED ADDITIONAL MARGIN FOR CONTROL OF HEATERS BY SET POINT ADJUSTMENTS AS DESCRIBED IN OMRSD WAIVER WK03886.

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S072379ZK	12/13/99	STS-103/OV-103, FLT 27. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-068. LD-068 ADDS THE REQUIREMENT TO MONITOR FOR SRB HPU PRIMARY PRESSURE OK TO REMAIN OFF BETWEEN START OF ET CRYO LOAD (T-6 HOURS) AND GO FOR RSLS START (T-31 SECONDS) WITH AN ACCOMPANYING PREPLANNED CONTINGENCY PROCEDURE WHICH WOULD ALLOW CONTINUATION IF INSTRUMENTATION FAILURE CAN BE VERIFIED. THIS REQUIREMENT PROTECTS APU REDUNDANCY MANAGEMENT PRIOR TO T-31 SECONDS.
S072379ZN	01/06/00	STS-103/OV-103, FLT 27. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-069. LD-069 REVISED THE ALTERNATE VERIFICATION REQUIREMENTS FOR THE LH2 FILL LINE DRAIN ANOMALY (SSID MPS-06). THE MINIMUM LH2 INLET TEMPERATURE MEASUREMENT (GLHT4118A) REQUIREMENT WAS CHANGED FROM -416 DEGREES F TO -412 DEGREES F. THE DEVIATION ALSO INCLUDED A WORKAROUND WHICH UTILIZED OTV FOR VERIFICATION THAT THE A100680 TSM DRAIN VALVE WAS OPENED IN THE EVENT OF AN ORBITER INLET TEMPERATURE MEASUREMENT FAILURE PRIOR TO TERMINATION OF LH2 REPLENISH. THIS DEVIATION ACCOUNTS FOR THE ORBITER INLET PRESSURE UPWARD SHIFT OF 4 DEGREES. THE MEASUREMENT WAS TRACKING AND APPREARED TO BE FUNCTIONAL WITH A 4 DEGREE BIAS.
S072380A	06/02/00	STS-101/OV-104, FLT 21. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-070. LD-070 ALLOWED THE DEVIATION FROM THE HOLD AND EVALUATE REQUIREMENT (FCP-03) FOR FUEL CELL SUBSTACK DELTA VOLTAGE ABSOLUTE CHANGE GREATER THAN 18 MV AT STEADY STATE LOAD. THE DEVIATION INCLUDES A WORKAROUND THAT, IF SUBSEQUENT TO LAUNCH, SHOULD SUBSTACK VOLTAGE DELTA ABSOLUTE INCREASE EXCEED 50 MV, THE FUEL CELL MONITORING SYSTEM (FCMS) WOULD BE POWERED UP ON ORBIT TO CONFIRM FUEL CELL INDIVIDUAL VOLTAGE READINGS.
S072380U	11/15/00	STS-97/OV-105, FLT 15. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/ DEVIATION LD-071. LD-071 ADDED TO REQUIREMENT (2) A DELAY OF UP TO 90 SECONDS THAT MAY BE REQUIRED FOR LUBE OIL SYSTEM STABILIZATION FOLLOWING APU START (CHAMBER PRESSURE INCREASE). THIS CHANGE ALSO ALIGNED THE LCC WITH THE FLIGHT RULE.

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S072380BC	12/04/01	STS-108/OV-105, FLT 17. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/DEVIATION LD-076. LD-076 ALLOWED LOWERING THE LOWER TEMPERATURE LIMIT ON MSID V46T0284A1 (APU 2 FUEL SERVICE LINE) FROM 45 DEGREES F TO 42 DEGREES F. THE 45 DEGREE F LCC LIMIT IS TO PROVIDE REACTION TIME TO PREVENT REACHING 35 DEGREES F IN CASE OF HEATER FAILURE. MOD FLIGHT RULES PROTECT FOR N2H4 FREEZING WITH A 40 DEGREE F FLIGHT RULE LOSS LIMIT, GIVING A 5 DEGREE F MARGIN.
S072380BQ	04/11/02	STS-110/OV-104, FLT 25. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/DEVIATION LD-077. LD-077 INCORPORATED CHANGES TO PREPLANNED CONTINGENCY PROCEDURE (6) TO EXPAND THE DEFINITION OF CONFIRMED INSTRUMENTATION FAILURE TO INCLUDE STEP FUNCTION CHANGES AND ERRATIC BEHAVIOR. THIS WAS IN RESPONSE TO INTERMITTENT ERRATIC BEHAVIOR OF FCL 1 ACCUMULATOR QUANTITY AND FCL 2 PUMP INLET PRESS MEASUREMENTS, WHICH BOTH SHARE THE SAME SYSTEM DSC ATCS OF1, SECTION 2.
S072380CJ	10/17/02	STS-112/OV-104, FLT 26. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/DEVIATION LW-078. LW-078 ACCEPTED VIOLATION OF THE FCP H20 RELIEF NOZZLE TEMPS A AND B IN EXCESS OF THE MAXIMUM ALLOWABLE OF 235 DEGREES DUE TO A HEATER B CONTROLLER ANOMALY. DUE TO THE FACT THAT HEATER A CONTROLLER WAS MAINTAINING THE TEMPERATURES BETWEEN 270-277 DEGREES F, THE WAIVER ALSO INCREASED THE MAXIMUM ALLOWABLE FCP H20 RELIEF NOZZLE TEMPS A AND B TO 317 DEGREES F FOR THE REMAINDER OF THE COUNT. THE INCREASED MAXIMUM ALLOWABLE WAS BASED ON SIMILAR EXISTING RATIONAL FOR USING 317 DEGREES F FOR A FAILED LOW TEMPERATURE SENSOR.
S072380EG	05/03/05	STS-114 TANKING TEST/OV-103, FLT 31. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/DEVIATION LW-080. LW-080 ACCEPTED VIOLATION OF THE ECL-40 MINIMUM REDLINE FOR FREON COOLANT LOOPS 1 AND 2 INTERCHANGER FLOW RATE (2150 LBM/HR) AND ALLOWED A REDUCED MINIMUM REDLINE OF 1950 LBM/HR (BASED ON OMRS V41GEN.130-1). THIS CHANGE WAS REQUIRED DUE TO THE TANKING TEST SPECIFIC CONFIGURATION OF THE FREON LOOPS IN RADIATOR FLOW, THE NOMINAL MINIMUM REDLINE LIMIT IS BASED ON THE FREON COOLANT LOOP CONFIGURATION TO BE IN RADIATOR BYPASS.

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S072380EM	06/22/05	STS-114 TANKING TEST/0V-103, FLT 31. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/DEVIATION LD-081. LD-081 CHANGES THE APPLICABILITY OF SSID GSE-22 SRB AFT SKIRT PURGE ANOMALY IN THE TANKING TEST APPLICABILITY MATRIX, TTEST-01, FROM MANDATORY TO NON-APPLICABLE. FOR TANKING TEST RUN 2, OMRSD S00JB0.174 SPECIFIES THAT THE SRB AFT SKIRT GN2 PURGE PRESSURE MUST BE A MINIMUM OF 35 PSIG FOR DURATION OF THE TANKING TEST. SSID GSE-22 REQUIRES 90 PSIG MINIMUM TO PROTECT AGAINST POSSIBLE FIRE AT SSME START AND AT T-0. FOR TANKING TEST THE LOWER LIMITS STATED IN THE OMRSD ARE SATISFACTORY TO MAINTAIN AN INERT ENVIRONMENT.
S072380GE	07/18/06	STS-121/OV-103, FLT 32. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/DEVIATION LD-082 TO MPS-22. LD-082 ALLOWED 3 OF 4 FUNCTIONAL LH2 LLCO SYSTEMS IF IDENTICAL FAILURES OCCURRED ON THE SAME LH2 LLCO SENSOR CIRCUIT ON CONSECUTIVE LAUNCH COUNTDOWNS THAT WERE NOT ASSOCIATED WITH ANY OTHER LH2 LLCO SYSTEM ANOMALIES, MONOBALL PROBLEMS OR EXERNAL CAUSES.
S072380GF	07/18/06	STS-121/OV-103, FLT 32. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/DEVIATION LD-084 FOR PRSD-01/06. LD-084 PROVIDED A MEANS OF CONFIRMING INSTRUMENTATION FAILURE FOR A FAILED LOW SENSOR ON AN UNPAIRED PRSD O2 OR H2 TANK.
S072380GG	07/18/06	STS-121/OV-103,FLT 32. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/DEVIATION LW-085 TO MEL-13 (STS-121). LW-085 ALLOWS LOSS OF THE L5L VERNIER JET HEATER. ALTHOUGH THE VERNIER JET HEATER REQUIREMENT WAS 6 OF 6, AN ASSESSMENT OF THE IMPACT OF POSSIBLE LOSS OF ASSOCIATED VERNIER JET DETERMINED THAT ALL MISSION OBJECTIVES AND DOCKED OPERATIONS COULD BE ACCOMPLISHED SAFELY WITHOUT USE OF L5L VERNIER HEATER/JET.
S072380GH	07/18/06	STS-121/OV-103,FLT 32. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/DEVIATION LW-086. LW-086 REFLECTS PROGRAM ACCEPTANCE OF LOOSE BX265 FOAM PARTICLES THAT RESULTED FROM CRUSHED ET TPS DAMAGE BETWEEN THE ET LO2 FEEDLINE AND FEEDLINE BRACKET. ASSESSMENT OF THESE PARTICLES INDICATED THE TOTAL MASS OF ALL OBSERVED LOOSE FOAM PARTICLES WAS WELL BELOW THE LIBERATED FOAM RISK ASSESSMENT MASS REFLECTED IN NSTS 60559 FOR THE FEEDLINE BRACKETS.

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S072380GJ	07/18/06	STS-121/OV-103,FLT 32. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/DEVIATION LW-087R02. LW-087R02 DOCUMENTS PROGRAM ACCEPTANCE OF DAMAGED/ CRACKED FOAM AT THE -Y ET/SRB CABLE TRAY TPS CLOSE-OUT THAT REPRESENTED A POSSIBLE DEBRIS SOURCE IF LIBERATED DURING LAUNCH OR ASCENT. AN EQUIVALENT MASS, IF RELEASED FROM THE NEARBY SRB PAL RAMP CLEARED THE ORBITER RCC DETERMINISTICALLY AND A PROBABILISTIC EVALUATION CLEARED TILE WITH A CONDITIONAL RISK INDEX OF 1/1000, ALLOWING THE ET/SRB CABLE TRAY FOAM DEBRIS TO BE CLEARED BY SIMILARITY.
S072380GK	08/09/06	STS-115/OV-104, FLT 27. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/DEVIATION LD-088 TO MPS-22. LD-088 ALLOWS 3 OF 4 FUNCTIONAL LH2 LLCO SYSTEMS IF IDENTICAL FAILURES OCCURRED ON THE SAME LH2 LLCO SENSOR CIRCUIT ON CONSECUTIVE LAUNCH COUNTDOWNS THAT WERE NOT ASSOCIATED WITH ANY OTHER LH2 LLCO SYSTEM ANOMALIES, MONOBALL PROBLEMS OR EXERNAL CAUSES.
S072380GQ	09/19/06	STS-115/OV-104,FLT 27. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/DEVIATION LD-089. LD-089 ALTERED THE FCP-04 FCP NO 1 H2 PUMP MTR CONDITION VOLTAGE MINIMUM AND MAXIMUM REDLINE VALUES BETWEEN T-6 HRS AND T-10 SECONDS TO ACCOMMODATE THE FACT THAT THE FUEL CELL 1 PUMP PHASE A CIRCIUT BREAKER WILL BE OPEN FOR THIS MISSION (DUE TO THE SHORT IN THE FUEL CELL 1 COOLANT PUMP MOTOR PHASE A CIRCUIT). THIS WILL RESULT IN FUEL CELL 1 HYDROGEN PUMP OPERATING ON 2 PHASES AND WILL IMPACT THE EXPECTED FCP NO 1 H2 PUMP MTR CONDITION VOLTAGE READINGS MONITORED BY FCP-04. THIS DEVIATION ADJUSTS THE FCP-04 REDLINES FOR THE AFFECTED PUMP ACCORDINGLY TO MAINTAIN PUMP LCC PROTECTION.
S072380HB	11/27/06	STS-116/OV-103,FLT 33. DOCUMENTS SHUTTLE LAUNCH. COMMIT CRITERIA WAIVER/DEVIATION LD-091R01. LD-091R01 ALTERED FCP-03 REQUIREMENT (6)AND PCP (8). TO REFLECT A NEW MAXIMUM LIMIT FOR FUEL CELL 2, SUBSTACK 3 FOR STS-116/OV-103. THE DEVIATION CHANGED THE EXISTING 28MV MAXIMUM LIMIT TO 50 MV TO ALLOW FOR KNOWN ACCEPTABLE PERFORMANCE VARIATION IN FCP2 SUBSTACK 3 DURING LOAD CHANGES. THE 50MV DEVIATION MAXIMUM LIMIT REPRESENTS THE WORSE CASE PERFORMANCE OF THIS S/N 120 FCP FOR LOAD CHANGES THAT GREATLY EXCEEDED THOSE EXPECTED DURING THE LCC TIME FRAME.

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S072380HE	12/04/06	STS-116/OV-103,FLT 33. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/DEVIATION LD-092R01. LD-092R01 ALTERED LPS-18, LPS-19, BFS-08, AND INS-01. BY THE ADDITION OF A NEW REQUIREMENT AND ASSOCIATED PREPLANNED CONTINGENCY PROCEDURE WHICH ALLOWS FOR SPECIFIC TEMPORARY VIOLATION IF THE VIOLATION IS DETERMINED TO BE DUE TO A FRAME 95 RESET ERROR (REFERENCE IPR 116V-0042). ACCEPTANCE OF THESE SPECIFIC VIOLATIONS PRIOR TO T-31 SECONDS WILL HAVE NO EFFECT ON SAFETY OF VEHICLE OR CREW AND WILL NOT IMPACT MISSION OBJECTIVES. MULTIPLE INSTANCES OF A FRAME 95 RESET ERROR WILL REQUIRE REASSESSMENT PRIOR TO REACHING A "GO" DETERMINATION.
S072380HF	12/20/06	STS-116/OV-103,FLT 33. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER LW-094. LW-094 WAIVED ICE-01 REQUIREMENT (2) SUCH THAT MULTIPLE HARD ICE PARTICLES, UP TO A MAXIMUM PARTICLE SIZE OF 1/2 IN. BY 1/2 IN. BY 1/2 IN., OBSERVED ON THE GVA DUCT OUTLETS, WERE ACCEPTABLE FOR LAUNCH BASED ON SE&I DTA AND ORBITER TILE AND RCC IMPACT DAMAGE ASSESSMENT. THE SUPPORTING DTA WAS VALID FOR WIND SPEEDS UP TO 33.5 KNOTS AND WIND DIRECTIONS FROM 270 TO 360 DEGREES ONLY. PARTICLES, IF LIBERATED, WOULD NOT RESULT IN UNACCEPTABLE DAMAGE TO ORBITER TILES OR RCC AND WERE NOT CONSIDERED AN IMPACT CONCERN FOR SSME NOZZLES (0.1 FT-LB KINETIC ENERGY VS AN SSME DAMAGE THRESHOLD OF 84 FT-LBS FOR METALLIC PARTICLES).
S072380HP	06/06/07	STS-117/OV-104, FLT 28.DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/DEVIATION LD-095 FOR LCC GSE-24. LD-095 IS DOCUMENTED TO ALLOW STS-117 TO LAUNCH WITH WINDS BETWEEN 19 KNOTS AND 23 KNOTS, FROM 002 TO 058 DEGREES IF REQUESTED BY THE LAUNCH TEAM.
S072380HY	08/03/07	STS-118/OV-105, FLT 20. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/DEVIATION LD-096R02 FOR LCC ECL-05. LD-096R02 IS DOCUMENTED TO ALLOW STS-118 TO LAUNCH WITH CABIN PRESSURE AT 15.4 PSIA AND THE AIRLOCK DIFFERENTIAL PRESSURE NUMBER 1 AT 0.5 PSID.

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S072380HZ	09/12/07	STS-118/OV-105, FLT-20. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/DEVIATION LW-098. LW-098 WAS APPROVED FOR STS-118 AND ALLOWED FOR LAUNCH WITH A 3 INCH BY 1/4 INCH CRACK IN THE INBOARD BASE FITTING OF THE XT-1973 LO2 FEEDLINE BRACKET. THE PRESENCE OF THE CRACK AND THE POSSIBILITY OF LIBERATION OF THE BASE FITTING FOAM AFT OF THE CRACK VIOLATED LCC ICE-01 REQUIREMENTS (2) AND (3). ET PROVIDED RATIONALE SUPPORTING NO IMPACT TO THE ET STRUCTURAL OR THERMAL PERFORMANCE DUE TO THE CRACK AND A WORSE CASE LIBERATION MASS OF 0.058 LBM. SE&I DTA AND ORBITER TPS IMPACT ASSESSMENT DETERMINED THAT THE RISK OF LIBERATION OF THIS ET TPS WAS WELL WITHIN THE ACCEPTED RISK FOR NEARBY ET ICE/FROST RAMP FOAM LOSS, AND THEREFORE ACCEPTABLE FOR LAUNCH AND ASCENT.
S072380JM	10/21/07	STS-120/ OV-103, FLT 34. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/DEVIATION LD-099. CURRENTLY THE PREPLANNED CONTINGENCY PROCEDURE FOR A FAILED LOW TANK HEATER CONTROL PRESSURE IN PRSD-01 AND PRSD-06 PROTECTS AGAINST SIMPLE INSTRUMENTATION FAILURE BUT DOES NOT PROTECT AGAINST THE LOSS OF CRYO CONTROLLER POWER AND THE SUBSEQUENT LOSS OF AUTOMATIC HEATER FUNCTION. THIS DEVIATION MODIFIES PRSD-01 AND PRSD-06 IN ORDER TO PROPERLY IDENTIFY THIS TYPE OF FAILURE INSTEAD OF INAPPROPRIATELY IDENTIFYING THE FAILURE AS ACCEPTABLE INSTRUMENTATION FAILURE AS IS CURRENTLY THE CASE.
S072380JP	10/21/07	STS-120/ OV-103, FLT 34. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/DEVIATION LD-101R01. THIS DEVIATION WILL ALLOW FOR LAUNCH AND USE OF CREW MANUAL PRSD TANK HEATER CONTROL ON ORBIT IF FAILURE REQUIRES AUTO HEATER CONTROL CAPABILITY VERIFICATION AND TIME REMAINING IN LAUNCH COUNTDOWN DOES NOT SUPPORT VERIFICATION OR IF AUTO HEATER CONTROL IS VERIFIED TO BE LOST. NEW DEVIATION PCP WILL REQUIRE EGIL, MOD AND FLIGHT DIRECTORS TO CONSIDER THIS POTENTIAL FAILURE WHEN MISSION PLANNING AND DETERMINE IF CREW CAN ACCOMMODATE ADDITION WORK LOAD BEFORE IMPLEMENTING.
S072380JQ	11/09/07	STS-120/OV-103, FLT 34. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/DEVIATION LW-102. LW-102 DOCUMENTS THE PRESENCE OF ICE/FROST FORMATION ON THE LH2 ET/ORBITER UMBILICAL FORWARD OUTBOARD PYRO CAN CLOSEOUT BONDLINE, AND HAD DIMENSIONS OF 7 INCH TOTAL LENGTH X 2" WIDE X 0.5" THICK. NOT ALL OF THE FORMATION IS HARD ICE. A DTA AND PRA WERE PERFORMED AND ORBITER ASSESSMENT WAS ACCEPTABLE. LW-102 WAS APPROVED TO WAIVE THE ICE-01 REQUIREMENT DURING STS-120 COUNTDOWN.

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S072380JY	11/30/07	STS-122/ OV-104, FLT 29. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/DEVIATION LD-103. THIS WILL ALLOW FOR LAUNCH WITH A SINGLE FORWARD NON-CRT MDU FAILED, AS LONG AS THE REMAINING TWO FAULT TOLERANT FOR ANY COMBINATION OF SYSTEM OR POWER BUS FAILURES DURING THE MISSION. IN ADDITION, BY UTILIZING DOWNLISTED BIT ERROR DETAILS IN EVALUATING MEDS BIT ERROR CONDITIONS, THIS ALLOWS SOME POST/OST BIT ERRORS TO BE DETERMINED TO BE NON-CRITICAL IN NATURE, THUS ALLOWING THE COUNT TO PROCEED.
S072380KK	03/07/08	STS-123/ OV-105, FLT 21. DOCUMENTS SHUTTLE LAUNCH COMMIT CRITERIA WAIVER/DEVIATION LD-104. THIS DEVIATION MODIFIES APU-24 TO SYNCHRONIZE IT WITH RECENTLY UPDATED S0007.500 PROCEDURES FOR VERIFYING ACCEPTABLE INSTRUMENTATION FAILURE IN THE EVENT THAT A PCA APU CONTROLLER RPC ANOMALY IS ENCOUNTERED.