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Apollo 1 Malfunction Procedures (A204) for Apollo Operations Handbook

National Aeronautics and Space Administration (NASA)

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APOLLO 1 MALFUNCTION PROCEDURES

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PROCEDURES ENTRY SHEET

SECTION 9.1.1.1

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PROCEDURES ENTRY SHEET

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Direct Village - Abnormal Maneuver

SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
S/C 012 Check List Error Code					
00101		Depress error reset. Wait for zero encoder light off. Place Optics Mode switch in Zero Optics position & wait until zero encoder light off again.		Optics Mode switch removed from Zero Optics position before end of 60 second wait.	
00102		Depress Error reset			Computer unable to achieve desired optics mode. The computer has failed to properly control the optics drive. The OCDU's may drive with no desired optics angles.
00104		Depress Error Reset on DSKY. Switch Optics Mode to Manual and complete optics drive manually.			
00105		Depress Error Reset and continue or return to P00 and start over.		Internal marks request with mark system busy.	
00106		Depress Error Reset and continue.		Too many marks	
00107		Depress Error Reset and continue.		Mark reject (V52E) with mark system not in use.	
00110		Depress Error Reset. If rejection of an accepted mark is desired, go back to P00 and start over.		Mark reject with no effect, i.e., no mark between mark rejects or all requested marks have been accepted when V52E entered.	
00112		Depress Error Reset and continue.		Optics mark with none requested.	
PREPARED BY: <u>MM</u>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
DATE: <u>Jan 27, 1967</u>		GUIDANCE AND NAVIGATION MALFUNCTION PROCEDURES		S/C <u>012</u>	REV <u>FINAL</u>
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
00122		Depress Error Reset. Re-enter program and make 2 marks or select a known landmark.		Only one mark made for unknown landmark.	
00123		Depress Error Reset. Re-enter program and try again.		Mark data unavailable after restart.	
00201		Depress Error Reset. Wait until zero encoder light off. Reselect Zero Encode Mode and wait until zero encode light off again.		IMU Mode changed from Zero Encode before end of 35 sec. delay.	
00202		Depress Error Reset. Check switches.			Computer unable to achieve desired mode.
00203		Depress Error Reset. Check IMU status.		No IMU mode indicated to computer.	
00204		Depress Error Reset. Select switch configuration to avoid this situation.		IMU mode changed with transfer switch at COMPUTER, but computer did not command the change.	
00205		Depress Error Reset. See PIPA failure malfunction procedures. (Entrance to POO is enabled by the alarm.)			Excessive accelerometer output (≥ 18.5 g's)
00310		Depress Error Reset and continue (cautiously)			Error return from routine.
00401		Depress Error Reset and continue or realign if desired.		Desired gimbal angles yield gimbal lock. (MGA $\geq 60^\circ$)	
PREPARED BY: <i>gmn</i>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
00402		Depress Error Reset. Maneuver vehicle to obtain stars. Reselect program.		Star out of FOV.	
00405		Depress Error Reset. Select proper mode. If no SCS monitor desired (wasn't disabled by V33E at the proper time), key V21N01E 730E 77776E.		SCS Mode not in desired state.	
00412		Depress Error Reset. Reselect program and change associated time by 15 min. or more.		Time and longitude too far apart.	
01101		Depress Error Reset. Check with ground.			Rupt 2 (not expected, not wired) Hardware suspect
01102		Record R2 and R3 contents. Relay to ground. Depress Error Reset.			AGC self-test error. Use computer with caution.
01103		Depress Error Reset.	1.0		Forbidden step executed (by computer). Use computer with caution.
01104		Record DSKY display. Depress Error Reset. Relay information to ground.			C-relay failed during test.
01201		Depress Error Reset.	1.0		No VAC areas available. Use computer with caution.
PREPARED BY: <i>g/c</i>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
01202		Depress Error Reset.	1.0		No correct areas available. Use computer with caution.
01203		Depress Error Reset.	1.0		Waitlist overflow
01204		Depress Error Reset.	1.0		Task couldn't be fit into the waitlist.
01206		Depress Error Reset.	1.0	Display system routine already in use.	
01207		Depress Error Reset.	1.0		No VAC area available for marks. Use computer with caution.
01210		Depress Error Reset	1.0	Job already waiting in --- STALL	
01301		Depress Error Reset.		Possible erasable memory disturbance.	Arccos or Arcsin argument too large. Use computer with caution.
01302		Depress Error Reset.	1.0	Possible erasable memory disturbance.	Square root argument excessively negative. Use computer with caution.
PREPARED BY: <i>JM</i>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
01401		Depress Error Reset. Select P00 and troubleshoot for poor alignment, control system problem etc.		Thrust misalignment exceeds 90°	
01405		Depress Error Reset. Return to prethrust program via P00 and try again.		Less than 5 min. to ignition.	
01406		Depress Error Reset. Select P00 and reselect prethrust program.		Error return from maneuver to ignition attitude.	This alarm may indicate transient computer error.
01407		Depress Error Reset. Similar to pattern 00401.		Commanded CDUZ exceeds 60°.	
01410		Depress Error Reset. Reselect P32 through P00. Change input parameters.		Entry conditions not computable.	
01411		Depress Error Reset. Reselect P32 through P00. Change latitude of target. If target beyond max. declination is desired, select latitude in P32 to avoid 01411 alarm. Reselect desired latitude in P62.		Target latitude exceeds declination of orbit.	
01421		Go to SCS entry procedures.		Avg. g not running for entry. (Not likely)	
01426		Depress Error Reset. Avoid roll into gimbal lock.		IMU orientation not satisfactory for entry (Computer waits 5 sec and proceeds)	
PREPARED BY: <i>gm</i>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
01427		Depress Error Reset. Add 180° to backup bank angle charts. 0 deg. roll is lift down.		IMU orientation reversed for entry (Computer waits 5 sec and proceeds.)	
01430		Depress Error Reset. Report condition to ground.		CM/SM sep. discrete present with major mode not 11 or 62.	Since spacecraft not wired for this discrete, appearance of this alarm implies computer transient error.
01431		Depress Error Reset. Report condition to ground.		SIVB sep. discrete present with major mode not 11 or 12.	Since spacecraft not wired for this discrete, appearance of this alarm implies computer transient error.
01501		Depress Error Reset	1.0	Internal display system alarm.	
	1.0	Allow program to continue			
		a. POO displayed	1.1		
		b. POO not displayed	1.2		
		c. Repeated aborts	1.3		
	1.1	Reselect program, try again			
	1.2	Program is attempting to start again at an appropriate point			
	1.3	Key V36E (Fresh Start). Reinitialize erasable memory.			
PREPARED BY: <i>YMM</i>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
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SYMPTOMS

PROBLEM SUSPECTED
IN G&N OPTICS
LOOP

1. OCDU DRIVE
PROBLEM
2. OPTICS DRIVE
PROBLEM
3. OPTICS ZERO
ENCODE PROBLEM

FAILURES

1. AGC
2. OCDU
3. AGC OR OCDU
ENCODER
4. TELESCOPE DRIVE
5. SEXTANT DRIVE

TROUBLE SHOOTING PROCEDURES

1. COMMAND ZERO OPTICS
2. VERIFY ZERO ENCODE ~~MODE~~
LIGHT COMES ON AND GOES OUT
3. SELECT OPTICS MANUAL
MODE
4. SELECT TELESCOPE STAR
LOS MODE

NO ZERO
ENCODER LIGHT

CONCL AGC P

OCDU'S DRIVING
CONTINUOUSLY?

YES

OCDU

NO

ARE OCDU'S ZERO

NO

OCDU

CALL UP DISPLAY ON
DSKY OF OCDU ANGLES
(V16N55E)

ARE DSKY R1 & R2
ZERO?

NO

AGC
PROB

YES

DRIVE OPTICS IN SHAFT
AND TRUNNION

DO OCDU'S DRIVE?

NO

CHANGE CONTROLLER M
SWITCH OR CONTROLLE
SPEED SWITCH

YES

DOES DSKY DISPLAY FOLLOW OCDU'S?

NO

AGC OR OC
PROBLEM

YES

DOES TELESCOPE FOLLOW

NO

TELESCO
PRC

YES

DOES SEXTANT FOLLOW

NO

SEXTA
PROBL

YES

SYSTEM LOOKS
GOOD



IONS

CORRECTIVE ACTIONS

BLEM

①

MANUALLY COMMAND
OCDU REGISTERS
TO ZERO (V24N57EEE)

MISSION
SUPPORT
TM POINTS

CG 3102 V SXT TRUN MOTOR
DRIVE IN PHASE

CG 3112 V SXT SHAFT MOTOR
DRIVE IN PHASE

CG 3133 V SCT. TRUN MOTOR
DRIVE

CG 3141 V TRUN CDU 16X RES.
ERROR IN PHASE

CG 3200 V TRUN CDU MOTOR
DRIVE IN PHASE

CG 3220 V SHAFT CDU MOTOR
DRIVE IN PHASE

LURE

②

1. PULL OPTICS CB'S ON
MDC 22 TO STOP CDU
DRIVE
2. USE MECHANICAL DRIVES

LURE

②

USE MECHANICAL
DRIVES

M

①

MANUALLY COMMAND
OCDU AGC REGISTERS
TO ZERO (V24N57EEE)

V16N55E

DO OCDU'S DRIVE?

YES

USE OPERATIONAL MODE

NO

ENCODER

③

PERFORM BACKUP
ALIGNMENTS ONLY

DRIVE

④

USE MECHANICAL DRIVES

RIVE

⑤

USE TELESCOPE FOR
SIGHTINGS

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G&N Optics Loop

Am 480 788 (Dec 68)

SYMPTOMS

TROUBLE SHOOTING PROCEDURES

ALIGNMENT PROBLEM
IL DSS LOCK

1. ACCEL FAIL
2. IMU FAIL
3. TUMBLED IMU
4. LARGE IMU ALIGNMENT ERRORS

IS THE ACCEL
FAIL LIGHT ON

YES

PERFORM PIPA BIAS
MEASUREMENT
(C/L P. 9-16)

NO

DO MEASURED & PRESENT
BIAS TERMS DIFFER MORE
THAN +/- _____

YES

NO

IS THE IMU FAIL
LIGHT ON

YES

IS THE IMU STABLE
(OBSERVE FDAI IN A
G&N MODE, S/C RATES
DAMPED)

REALIGN
AND LOCK
LARGE D

YES

NO

HAS IMU TUMBLED
& UNSTABLE

YES

V37E51E
(IMU FAIL LIGHT INHIBITED
BY AGC DURING COARSE ALIGN
MODE)

NO

NO

IMU DRIFTS
BEYOND LIMITS
BETWEEN FINE
ALIGNMENTS

YES

DID IMU CAGE AT 0, 0, 0
(FDAI NAV SYMBOL)

NO

YES

PRESS ENTER
(IMU FAIL LIGHT MAY COME ON
AFTER COMPLETION OF COARSE
ALIGN MODE, BUT WILL GO OUT
IN A FEW SECONDS IF STAB
LOOP IS NORMAL)

IS THE IMU STABLE &
THE IMU FAIL LIGHT OUT

NO

V37E51E
V37E51E
(G&N)

YES

COMPLETE P51
(IMU ORIENTATION DETERMINATION)

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DLB

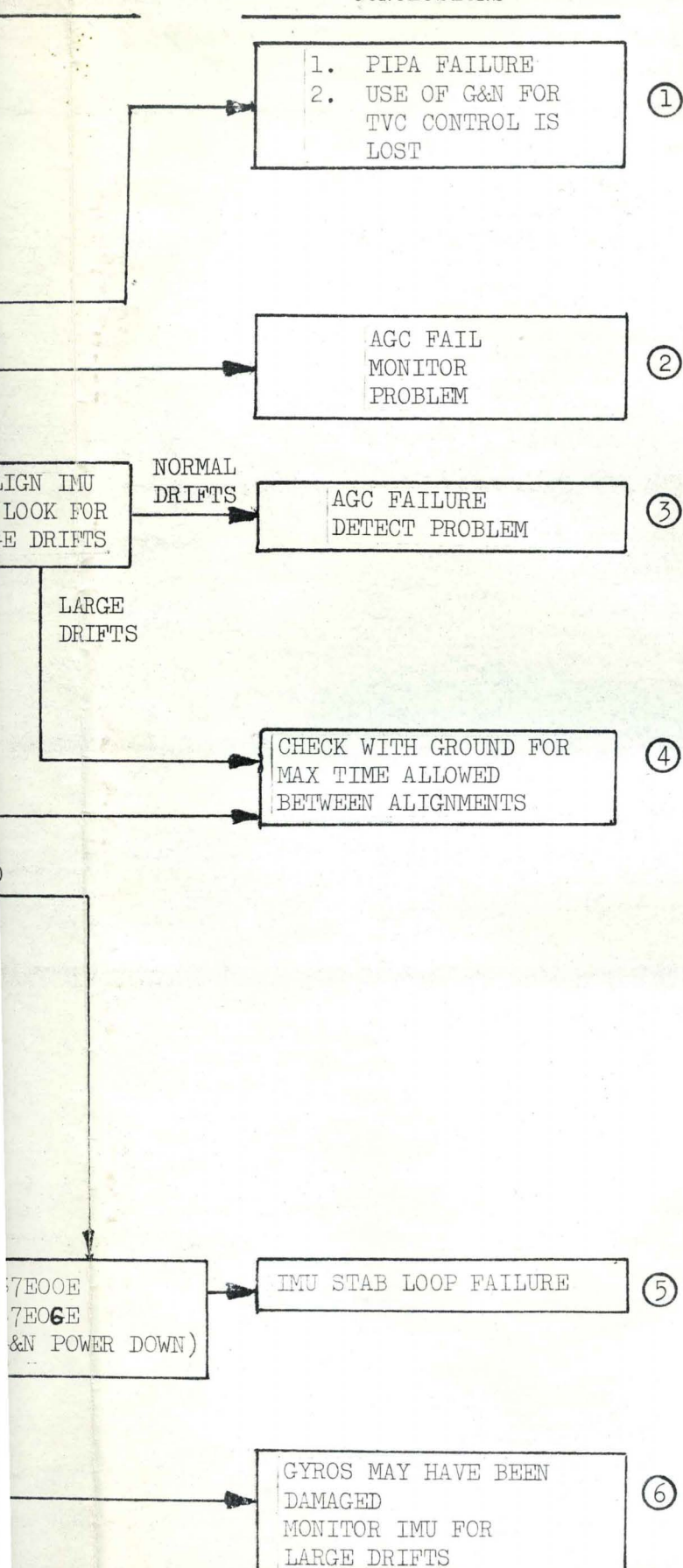
FLIGHT CREW SUPPORT DIVISION

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GUIDANCE
MALFUNCTION

CONCLUSIONS



CORRECTIVE ACTIONS

1. LOSS OF G&N ΔV AND AUTOMATIC ENTRY CAPABILITIES. IMU MAY BE ALIGNED AND USED AS ATTITUDE REFERENCE.
2. NO MISSION IMPACT
3. NO MISSION IMPACT
4. PERFORM ADDITIONAL EXTERNAL CHECKS ON S/C ATTITUDE FOR ΔV MANEUVERS
5. LOSS OF G&N (AGC MAY BE USED TO DISPLAY GROUND ELAPSED TIME)
6. PERFORM ADDITIONAL EXTERNAL CHECKS ON S/C ATTITUDE FOR ΔV MANEUVERS

MISSION SUPPORT TM POINTS

CG 6000 IMU PRESSURE
 CG 2300 PIPA TEMP
 CG 2301 IRIG TEMP
 CG 2302 IMU HEATER CURRENT
 CG 2303 IUM BLOWER CURRENT
 CG 1101 -28 VDC SUPPLY
 CG 0001 COMPUTER DIGITAL DATA
 CG 1503 IMU +28 VDC OPERATE
 CG 5000 PIPA FAIL
 CG 5001 IMU FAIL
 CG 2110 1GA TORQUE MOTOR INPUT
 CG 2112 1GA 1X RESOLVER OUT SINE IN PHASE
 CG 2113 1GA 1X RESOLVER OUT COS IN PHASE
 CG 2142 MGA 1X RESOLVER OUT SINE IN PHASE
 CG 2143 MGA 1X RESOLVER OUT COS IN PHASE
 CG 2172 OGA 1X RESOLVER OUT SINE IN PHASE
 CG 2173 OGA 1X RESOLVER OUT COS IN PHASE
 CG 2117 1GA SERVO ERROR IN PHASE
 CG 2140 MGA TORQUE MOTOR INPUT
 CG 2147 MGA SERVO ERROR IN PHASE
 CG 2170 OGA TORQUE MOTOR INPUT
 CG 2177 OGA SERVO ERROR IN PHASE
 CG 2206 1GA CDU 1X RES. ERROR IN PHASE
 CG 2236 MGA CDU 1X RES. ERROR IN PHASE
 CG 2266 OGA CDU 1X RES. ERROR IN PHASE

SYMPTOMS

TROUBLESHOOTING PROCEDURES

PROBLEM SUSPECTED IN G&N ICDU LOOP

1. CDU FAIL LIGHT ON.
2. ABNORMAL FDAI ATT
ERROR NEEDLES IN G&N
ATT. HOLD OR MONITOR.

FAILURES

1. IMU RESOLVER PROBLEM
2. CDU DRIVE
3. CDU ENCODER
4. CDU ENCODER OR AGC
5. CDU-SCS INTERFACE
6. AGC-CDU INTERFACE
7. AGC

1. V37E00E
2. AME - MONITOR
3. COMMAND ICDU ZERO ENCODE (V40N20E)
4. CALL ICDU ANGLES (V16N20E)
5. VERIFY DSKY DISPLAYS GO TO ZERO
6. VERIFY ZERO ENCODE LIGHT OUT
7. VERIFY ISS FINE ALIGN LIGHT ON

DID THE DSKY DISPLAY
GO TO ZERO

A CDU RUNNING CONTINUOUSLY

IS THE FDAI TOTAL
ATT. BALL DRIVING

CALL ICDU DISPLAY ON DSKY
(V16N20E). IS CDU VALUE SAME
AS DSKY DISPLAY

IS A DSKY DISPLAY ZERO

ARE VALUES AT NAV SYMBOL
ON FDAI \approx TO DSKY VALUES

ATT ERROR NEEDLES NULLED

1. COMMAND G&N ATT CONTROL (V44E)
2. V33E000E

CDU DRIVE TO COMMANDED
ANGLES (0,0,0)

ARE CDU'S DRIVING? (CONTINUOUSLY)

YES, SYSTEMS LOOKS GOOD

PREPARED BY:

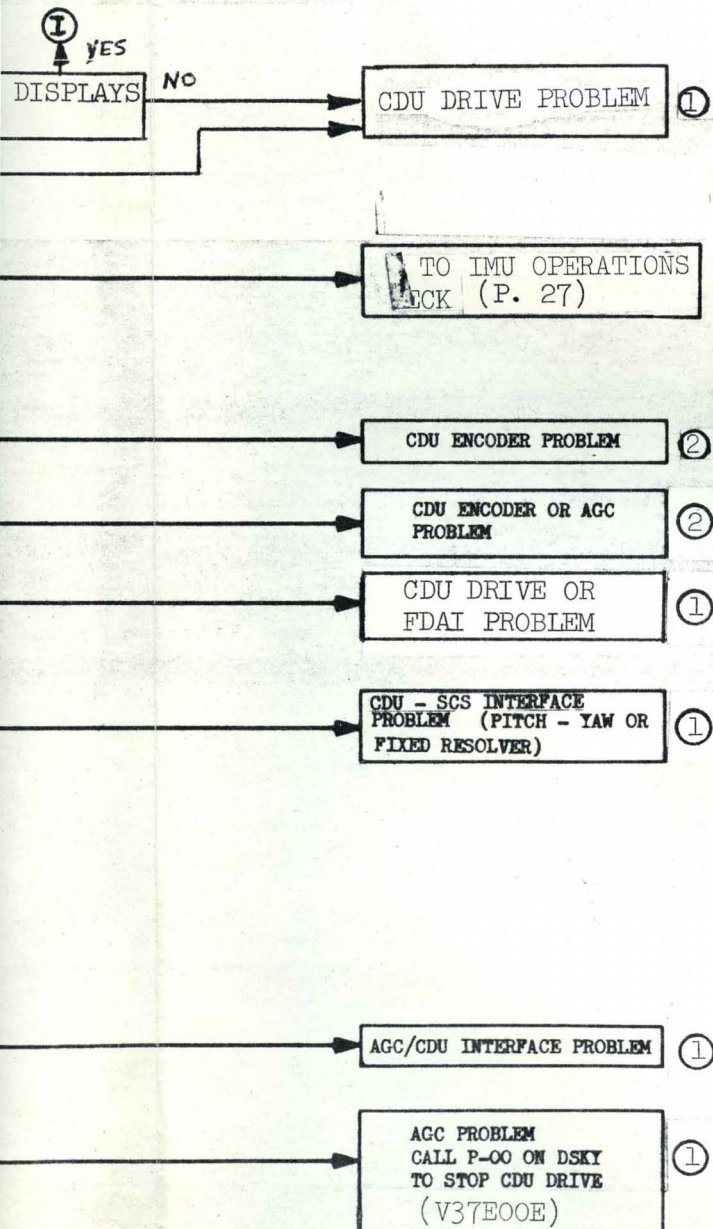
DLB

MSC Form 460 (Rev Dec 66)



CONCLUSIONS

CORRECTIVE ACTIONS



- 1 Attitude error indicator abnormal.
No auto G&N modes available.
IMU useful as an attitude reference only.
- 2 No auto G&N modes available.
IMU useful as an attitude reference only.

MISSION SUPPORT TM POINTS

CG 1503X IMU +28 VDC OPERATE
 CG 5001X IMU FAIL
 CG 5002X CDU FAIL
 CG 5006G IMU TEMP. LIGHT
 CH 0100X G-N ΔV MODE CONTROL
 CH 0101X G-N ATTITUDE MODE CONTROL
 CH 0102X G-N ENTRY MODE CONTROL
 CH 0103X MONITOR MODE CONTROL
 CH 1100X SCS ΔV MODE CONTROL
 CH 1101X SCS ATTITUDE MODE CONTROL
 CH 1102X SCS ENTRY MODE CONTROL
 CH 1103X SCS LOCAL VERTICAL MODE CONTROL
 CH 1104X MTVC MODE CONTROL
 CG 0001 COMPUTER DIGITAL DATA
 CG 2302C IMU HEATER CURRENT
 CG 2303C IMU BLOWER CURRENT
 CG 2112H 1GA 1X RESOLVER OUT. SINE IN PHA
 CG 2113H 1GA 1X RES. OUTPUT COS. IN PHA
 CG 2142H MGA 1X RES. OUTPUT SINE IN PHA
 CG 2143H MGA 1X RES. OUTPUT COS IN PHAS
 CG 2172H OGA 1X RES. OUTPUT SINE IN PHA
 CG 2173H OGA 1X RES. OUTPUT COS IN PHAS
 CG 2206V 1GA CDU 1X RES. ERROR IN PHASE
 CG 2236V MGA CDU 1X RES. ERROR IN PHASE
 CG 2266V OGA CDU 1X RES. ERROR IN PHASE

G&N ICDU Loop Check

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CONCLUSIONS

AGC FAILURE

①

FAILURE DETECTION
CIRCUIT PROBLEM

②

GO TO AGC FAIL
INDICATOR CHECKS

NO REPEAT - NOTE
OCCURRENCE

COMPUTER PROBLEM
SUSPECTED

③

CHECKS GOOD

COMPUTER PROBLEM -
CHECK WITH
GROUND

④

PROBLEM

ORIGINAL STATE
VECTOR OR
REFSMAT
INCORRECT

⑤

COMPUTER PROBLEM -
CHECK WITH GROUND

⑥

INFORM GROUND
OF AGC STATUS

⑦

OBSERVE OTHER DSKY
IF NECESSARY

MODE SYSTEM MANUALLY,
IF POSSIBLE -
CHECK WITH GROUND

CORRECTIVE ACTIONS

- 1 LAUNCH - NO ACTION UNTIL SAFE
ORBIT INJECTION
ALL OTHER
PHASES - AGC INOPERABLE
- 2 LAUNCH - NO ACTION UNTIL SAFE
ORBIT INJECTION
ALL OTHER
PHASES - NO IMPACT
- 3 COMPUTER APPEARS UNRELIABLE -
USE WITH CAUTION
- 4 COMPUTER APPEARS UNRELIABLE FOR
MISSION TASKS
- 5 AGC OK - NO MISSION IMPACT
- 6 ALL PHASES - COMPUTER APPEARS
UNRELIABLE
- 7 PERFORM BACKUP MISSION AS
DIRECTED BY MCC/MSC

MISSION SUPPORT TM POINTS

CG 0001 COMPUTER DIGITAL DATA
CG 5030 COMPUTER FAIL LIGHT

GUIDANCE AND NAVIGATION
MALFUNCTION PROCEDURES

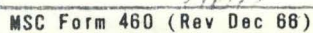
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A G C Operations Check

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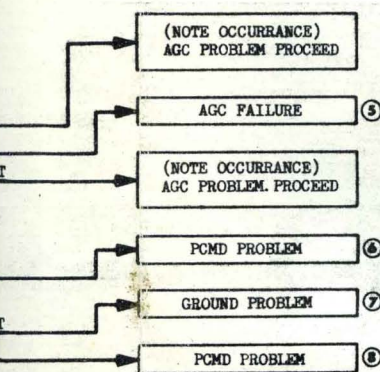
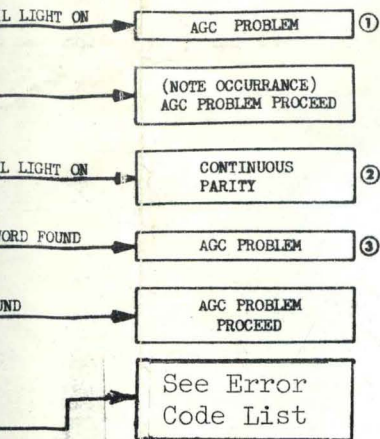
TROUBLE SHOOTING PROCEDURES



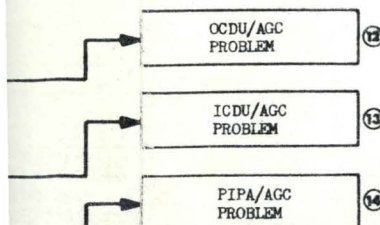
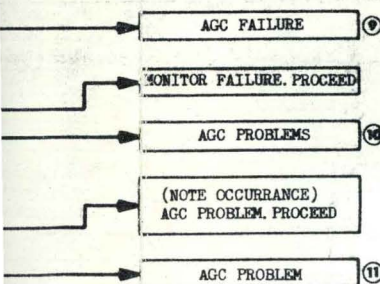
CONCLUSIONS

CORRECTIVE ACTIONS

MISSION SUPPORT TM POINTS



Check AGC clock time
and update if necessary



USE COMPUTER WITH CAUTION

COMPUTER LOST

SOME LOSS OF CAPABILITY
CHECK GROUND

COMPUTER LOST

NO UP OR DOWNLINK AVAIL-
ABLE FROM AGC. USE VOICE
COORDINATION

MANUAL UPLOAD NECESSARY

NO UP OR DOWNLINK AVAIL-
ABLE FROM AGC. USE VOICE
COORDINATION

COMPUTER LOST

COMPUTER LOST

USE COMPUTER WITH CAUTION

PROBABLE LOSS OF PLATFORM
FINE ALIGN AND NAVIGATION
CAPABILITY

PROBABLE LOSS OF G&N
ATTITUDE CONTROL

BAD OR QUESTIONABLE
ACCELEROMETER DATA

CG 5020 AGC ALARM 1 (PROGRAM)

CG 5021 AGC ALARM 2 (AGC ACTIVITY)

CG 5022 AGC ALARM 3 (TM)

CG 5023 AGC ALARM 4 (PROG. CHK. FAIL)

CG 5024 AGC ALARM 5 (SCALAR FAIL)

CG 5025 AGC ALARM 6 (PARITY FAIL)

CG 5026 AGC ALARM 7 (COUNTER FAIL)

CG 5028 AGC ALARM 9 (RUPT. LOCK)

CG 5029 AGC ALARM 10 (TC TRAP)

CG 0001 COMPUTER DIGITAL DATA

CG 1110 2.5 VDC BIAS

GUIDANCE AND NAVIGATION
FUNCTION PROCEDURES

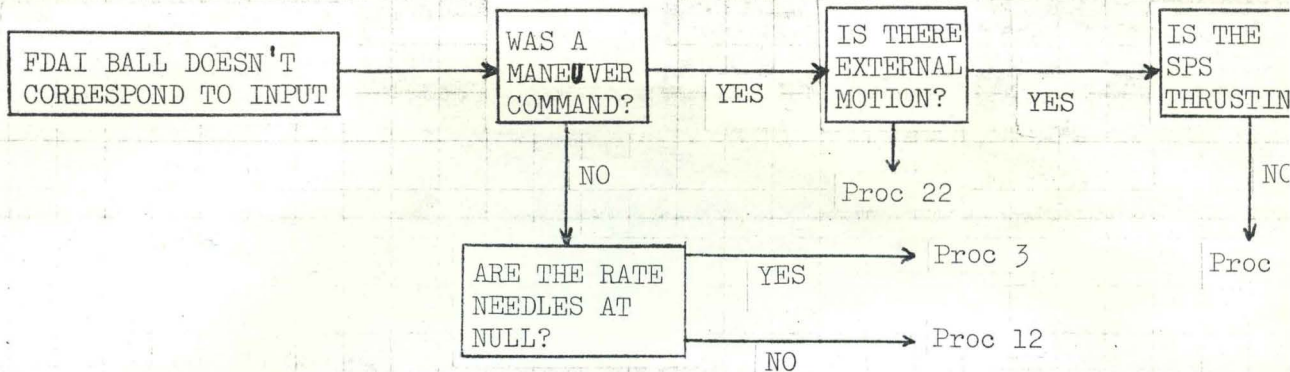
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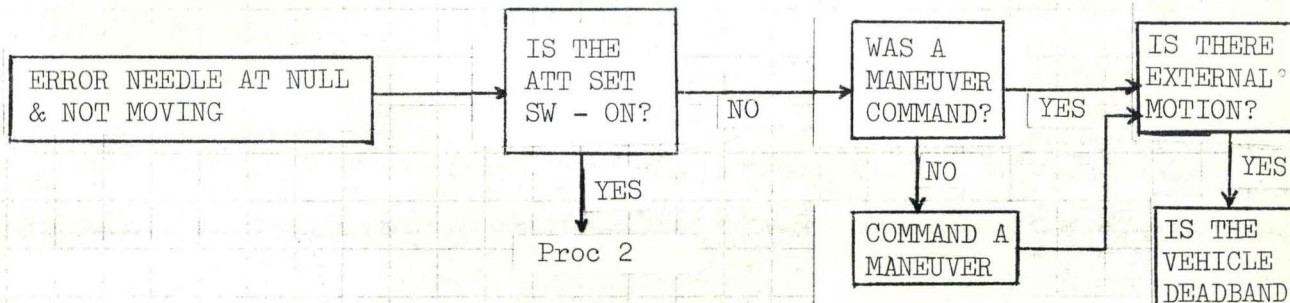
AGC Fail Indicator Checks

30

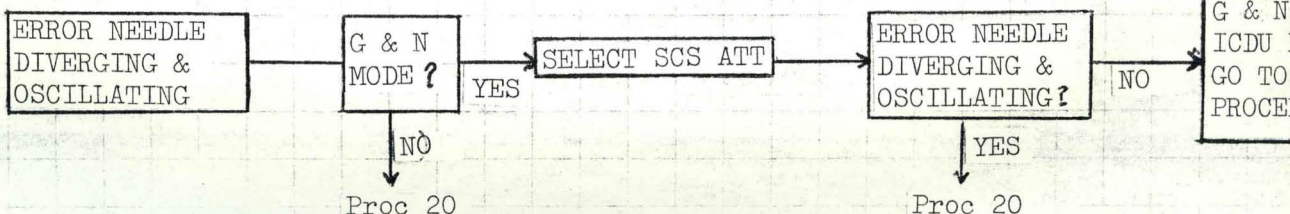
SYMPTOM A



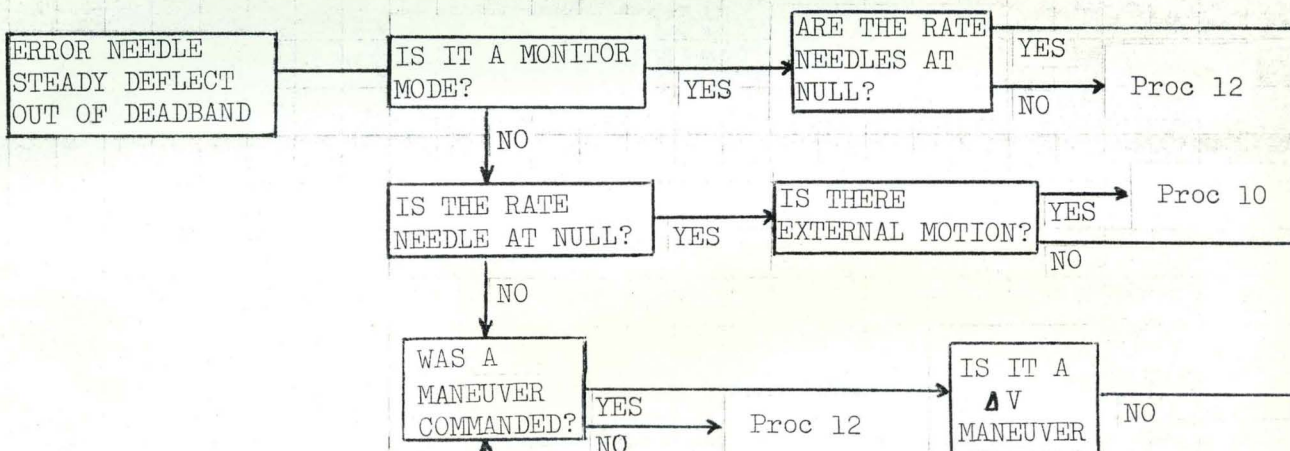
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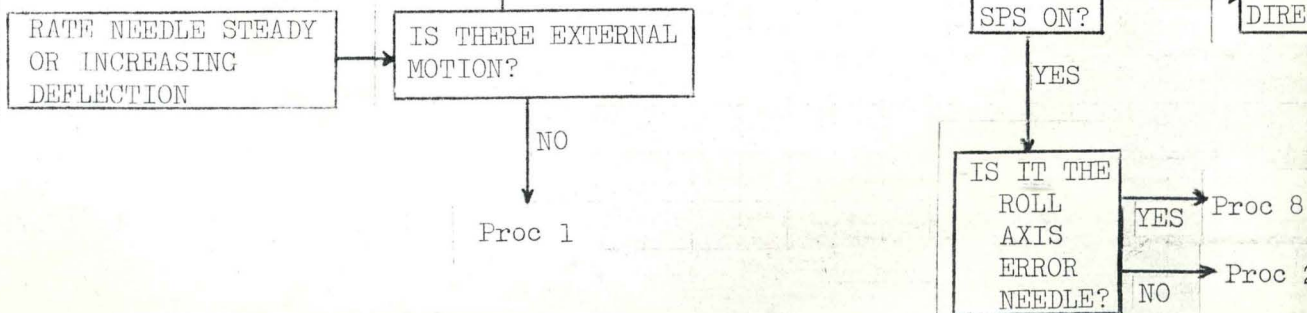
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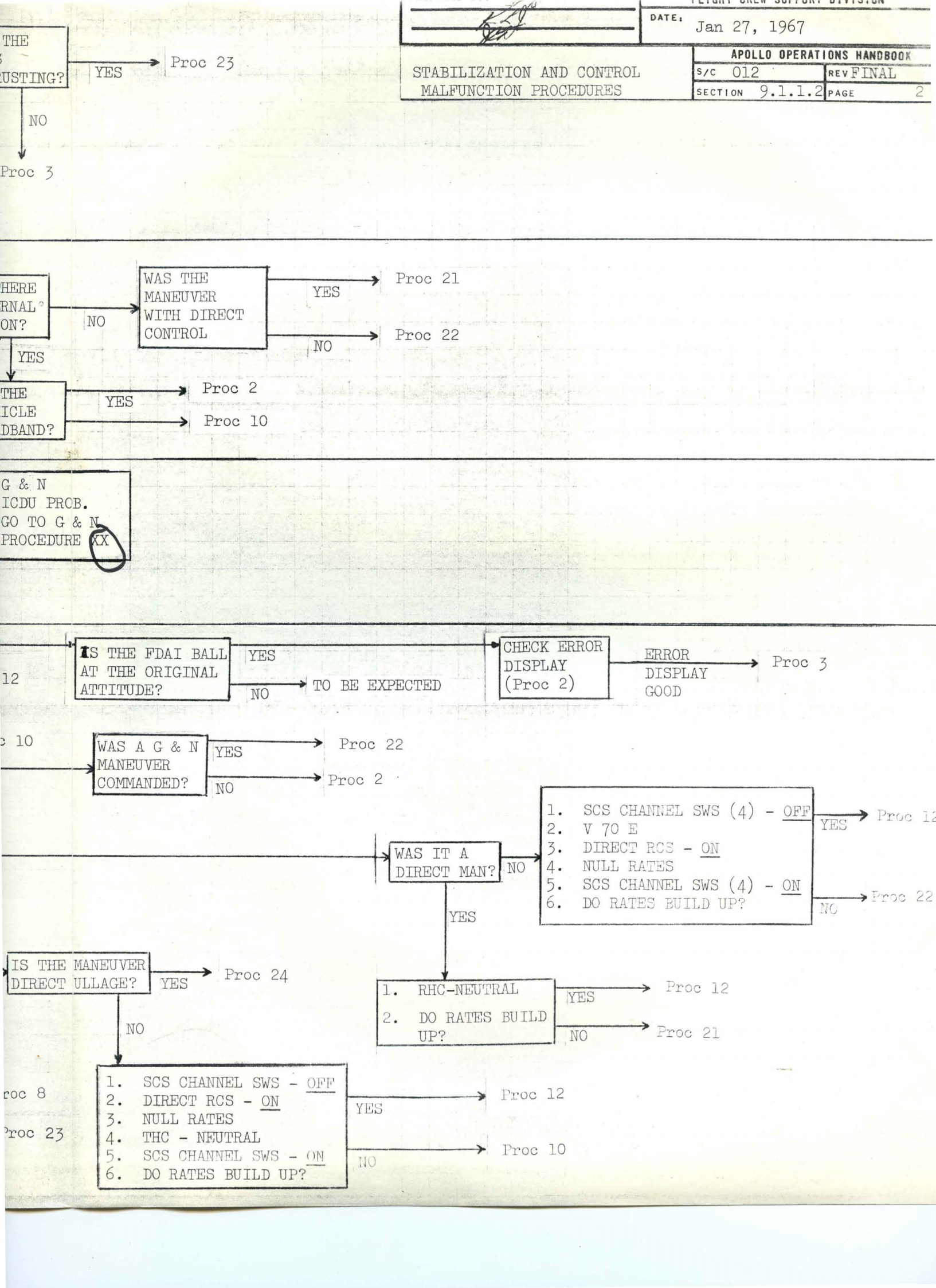


SYMPTOM D



SYMPTOM E





SYMPTOM F

RATE NEEDLE REMAINS
AT ZERO

IS THE ERROR NEEDLE
DIVERGING AND
OSCILLATING?

NO

WAS A
MANEUVER
COMMAND?

NO

Proc 20

Proc 1

SYMPTOM G

OSCILLATING RATE
NEEDLE

WHAT ARE
THE ATT
ERROR
NEEDLES
DOING?

OSCILLATING
& DIVERGING

Proc 20

OSCILLATING
ABOUT DEADBAND

Proc 12

SYMPTOM H

ΔV COUNTER
DRIFTS

Proc 5 - A

SYMPTOM I

RUNAWAY
 ΔV COUNTER

Proc 5 - B

SYMPTOM J

ΔV COUNTER
MOVES AT ONE
SPEED ONLY

Proc 5 - C

SYMPTOM K

ΔV COUNTER
IS ERRATIC OR
ONE-WAY ONLY

Proc 5 - D

SYMPTOM L

ΔV COUNTER
FAILS TO START
COUNTING

Proc 5 - E

SYMPTOM M

THRUST FAILS
TO CUT-OFF

Proc 6 - A

SYMPTOM N

THRUST PRE-
MATURELY CUTS-
OFF

1.

Proc 6 - B

SYMPTOM O

THRUST FAILS
TO INITIATE

Proc 6 - C

SYMPTOM P

GPI
HARDOVER

Proc 23

SYMPTOM Q

GPI
NO RESPONSE

Proc 23

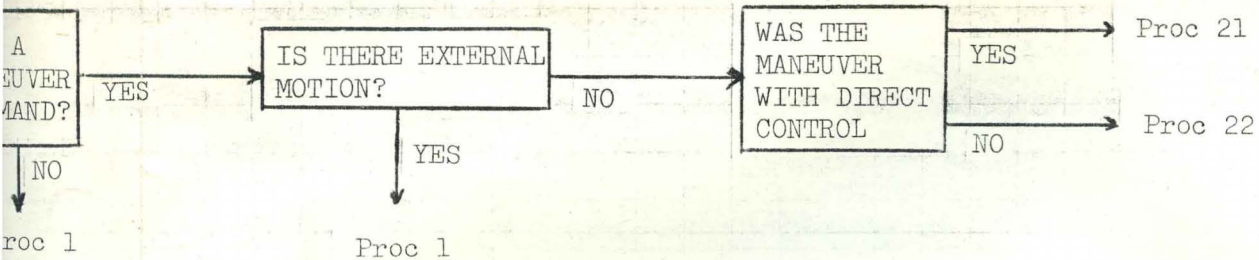
SYMPTOM R

FDAI LIGHTING
WON'T ADJUST

Proc 4

PREPARED BY:

CTD
1/20
JCS



REMARKS

1. ALSO CONSIDERS ECO AT IGNITION

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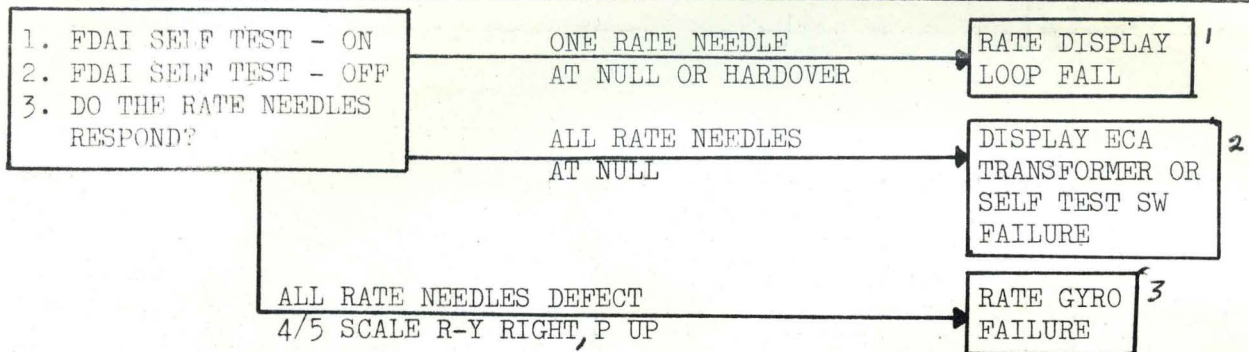
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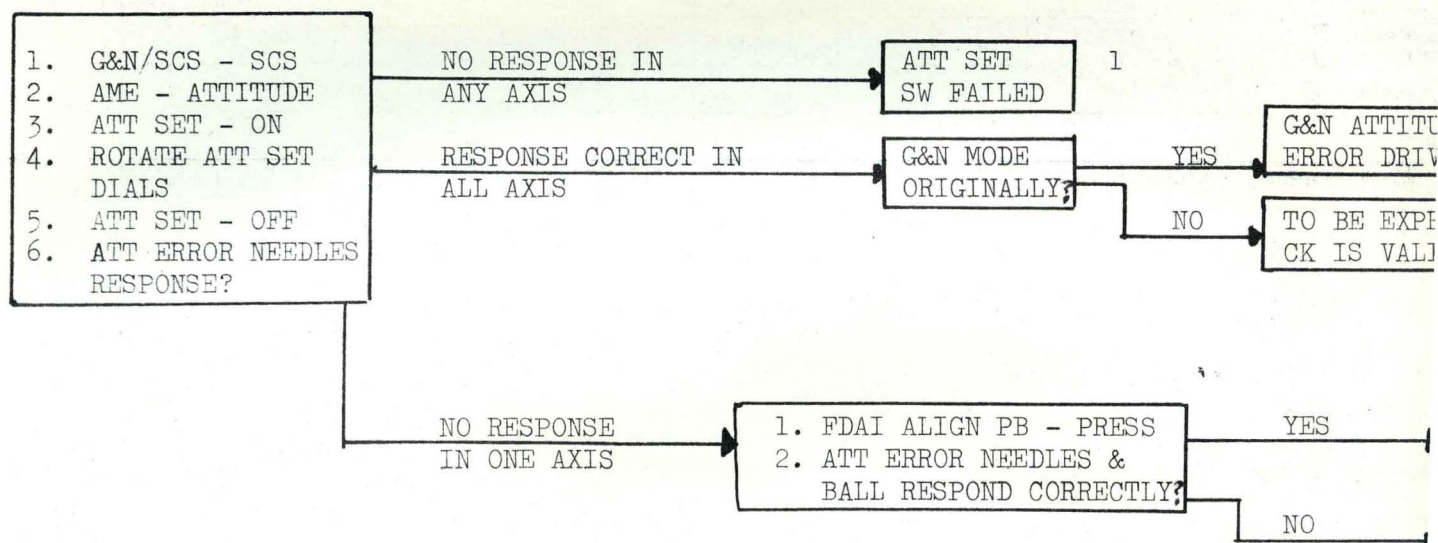
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SCS 1

PROCEDURE



SCS 2



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REV 1.2

REV 1.2

SECTION 1.1.2

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REMARKS

1. LAUNCH: NO ACTION

ERROR INDICATORS, BALL, RATE DISPLAYS AND PHYSICAL SENSES ARE AVAILABLE AS BACKUP ATTITUDE CUES. USE ATTITUDE ERROR INDICATOR AFTER INJECTION.

MIDCOURSE, Δ 'S & ENTRY:
BALL OR EXTERNAL REFERENCES, ATTITUDE ERROR INDICATORS, AND/OR PHYSICAL SENSES ARE AVAILABLE AS BACKUP ATTITUDE CUES. DISSEMINATE RATE DISPLAY IN AFFECTED AXIS.

2. ALL PHASES: DISPLAY SELF TEST FUNCTION IS LOST. USE CROSS CHECK OF BALL OR EXTERNAL REFERENCES, ATTITUDE ERROR INDICATORS AND/OR PHYSICAL SENSES FOR CORRECT CONTROL RESPONSE FOR REMAINDER OF MISSION. IF TRANSFORMER FAILURE, DISPLAY WILL NOT FUNCTION PROPERLY.

3. TBD

To be written (in work)

ATTITUDE
R DRIVE FAIL

2

G&N
MALF

EXPECTED
S VALID

ATTITUDE ERROR
DISPLAY FAIL IN
THAT AXIS

3

ATTITUDE SET
INPUT FAIL

4

1. ALL PHASES: ATTITUDE SET FUNCTION IS LOST. FDAI ALIGN STILL FUNCTIONAL.

2. LAUNCH: NO ACTION

BALL, RATE DISPLAYS AND PHYSICAL SENSES ARE AVAILABLE AS BACKUP ATTITUDE CUES. USE ATTITUDE ERROR INDICATOR AFTER INJECTION.

MIDCOURSE, Δ 'S, AND ENTRY:
BALL OR EXTERNAL REFERENCES, ATTITUDE ERROR INDICATORS, AND/OR PHYSICAL SENSES ARE ALL AVAILABLE AS BACKUP ATTITUDE CUES. DISSEMINATE ATTITUDE ERROR INDICATION IN AFFECTED AXIS.

POST 0.05G: ROLL COMMAND ANGLE δ WILL BE DISPLAYED IN FIDAI LONG AS THE FIDAI DISPLAY IS PRESENT. SWITCH AND TAP TO CORRECT ERRORS NO LONGER REQUIRED.

3. ALL PHASES: SAME AS 1 EXCEPT BOTH FIDAI ATTITUDE ERROR DISPLAY ARE LOST.

4. ALL PHASES: ATTITUDE SET FUNCTION IS LOST. FIDAI ALIGN LOST. FIDAI ATTITUDE ERROR DISPLAY STILL FUNCTIONAL.

700 3

1. ARREST SC MOTION
IF APPROPRIATE
2. SET SCS-SCS
3. ATT-ATTITUDE
4. ATT SET DIALS-
RO PSL YO*
5. FEAT ALIGN-PRESS
6. FEAT BALL RO
PSL YO ON
7. PLACE ATT SET
SW ON

BALL FIXED OR
ALIGNS INCORRECTLY

AND ATT ERROR NOT NULLED
IN ONE OR ALL AXES

1. SELECT POO
2. G&N/SCS-G&N
3. KEY V16N20E
4. MONITOR DSKY
DISPLAY OF IMU
ANGLES
5. BALL MOVES TO
IMU ANGLES

BALL ALIGNS INCORRECTLY

AND ATT ERROR NULLED

BALL ALIGNS CORRECTLY

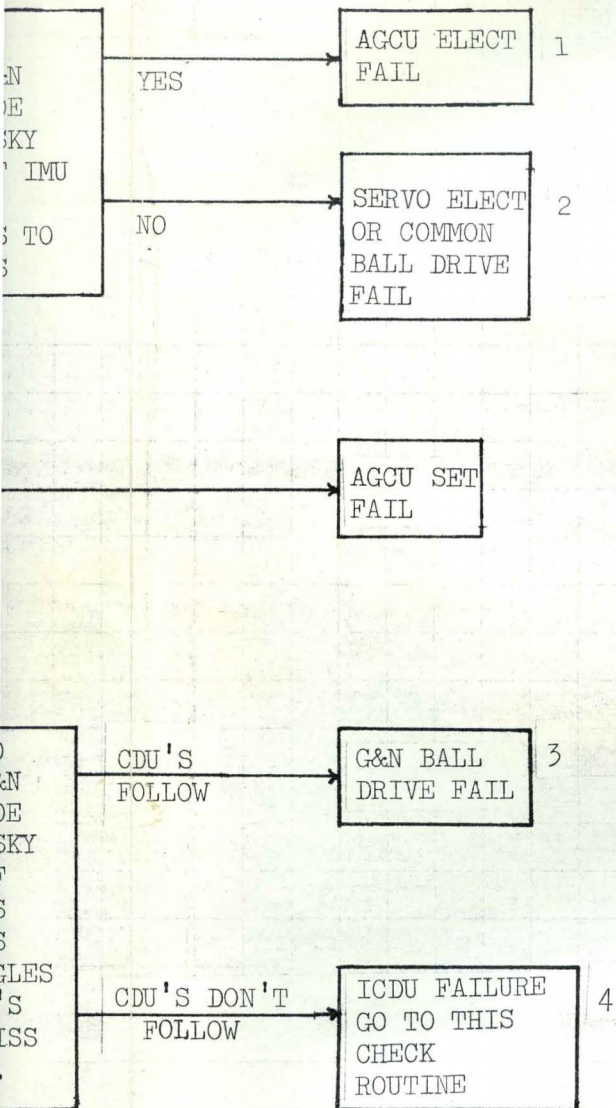
AND ATT ERROR NULLS

1. SELECT POO
2. G&N/SCS-G&N
3. KEY V16N20E
4. MONITOR DSKY
DISPLAY OF
IMU ANGLES
5. BALL MOVES
TO IMU ANGLES
6. CHECK CDU'S
FOR FINE ISS
FOLLOWING.

*THESE VALUES OR THE VALUES FOR THE NEXT MANEUVER MAY BE USED.

PREPARED BY: *CFD*

8/7



GENERAL FOR LAUNCH PHASE: NO ACTION IF BALL DRIVE IS INCONSISTENT. USE OTHER CUES AND PERFORM TROUBLESHOOTING FOLLOWING INJECTION INTO ORBIT.

- 1 MIDCOURSE & V'S: USE G&N MODES FOR BALL DISPLAY OR DSKY CALLUP (V16N2OE) WHEN SCS MODES ARE NEEDED. SCS ATTITUDE DISPLAY IS LOST FOR THE REST OF THE MISSION.

ENTRY: USE G&N ENTRY MODE AND DISPLAY AS PRIMARY PATH. VISUAL "OUT-THE-WINDOW" ORIENTATION IS AVAILABLE UNTIL POST.05G ROLLING ENTRY IS FINAL BACKUP.

- 2 MIDCOURSE & V'S: USE DSKY DISPLAY (V16N2OE) FOR TOTAL ATTITUDE INDICATION OR READ CDU'S AT LEB.

ENTRY: NORMAL ENTRY EXCEPT NO TOTAL ATTITUDE BALL.

- 3 SAME AS 1 EXCEPT THAT THE AGCU DRIVEN BALL DISPLAY IS AVAILABLE AS A RELATIVE INDICATOR IF THE LOSS OF RESET CAPABILITY DOES NOT MAKE THE MENTAL COORDINATE TRANSFORMATION PROBLEM TOO DIFFICULT.

- 4 MIDCOURSE: USE SCS MODES FOR BALL DISPLAY OR DSKY CALLUP (V16N2OE). G&N TOTAL ATTITUDE DISPLAY IS LOST BUT ALL G&N MODES MAY STILL BE USED WITHOUT TOTAL ATTITUDE FUNCTIONAL.

V'S: EITHER G&N OR SCS V'S MAY BE PERFORMED BUT THE TAKE OVER ATTITUDE REFERENCE MUST BE THE EXTERNAL REFERENCE SUPPLIED BY MSFN.

ENTRY: G&N MANUAL ENTRY IS POSSIBLE BY USING PROCEED (V33E) AT THE G&N ENTRY MODE SELECT POINT. AN SCS BALL WITH DSKY DISPLAY OF PROGRAMS 61-67 WOULD BE USED OR ANY OF THE OTHER BACKUP MODES.

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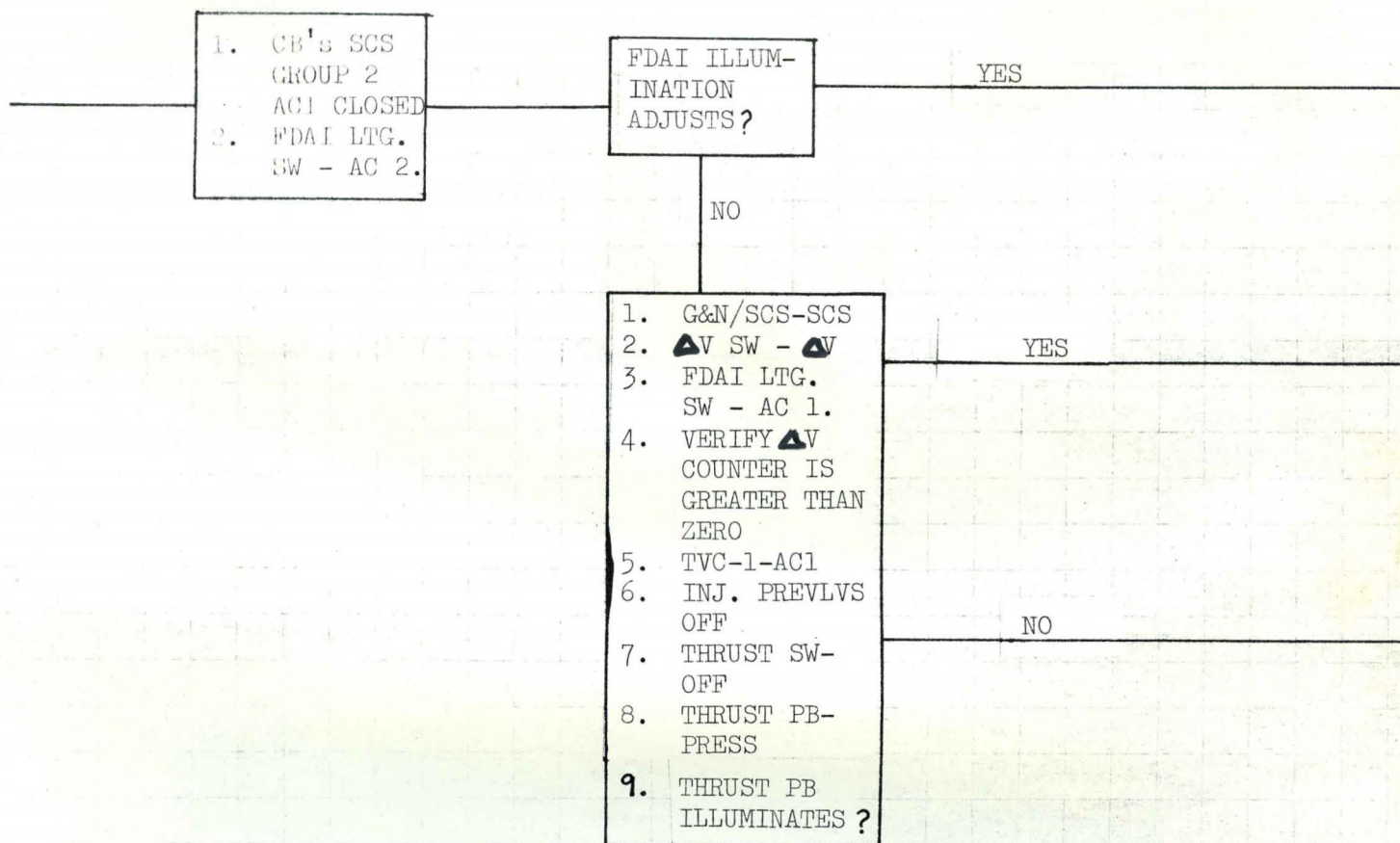
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REMARKS

AC1 SW
CONTACT
FAIL

2.

FDAI
INTEGRAL
LIGHTING
FAILURE

1.

FDAI LTG. &
THRUST PB
XFORMER FAIL

3

1 ALL PHASES: ADJUST FLOODLIGHTING FOR BEST ILLUMINATION AND CONTINUE WITH MISSION.

2 ALL PHASES: USE AC-2 SWITCH POSITION FOR FDAI LIGHTING SWITCH. REVERSE THE TVC SWITCHING CONVENTION FOR V'S, i.e.,

SCS POWER - AC2
RATE GYROS - AC2
TVC-1 - AC2
BMAG's - AC1
ROTATION CONTROL - AC1
TVC-2 - AC1
G&N LIGHTING - AC2
SPS GUAGING - AC2

3 ALL PHASES: ADJUST FLOODLIGHTING FOR BEST ILLUMINATION. THRUST ON LIGHT CHECKS NO LONGER POSSIBLE. CONTINUE WITH MISSION.

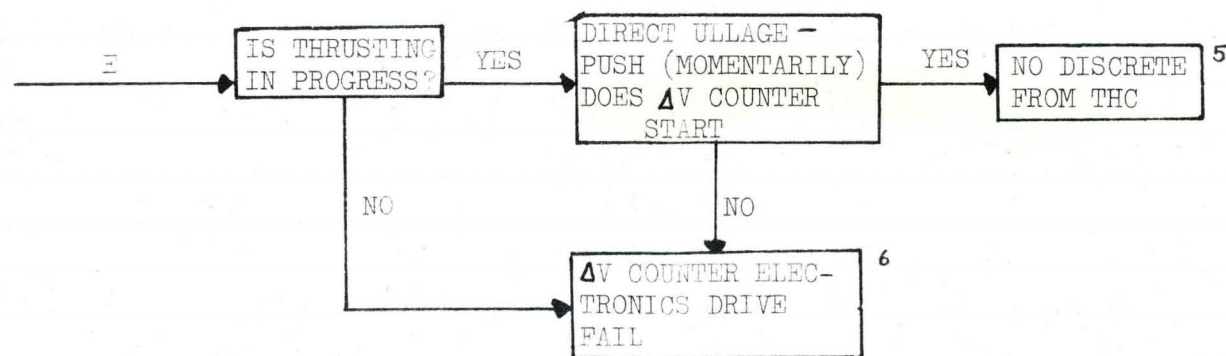
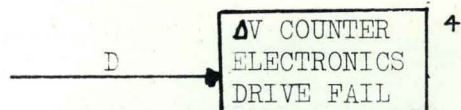
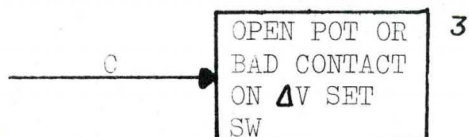
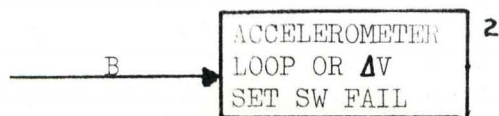
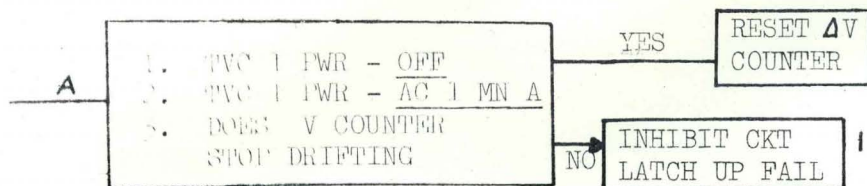
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PREPARED BY:

1. USE G&N FOR THRUST MAGNITUDE CONTROL
2. USE G&N CONTROLLED BURNS
3. USE OTHER THREE DRIVE SPEEDS TO GET PROPER COUNTER SETTING
4. USE G&N CONTROLLED BURNS
5. NEXT BURN ULLAGE WITH OTHER THC
6. USE G&N CONTROLLED BURNS

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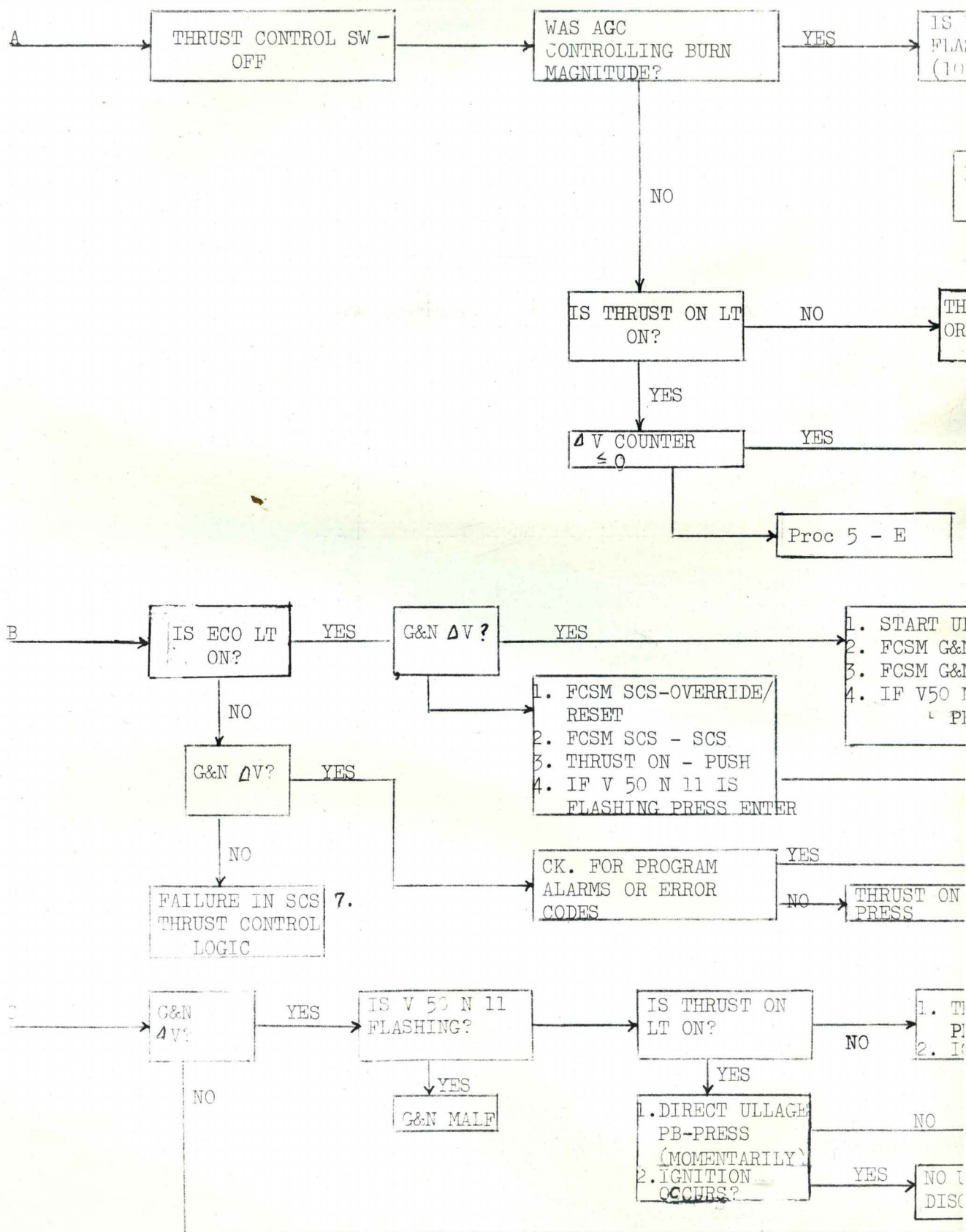
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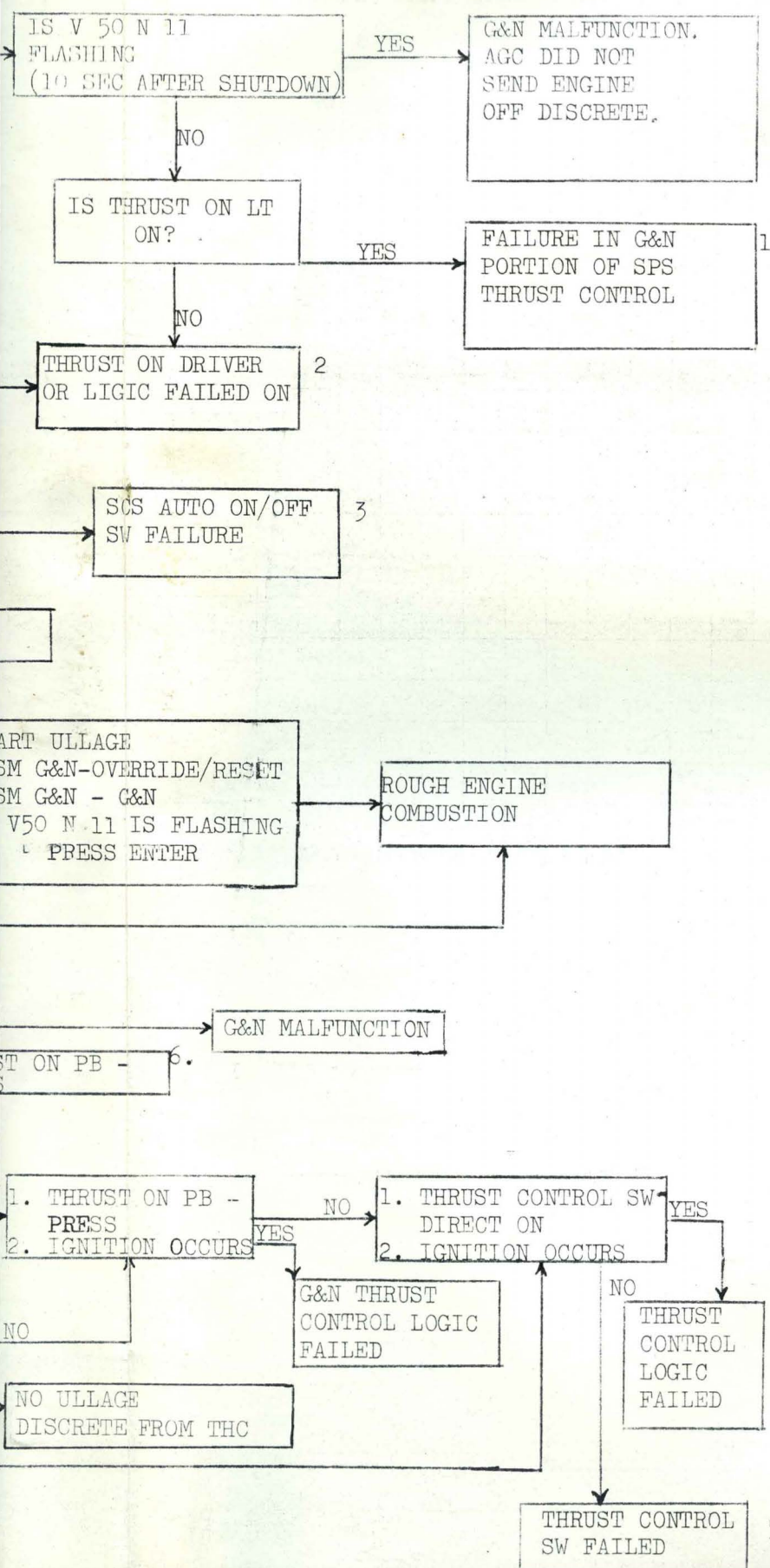
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1. USE SCS THRUST CONTROL
2. USE DIRECT ON/OFF OF THRUST CONTROL SW FOR SUBSEQUENT BURNS.
3. USE G&N TO CONTROL BURN OR DIRECT ON/OFF OF THRUST CONTROL SW FOR SUBSEQUENT BURNS.
4. USE DIRECT ON/OFF OF THRUST CONTROL SW FOR SUBSEQUENT BURNS
5. SPS NON-OPERATIONAL
6. G&N THRUST CONTROL LOGIC FAILURE, USE SCS FOR SUBSEQUENT BURNS.
7. USE G&N FOR ALL SUBSEQUENT BURNS.

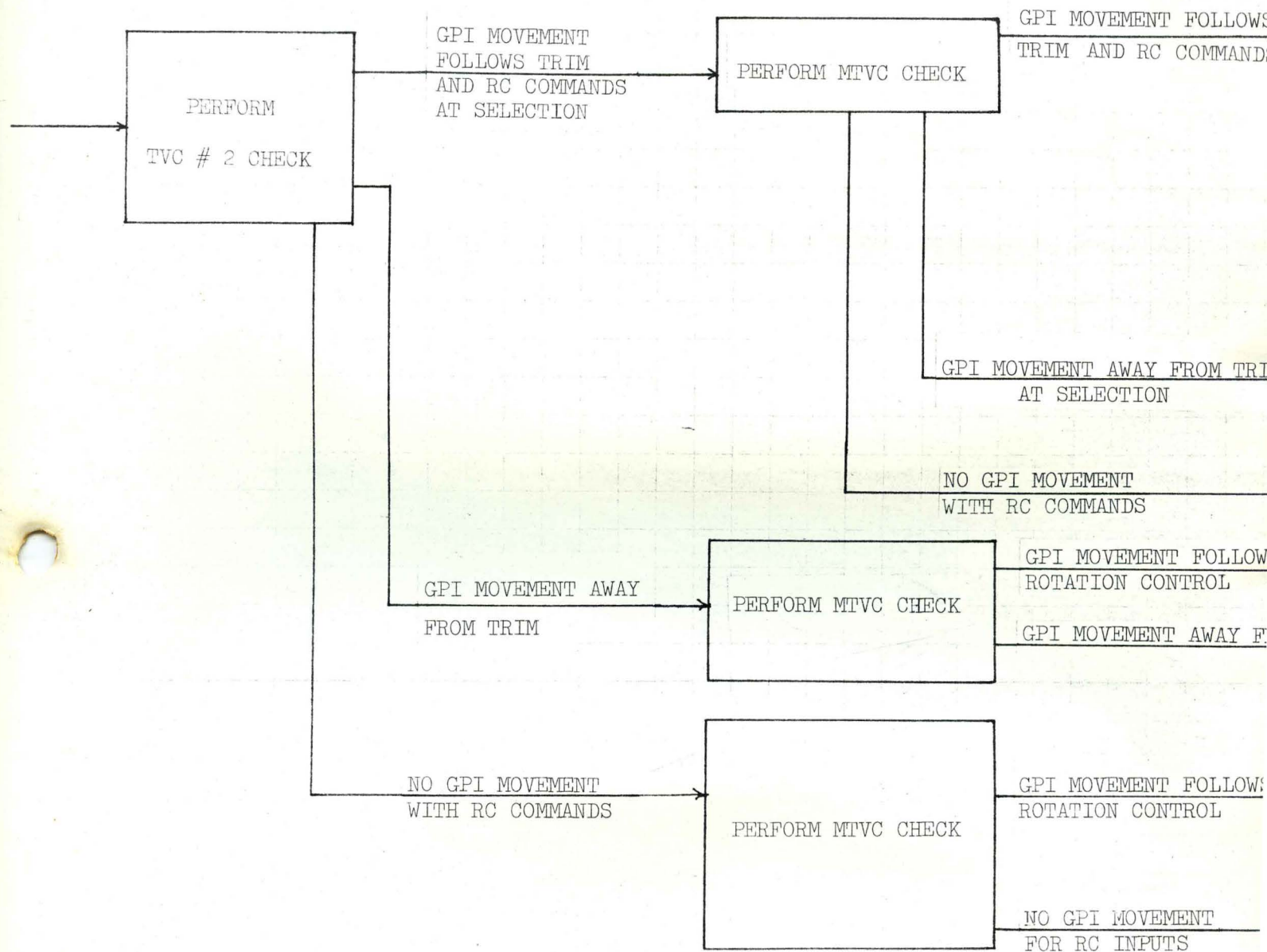
TVC #2 CHECK

1. TVC #1 SWITCH - AC #1
2. TVC #2 SWITCH - AC #2
3. START PITCH #2 GIMBAL MOTOR
4. START YAW #2 GIMBAL MOTOR
5. CHANGE PITCH TRIM POSITIVE THEN NEGATIVE
6. CHANGE YAW TRIM POSITIVE THEN NEGATIVE

MTVC CHECK

1. V SWITCH - ON
2. ROTATE TRANSLATION CONTROL CE
3. ROTATE ROTATION CONTROL POSITIVE THEN NEG. IN PITCH
4. ROTATE ROTATION CONTROL POSITIVE THEN NEG. IN YAW
5. ΔV SWITCH - OFF
6. RETURN TRANSLATION CONTROL TO CENTER

1. GIMBAL YAW #2
2. GIMBAL START
3. GIMBAL
4. ΔV sw
5. Verify
6. CHANGE THEN N
7. CHANGE NEGATI

PREPARED BY: *[Signature]*

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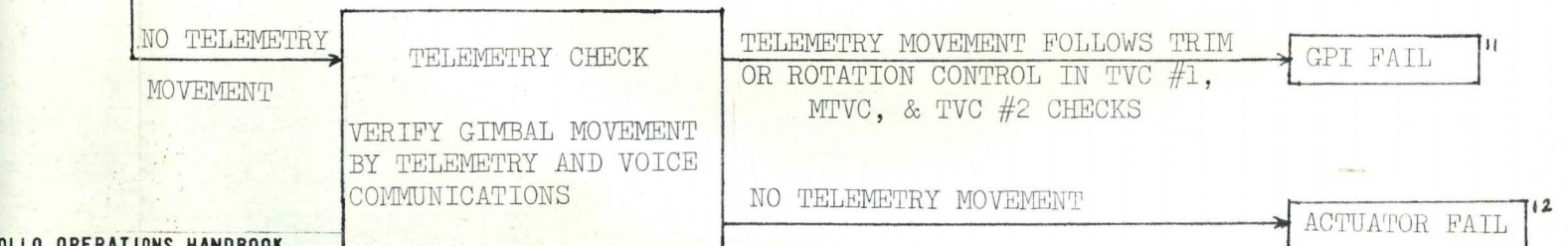
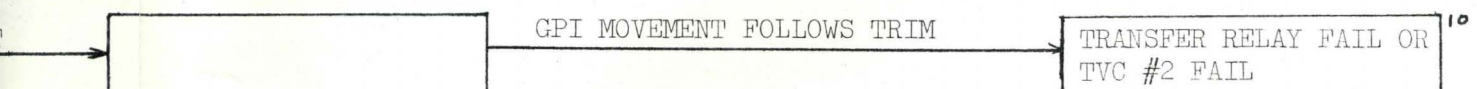
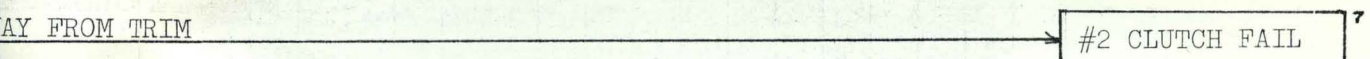
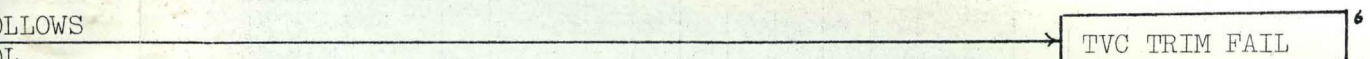
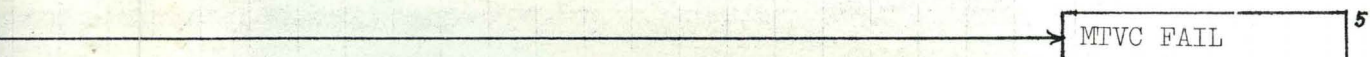
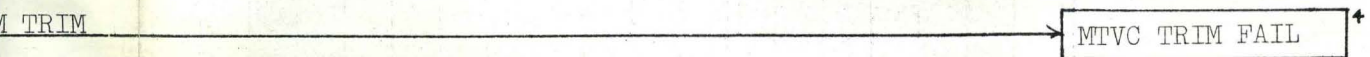
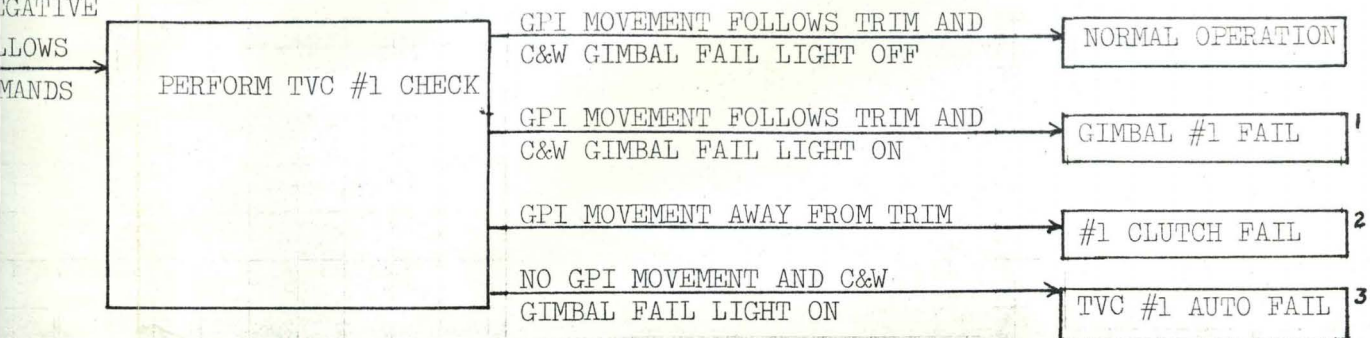
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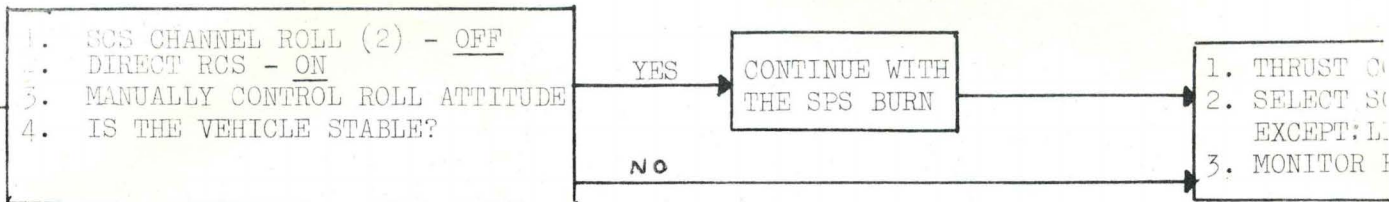
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GIMBAL MOTORS PITCH #2 &
 YAW #2 - OFF
 GIMBAL MOTORS PITCH #1 -
 START/ON
 YAW #1 - START/ON
 sw - ON
 Verify C&W GIMBAL FAIL LT OFF
 CHANGE PITCH TRIM POSITIVE
 WHEN NEGATIVE
 CHANGE YAW TRIM POSITIVE THEN
 NEGATIVE





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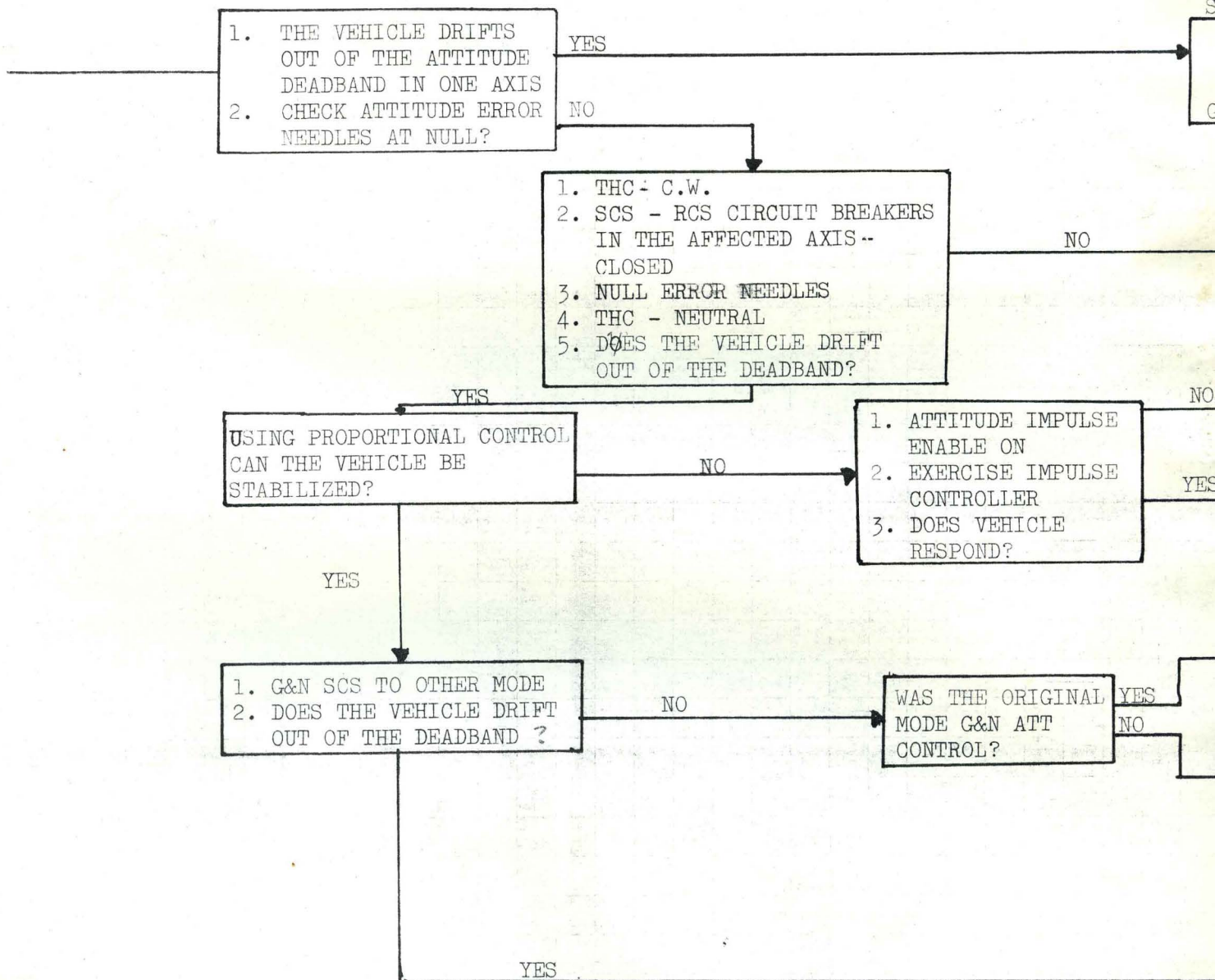
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REMARKS

TEST CONTROL SW - OFF
TEST SCS ATT HOLD
TEST LIMIT CYCLE - OFF
TEST FOR OTHER SYMPTOMS

SCS 10



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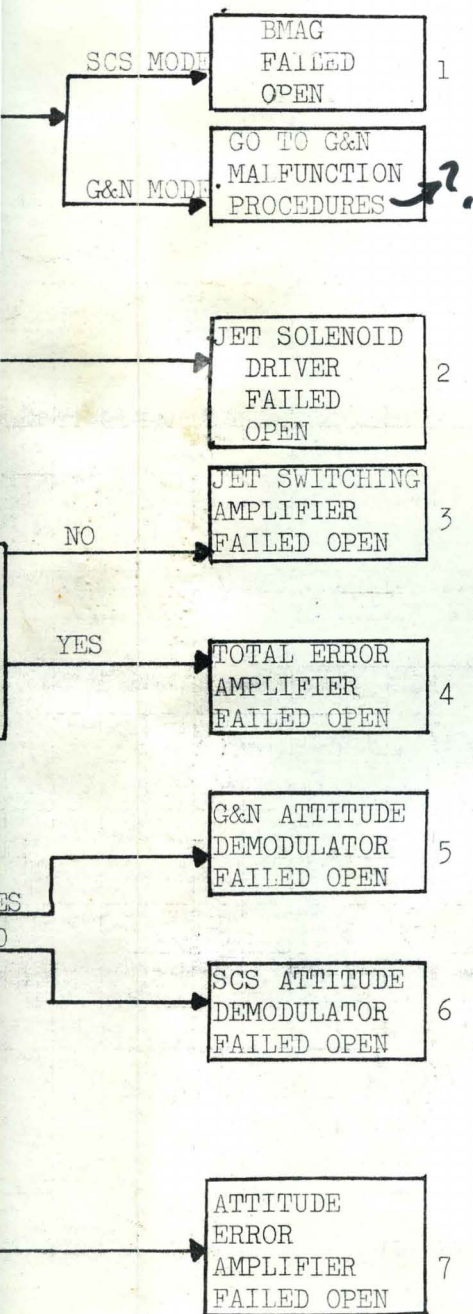
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REMARKS



1. BMAG OPEN.

LAUNCH - NOT DETECTABLE

ALL OTHER PHASES - SCS AUTO. CONTROL LOST IN ONE AXIS.
G&N, DIRECT & PROPORTIONAL CONTROL
REMAIN. SCS V, MTVC (IF FAILURE IS
PITCH OR YAW) & SCS ATTITUDE ARE

2. DRIVER OPEN:

LAUNCH - NOT DETECTABLE

MIDCOURSE & V'S - USE OPPOSITE JET PAIR FOR SINGLE J
ATTITUDE CONTROL AND/OR TRANSLATION
(ROLL FAILURES FAIL 1/2 OR Y OR Z
± OR - CONTROL)

ENTRY - SET UP FOR EITHER AN "A" OR "B" AUTO ENTRY DE
PENDING ON WHETHER OR NOT THE FAILED DRIVER IS
"B" OR "A" (IGNORE IF IT WAS AN A&C ROLL DRIVE

3. SWITCHING AMPLIFIER OPEN

LAUNCH - NOT DETECTABLE

ALL OTHER PHASES - AUTO ATTITUDE, RATE, AND PROPORTION
RATE CONTROL IS LOST IN THIS AXIS.
DIRECT CONTROL IS THE ONLY REMAINING
RCS CONTROL PATH.

4. TOTAL ERROR AMPLIFIER OPEN

LAUNCH - NOT DETECTABLE

ALL OTHER PHASES - AUTO ATTITUDE, RATE, AND PROPORTION
RATE CONTROL IS LOST IN THIS AXIS.
DIRECT CONTROL IS THE ONLY REMAINING
RCS CONTROL PATH OTHER THAN MINIMUM
IMPULSE CONTROL.

5. G&N ATTITUDE DEMODULATOR OPEN

LAUNCH - NOT DETECTABLE

ALL OTHER PHASES - G&N AUTO CONTROL LOST IN ONE AXIS.
DIRECT OR PROPORTIONAL CONTROL OF
REMAINS. SCS V OR MTVC FOR BURNS
MANUAL G&N FOR ENTRY. SCS ATTITUDE
ATTITUDE HOLD.

6. SCS ATTITUDE DEMODULATOR OPEN

LAUNCH - NOT DETECTABLE

ALL OTHER PHASES - SCS AUTO CONTROL. LOST IN ONE AXIS
G&N, DIRECT, AND PROPORTIONAL CONT
ALL REMAIN. SCS V (IF FAILURE IS
PITCH OR YAW) AND SCS ATTITUDE ARE

7. ATTITUDE ERROR AMPLIFIER OPEN

LAUNCH - NOT DETECTABLE

ALL OTHER PHASES - AUTO CONTROL FROM EITHER G&N OR SCS
HOLD SIGNALS LOST IN THIS AXIS.
DIRECT RCS CONTROL AND MINIMUM IMP
CONTROL ARE THE ONLY REMAINING RCS
CONTROL PATHS FOR THE AFFECTED AXIS
USE MTVC IF PITCH OR YAW.

1. SCS CHANNEL (4) - OFF
2. ARE THE RATES INCREASING?

NO

1. DIRECT RCS - ON
2. NULL RATES
3. G&N/SCS - SCS
4. AME-ATTITUDE

RATE NEEDLE NOT AT NULL

ATTITUDE ERROR NEEDLES H

RATE NEEDLES

AT NULL

1. C/B SCS PITCH (YAW, ROLL)
MNA OR MNB-OPEN
2. ROT. CONT. PWR - OFF
3. THC - C.W.
4. SCS CHANNEL PITCH (YAW, ROLL (2)
-ON (SCS CHANNEL PITCH (YAW,
ROLL (2)-OFF AND STABILIZE S/C
5. IF NECESSARY
REPEAT STEPS 1 AND 4 FOR THE
OTHER C/B(s) IN THE AFFECTED
CHANNEL

RATES INCREA

MORE THAN 1

NO RATE
INCREASE

YES

1. VERIFY C/B SCS PITCH (YAW,
ROLL) MNA OR MNB-CLOSED
2. ROT. CONT. PWR - AC2
3. SCS CHANNEL PITCH (YAW, ROLL (2)
-ON (SCS CHANNEL PITCH (YAW,
ROLL (2)-OFF AND STABILIZE S/C
IF NECESSARY)
4. DID THE RATES INCREASE?

YES

NO

1. AME-MONITOR
2. THC-NEUTRAL
(SCS CHANNEL PITCH
ROLL (2) - OFF AN
ILIZE S/C IF NECE
3. DID THE RATES INC

(CONTINUED ON
SCS - 12 B)

PREPARED BY:

NULL

RATES HARDOVER: RATE NEEDLES AT NULL

RATE GYRO FAILURE 1

BMAG LOOP FAILURE 2

ONLY 1 C/B CAUSES RATE INCREASE

JET DRIVER FAILED ON 3

INCREASE WITH
AN 1 C/B COMBINATION

1. VERIFY LIMIT CYCLE-OFF
2. SCS CHANNEL PITCH (YAW, ROLL (2))-ON/OFF (STABILIZE S/C IF NECESSARY)
3. DO RATES INCREASE?

NO

PSEUDO RATE FAILED 6

YES

1. THC-NEUTRAL
2. C/B SCS GROUP 1 MN A-OPEN
3. SCS CHANNEL PITCH (YAW, ROLL (2))-ON (SCS CHANNEL PITCH (YAW, ROLL (2))-OFF AND STABILIZE S/C IF NECESSARY)
4. REPEAT STEPS 1 THRU 3 FOR GROUP 1 MN B C/B
5. SCS PARTIAL PWR & RATE GYRO TO NON-AFFECTED BUS

RATES INCREASE WITH ONLY ONE C/B

ONE TRANSLATION CONTROL FAILED ON

RATES INCREASE WITH BOTH C/B

FAILURE IN CONTROL ELECTRONICS (RATE DEMODULATOR, RATE ERROR AMPLIFIER, TOTAL ERROR AMPLIFIER, OR SWITCHING AMPLIFIER)

ONE RHC FAILED ISOLATION PROCEDURE T.B.D. 7

PITCH (YAW, ROLL (2))-OFF AND STABILIZE S/C IF NECESSARY) RATES INCREASE?

NO

YES

WAS THE ORIGINAL MODE SCS?

YES

1. SELECT POO
2. ATT ERROR NEEDLES AT NULL

NO

GO TO G&N MALF PROCEDURE 8

YES

1. G&N/SCS-G&N
2. AME-ATTITUDE
3. SCS CHANNEL PITCH (YAW, ROLL (2))-OFF AND STABILIZE S/C IF NECESSARY
4. DID RATES INCREASE?

YES

G&N ATT DEMOD FAILED 9

NO

GO TO G&N MALFUNCTION PROCEDURE 10

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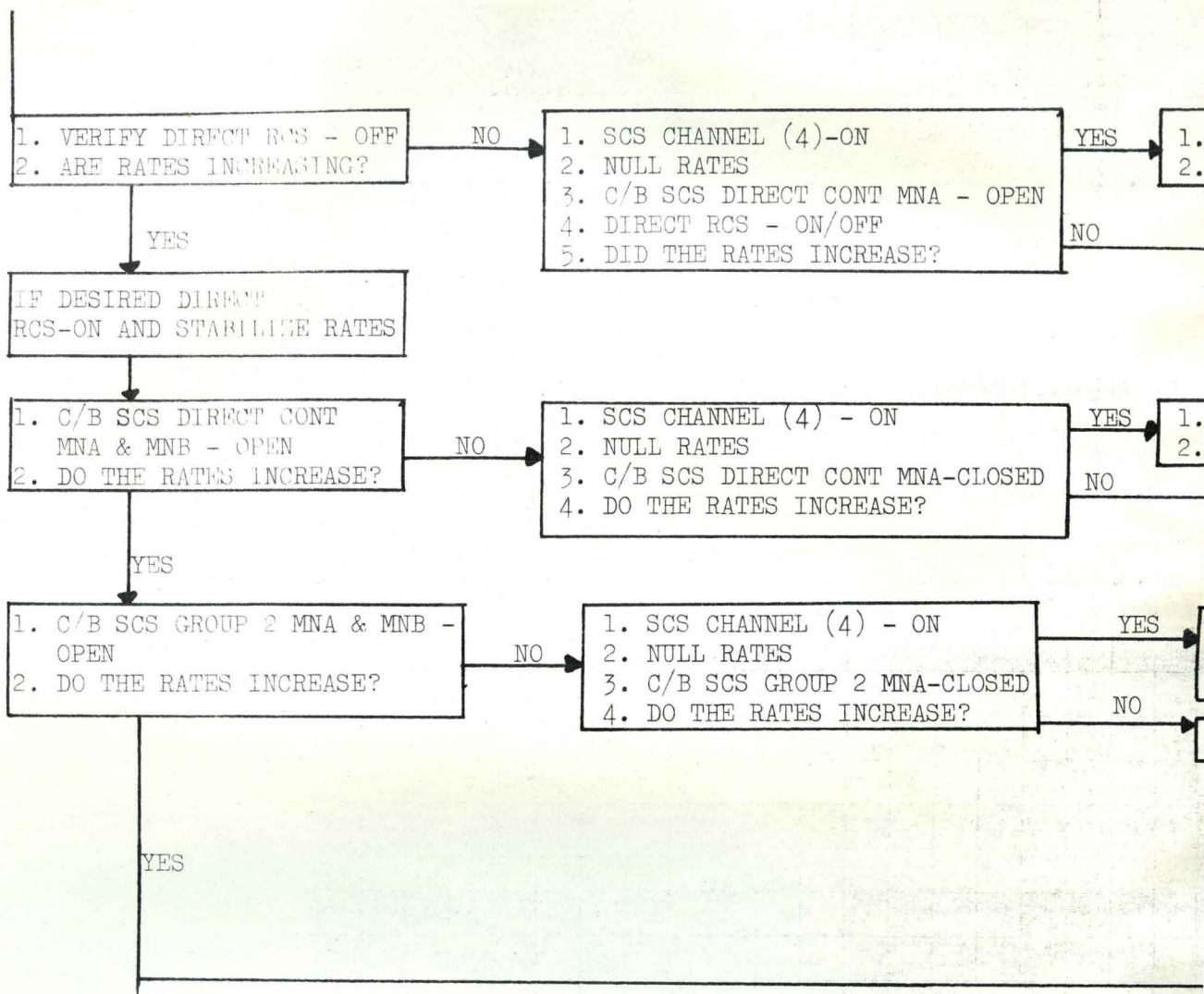
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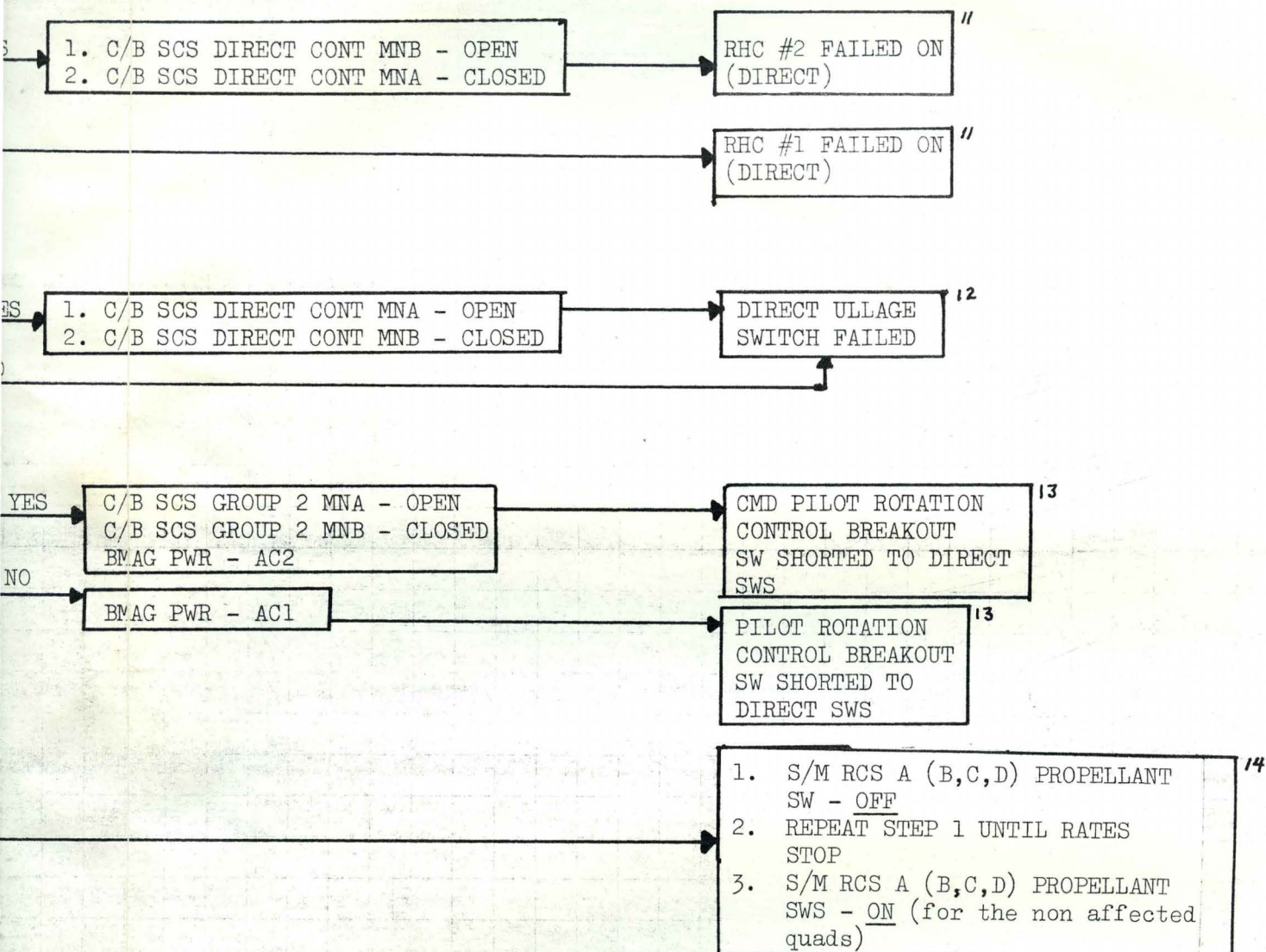
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1 RATE GYRO HARDOVER FAILURE

- LAUNCH - RATE DISPLAY WILL NOT AGREE WITH ATTITUDE, ATTITUDE ERROR (IF STILL ACTIVE), AND PHYSICAL SENSES. THIS CAN BE CORRECTED BY SELECTING BACKUP RATE IN THE AFFECTED AXIS.
- MIDCOURSE - LEAVE THE RATE GYRO SWITCH OFF MOST OF THE TIME. ATTITUDE HOLD CAN BE HANDLED BY THE G&N AND LIMIT CYCLE SWITCH OR THE BMAG'S AND LIMIT CYCLE SWITCH. FOR MANEUVERS, PLACE THE BMAG'S TO BACKUP RATE OR USE DIRECT AUTO CONTROL IN ALL THREE AXES. IN THE FORMER CASE THE AGCU CAN NO LONGER UPDATE.
- V'S - SCS V MODE IS NO LONGER FUNCTIONAL FOR A PITCH OR YAW AXIS PROBLEM. G&N V WITH A BMAG IN BACKUP RATE AND MTVC ARE STILL OPERATIONAL. IN THESE MODES THE RATE GYROS WOULD BE ON WITH BACKUP RATE SELECTED IN THE AXIS AFFECTED.
- ENTRY - IN THESE MODES, THE RATE GYROS WOULD BE ON WITH BACKUP RATE SELECTED IN THE AXIS AFFECTED. THIS WILL LOSE THE AGCU BACKUP ATTITUDE REFERENCE.

2 BMAG LOOP HARDOVER FAILURE

- LAUNCH - THE BACKUP ATTITUDE REFERENCE WILL NOT BE FUNCTIONAL BUT THIS WILL NOT BE DETECTABLE DURING A NORMAL BOOST.
- MIDCOURSE - G&N ATTITUDE HOLD MUST BE USED FOR HOLD PERIODS. THE AGCU FUNCTION IS LOST. BACKUP RATE IS NOT AVAILABLE IN THE AFFECTED AXIS. DISABLE THIS AXIS IF SCS MODE SELECTED.
- V'S - ONLY THE G&N V MODE REMAINS FUNCTIONAL. SCS V AND MTVC ARE BOTH LOST FOR PITCH OR YAW FAILURE. FOR ROLL, DIRECT CONTROL MUST BE USED WITH CHANNEL DISABLED.
- ENTRY - THR BACKUP ATTITUDE REFERENCE WILL NOT BE FUNCTIONAL. BACKUP RATE IS NOT AVAILABLE IN THE AFFECTED AXIS. DISABLE AFFECTED AXIS IF SCS MODE IS SELECTED. DAMPING OR CONTROL IN THE AXIS MUST BE WITH DIRECT CONTROL.

3 DRIVER FAILED ON

- LAUNCH - NOT DETECTABLE
- MIDCOURSE & V'S - APPLICABLE CIRCUIT BREAKER MUST BE OPENED AND REMAIN PULLED FOR REMAINDER OF MISSION. SELECT TWO JET ULLAGE AND ROTATE DUTY CYCLE FOR PROPELLANT MANAGEMENT BASED UPON THE TWO JETS LOST. CONTINUE MISSION.
- ENTRY - SET UP FOR SINGLE SYSTEM RCS ENTRY ON THE UNFAILED SYSTEM (1E: FOR AN MNA BREAKER SET UP FOR AN AUTOMATIC "B" SYSTEM ENTRY) IF THE FAILURE WAS IN PITCH, YAW, OR B&D ROLL.

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4 ONE TRANSLATION CONTROL BAD

LAUNCH - NOT APPLICABLE

MIDCOURSE &

V'S - PULL EITHER THE MNA OR MNB BREAKER FOR SCS GROUP 1 POWER. SET SCS POWER AND TVC #1 POWER TO OPPOSITE POSITIONS. USE OTHER TRANSLATION CONTROL. HALF OF THE POWER FOR THE SCS CONTROL PANEL IS NOW OFF.

ENTRY - THE CIRCUIT BREAKER CAN BE RE-CLOSED AS BOTH THE POWER PATHS ARE OPENED BY CM-SM SEPARATION.

5 FAILURE IN CONTROL ELECTRONICS

LAUNCH - NOT DETECTABLE

MIDCOURSE - AFFECTED AXIS MUST BE DISABLED. DIRECT RCS CONTROL AND DIRECT ULLAGE ARE THE ONLY REMAINING MEANS OF FIRING THE JETS IN THIS AXIS.

V'S - THIS FAILURE GROUP MUST BE FURTHER ISOLATED TO DETERMINE IF THE TVC CONTROL CAPABILITY HAS BEEN AFFECTED, WHEN THERE IS A PITCH OR YAW FAILURE. FOR A ROLL FAILURE, DIRECT ROLL CONTROL MUST BE USED.

THE ISOLATION SHOULD BE ACCOMPLISHED AS FOLLOWS:

1. SELECT SCS V MODE
2. RECONFIRM THRUST CONTROL SWITCH - OFF
3. RECONFIRM PREVALVE SWITCHES (2) - OFF
4. GIMBAL MOTORS IN AFFECTED AXIS (2) - START - ON
5. CONFIRM RESPONSE TO GIMBAL TRIM THEN STABILIZATION AT TRIM POINT
6. THRUST ON PUSHBUTTON - PRESS
7. CONFIRM THRUST ON LIGHT - ON
8. OBSERVE GPI IN AFFECTED AXIS. DOES IT REMAIN STABLE?
(CONFIRM WITH TM IF COVERAGE IS AVAILABLE)

STABILITY ISOLATES THE FAILURE TO THE TOTAL ERROR AMPLIFIER OR THE SWITCHING AMPLIFIER SO THAT ANY OF THE THREE TVC CONTROL METHODS MAY BE USED. DIRECT ULLAGE AND DIRECT ROTATION MUST BE USED THOUGH FOR RCS CONTROL.

LACK OF STABILITY MEANS NO TVC. RCS DEORBIT MUST BE USED.

ENTRY - SAME AS MIDCOURSE EXCEPT THAT THE DIRECT ULLAGE DOES NOT APPLY

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6 PSEUDO RATE FAILED

LAUNCH &
ENTRY - NOT DETECTABLE (IN ENTRY THE LIMIT CYCLE SWITCH MUST BE OFF)
MIDCOURSE &
V'S - LIMIT CYCLE SWITCH MUST BE OFF. HIGHER RCS PROPELLANT CONSUMPTION AND LIMIT CYCLE RATES WILL BE OCCURRING.

7 ROTATION CONTROL BAD (PROPORTIONAL)

ALL PHASES - T.B.D.

8 ATTITUDE ERROR AMPLIFIER FAILED

LAUNCH - NOT DETECTABLE
ALL OTHER
PHASES - THE AFFECTED AXIS MUST REMAIN DISABLED. ALL CONTROL METHODS USING THE AUTOMATIC RCS COILS IN THIS AXIS ARE LOST. PITCH OR YAW FAILURES ALSO LOSE BOTH AUTOMATIC TVC CONTROL PATHS BUT MTVC IS STILL FUNCTIONAL.

9 BMAG DEMODULATOR FAILURE

LAUNCH - NOT DETECTABLE
ALL OTHER
PHASES - SCS AUTOMATIC RCS CONTROL AND SCS V MODES (FOR PITCH AND YAW FAILURES) ARE LOST. IF AN SCS MODE IS SELECTED THE AXIS MUST BE DISABLED FOR AUTO CONTROL AND DIRECT RCS OR DIRECT ULLAGE SUBSTITUTED.

10 G&N ATTITUDE DEMODULATOR FAILURE

LAUNCH - NOT DETECATBLE
ALL OTHER
PHASES - G&N AUTOMATIC CONTROL IS LOST BUT, USING THE TRANSLATION CONTROL LOCKOUT (HANDLE CW), THE COMMAND CAN BE FLOWN OUT FROM G&N DISPLAY WITH THE PROPORTIONAL CONTROL OR MTVC AS APPROPRIATE.

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11 ROTATION CONTROL BAD (DIRECT)

ALL PHASES - THE DIRECT CONTROL CIRCUIT BREAKER FOR THE SHORTED SWITCH CONTACT MUST BE OPENED. ONLY ONE ROTATION CONTROL WILL BE EFFECTIVE FOR DIRECT CONTROL. ONLY ONE SIDE OR THE THRUST CONTROL SWITCH WILL BE ACTIVE. FULL DIRECT ULLAGE CAN BE OBTAINED USING THE ABORT POSITION OF THE TRANSLATION CONTROL THROUGH THE MESC.

12 DIRECT ULLAGE SWITCH FAILED

ALL PHASES - THE DIRECT CONTROL CIRCUIT BREAKER FOR THE SHORTED SWITCH CONTACT MUST BE OPENED. ONLY ONE ROTATION CONTROL WILL BE EFFECTIVE FOR DIRECT CONTROL. ONLY ONE SIDE OF THE THRUST CONTROL SWITCH WILL BE ACTIVE. FULL DIRECT ULLAGE CAN BE OBTAINED USING THE ABORT POSITION OF THE TRANSLATION CONTROL THROUGH THE MESC.

13 BREAKOUT SWITCH POWER SHORTED TO DIRECT CONTROL

ALL PHASES - THE GROUP 2 MNA OR MNB CIRCUIT BREAKER INVOLVED MUST BE OPEN FOR THE REST OF THE MISSION. THE BMAG POWER SWITCH SHOULD BE PLACED TO THE OPPOSITE POWER SETTING. ONE ROTATION CONTROL WILL NO LONGER HAVE BREAKOUT SWITCH POWER AND SHOULD NO LONGER BE USED. THE CONTROL CAN BE DETERMINED BY:

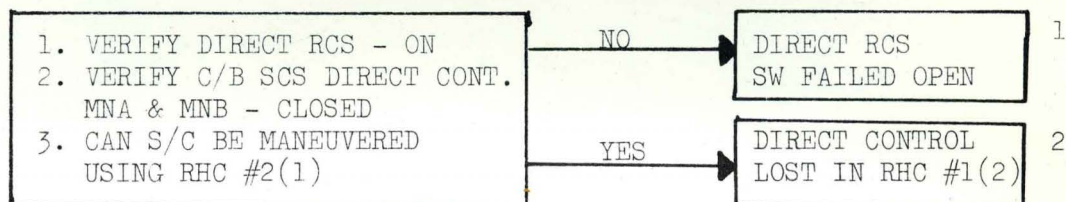
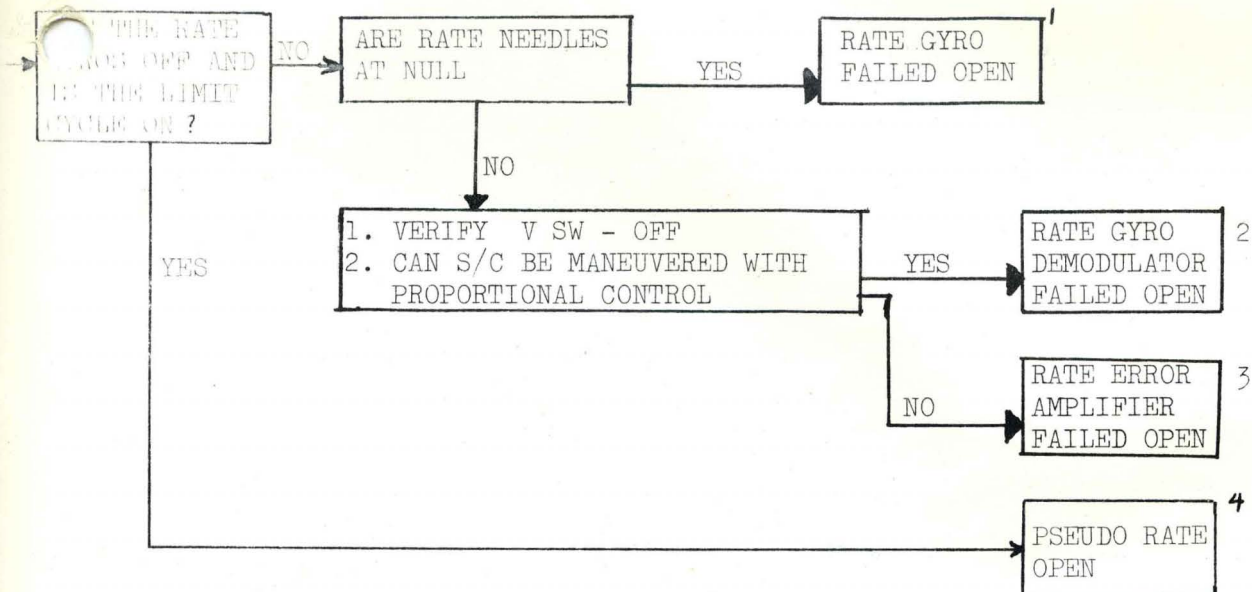
1. DISABLING THE RCS CHANNELS
2. SELECTING THE SCS ΔV MODE
3. WAITING FOR AN ATTITUDE ERROR INDICATION FROM THE BMAGS
4. DISPLACING ONE ROTATION CONTROL PAST BREAKOUT
5. IF THE BMAG'S CAGE ATTITUDE ERROR WILL GO TO ZERO AND THE BALL DRIVE WILL START. THIS IS THE GOOD ROTATION CONTROL.

14 RCS QUAD PROBLEM

ALL PHASES - QUAD USE IS LOST FOR REST OF MISSION.

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REMARKS

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1. DIRECT RCS SWITCH FAILED OPEN

LAUNCH - NOT DETECTABLE

ALL OTHER - DIRECT ROTATION CONTROL IS
PHASES LOST. AUTOMATIC PROPORTIONAL
CONTROL, MANUAL PROPORTIONAL
CONTROL, AND DIRECT AUTO
CONTROL ALL REMAIN FOR RCS
CONTROL.

2. DIRECT CONTROL LOST IN ONE ROTATION CONTROL

LAUNCH - NOT DETECTABLE

ALL OTHER - KEEP OPERABLE ROTATION CONTROL
PHASES AT CMD PILOTS' STATION

1. RATE GYRO FAILED OPEN

- LAUNCH - DETECTABLE FROM LACK OF DISPLAY MOTION DURING LAUNCH. CAN BE CORRECTED BY SELECTION OF BACKUP RATE RESTORING RATE DISPLAY.
- MIDCOURSE & - SELECTION OF BACKUP RATE PROVIDES AN ALTERNATE RATE SOURCE BY CHANNEL FOR MANEUVERS OR TVC. ATTITUDE CONTROL DURING LOW RATE CONDITIONS CAN BE HANDLED BY PSEUDO RATE SO THAT THE BMAG CAN STILL BE USED FOR ATTITUDE HOLD. THE SCS DELTA V MODE IS LOST THOUGH AND THE BMAG IS COMMON TO BOTH G&N DELTA V AND MTVC FOR PITCH OR YAW FAILURES.
- ENTRY - BMAG IS AFFECTED AXIS CAN BE PLACED TO BACKUP RATE FOR G&N OR SCS MODES. UPDATING OF THE AGCU WILL BE LOST. ATTITUDE HOLD IN SCS ENTRY MODE MUST BE MANUAL. VISUAL BACKUP ATTITUDE REFERENCE IS AVAILABLE.

2. RATE GYRO DEMOD OPEN

- ALL PHASES - RATE DISPLAYS REMAIN FUNCTIONAL
- LAUNCH - NOT DETECTABLE
- MIDCOURSE & - ONLY DIRECT CONTROL - DIRECT AUTO CONTROL AND MTVC (FOR PITCH OR YAW CHANNEL PROBLEMS) REMAIN IN THE AXIS.
- DELTA V'S - ONLY DIRECT CONTROL OR DIRECT AUTO CONTROL REMAIN IN THE AXIS AFFECTED.
- PRE 0.05G - AUTOMATIC RATE DAMPING LOST IN AXIS. DIRECT AUTO OR DIRECT CONTROL CAN BE USED WITH THE ACTIVE RATE DISPLAY OR IN ROLL TO CONTROL ATTITUDE.
- POST 0.05G -

3. RATE ERROR AMP OPEN

- ALL PHASES - RATE DISPLAYS REMAIN FUNCTIONAL
- LAUNCH - NOT DETECTABLE
- MIDCOURSE & - ONLY DIRECT CONTROL AND MTVC (FOR PITCH OR YAW CHANNEL PROBLEMS) REMAIN IN THE AXIS.
- PRE 0.05G - ONLY DIRECT CONTROL REMAIN IN THE AXIS AFFECTED.
- POST 0.05G - AUTOMATIC RATE DAMPING LOST IN AXIS. DIRECT CONTROL CAN BE USED WITH THE ACTIVE RATE DISPLAY OR IN ROLL TO CONTROL ATTITUDE.

4. PSEUDO RATE OPEN

- LAUNCH & - NOT DETECTABLE
- ENTRY
- MIDCOURSE & - RATE OR BACKUP RATE MUST REMAIN ON IN AXIS AFFECTED FOR ATTITUDE HOLD. HIGHER RCS PRE DELTA V'S PROPELLANT CONSUMPTION WILL EXIST IN THAT AXIS.

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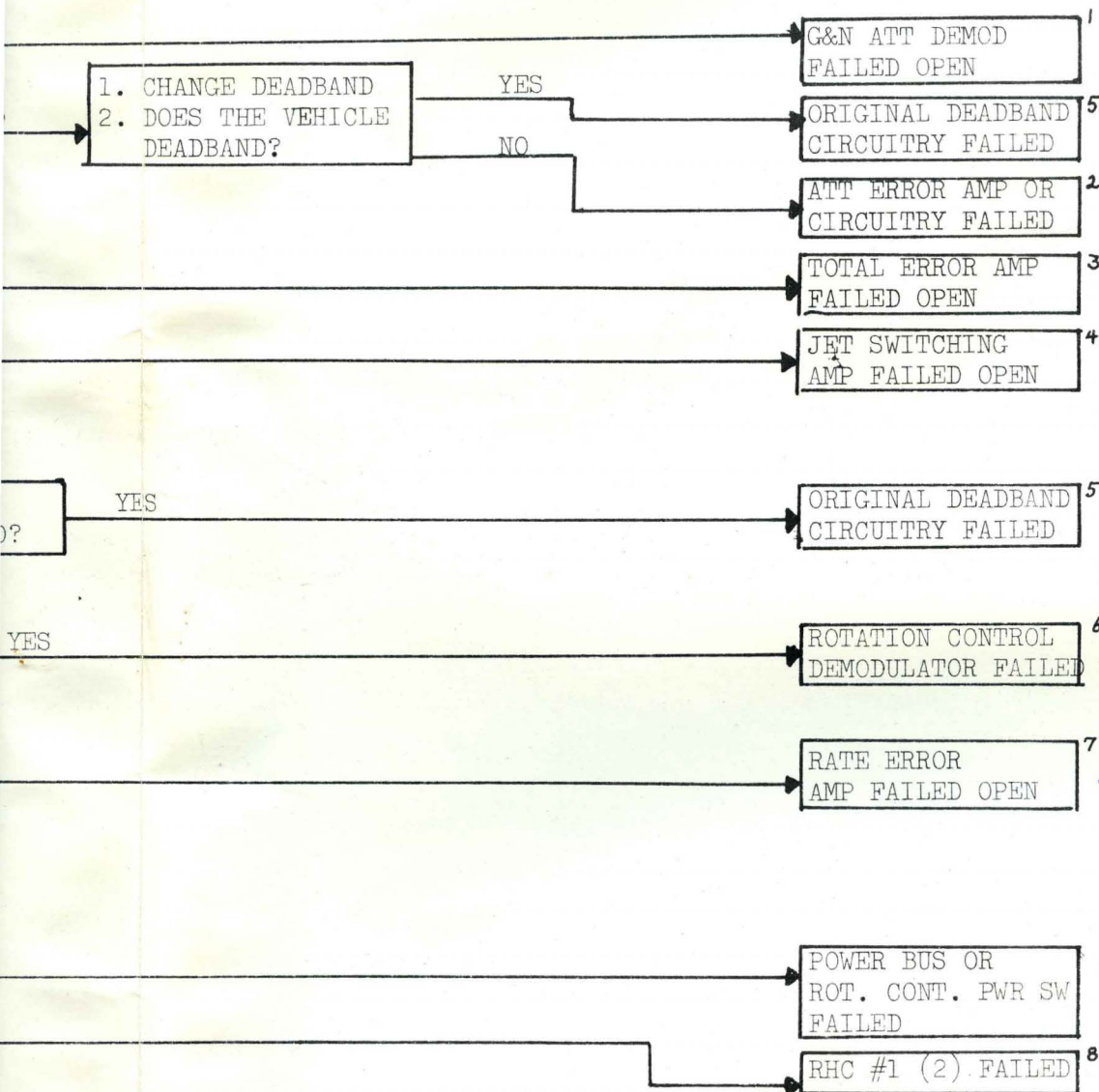
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REMARKS

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← Remarks 15(b)

← 15(b)

1. G&N ATTITUDE DEMOD OPEN

LAUNCH - NOT DETECTABLE
ALL OTHER - G&N AUTO CONTROL LOST IN ONE AXIS. DIRECT OR PROPORTIONAL CONTROL OF RCS REMAINS. SCS V OR
PHASES MTVC FOR BURNS AND MANUAL G&N FOR ENTRY. SCS ATTITUDE FOR ATTITUDE HOLD.

2. ATTITUDE ERROR AMPLIFIER OPEN

LAUNCH - NOT DETECTABLE
ALL OTHER - AUTO CONTROL FROM EITHER G&N OR SCS HOLD SIGNALS LOST IN THIS AXIS. DIRECT RCS CONTROL AND
PHASES MINIMUM IMPULSE CONTROL ARE THE ONLY REMAINING RCS CONTROL PATHS FOR THE AFFECTED AXIS

3. TOTAL ERROR AMPLIFIER OPEN

LAUNCH - NOT DETECTABLE
ALL OTHER - AUTO ATTITUDE AND RATE PROPORTIONAL RATE CONTROL IS LOST IN THIS AXIS. DIRECT CONTROL IS THE
PHASES ONLY REMAINING CONTROL PATH OTHER THAN MINIMUM IMPULSE CONTROL.

4. SWITCHING AMPLIFIER OPEN

LAUNCH - NOT DETECTABLE
ALL OTHER - AUTO ATTITUDE AND RATE AND PROPORTIONAL RATE CONTROL IS LOST IN THIS AXIS. DIRECT CONTROL IS THE
PHASES ONLY REMAINING CONTROL.

5. DEADBAND CIRCUITRY FAILED

LAUNCH - NOT DETECTABLE
ALL OTHER - MANUAL ATTITUDE HOLD REQUIRED WHEN AFFECTED DEADBAND IS SELECTED.
PHASES

6. ROTATION CONTROL DEMODULATOR OPEN

ALL PHASES- THE USE OF PROPORTIONAL RCS CONTROL AND MANUAL TVC ARE LOST FOR THE REMAINDER OF THE MISSION.
AUTO TVC MODES WITH RATE DAMPING AND NO MANUAL INPUT MTVC BACKUP ARE STILL AVAILABLE. DIRECT AND
AUTO RCS CONTROL STILL REMAIN FOR ALL MODES.

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7. RATE ERROR AMPLIFIER OPEN

ALL PHASES - RATE DISPLAYS REMAIN FUNCTIONAL
LAUNCH - NOT DETECTABLE
MIDCOURSE
& V'S - DIRECT RCS IS ONLY AVAILABLE CONTROL MODE IN THAT AXIS.
PRE-0.05G - ONLY DIRECT CONTROL AVAILABLE IN AFFECTED AXIS
POST-0.05G - AUTOMATIC RATE DAMPING LOST IN AXIS. DIRECT RCS CAN BE USED WITH THE ACTIVE RATE DISPLAY OR IN ROLL TO CONTROL ATTITUDE.

8. ONE ROTATION CONTROL LOST

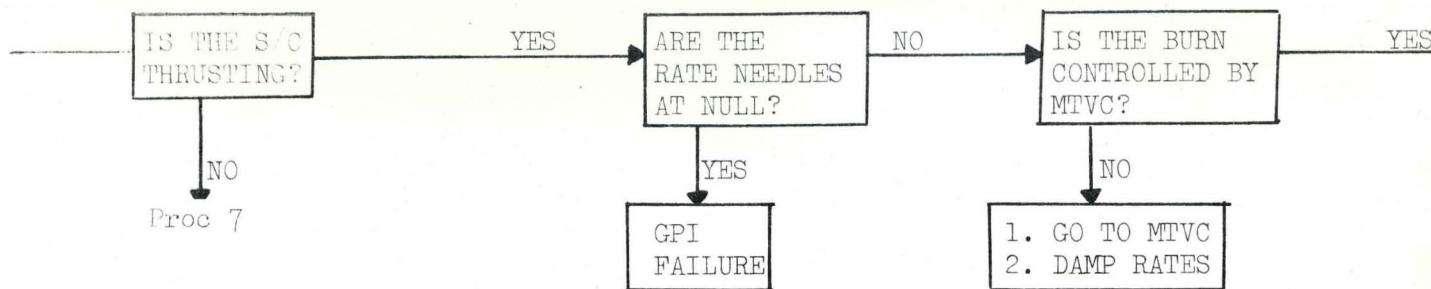
ALL PHASES - USE THE OPERATIONAL ROTATION CONTROL AT BOTH THE G&N LEB STATION AND PILOTS STATION FOR PROPORTIONAL CONTROL. DIRECT CONTROL SHOULD STILL BE FUNCTIONAL IN THE OTHER CONTROL.

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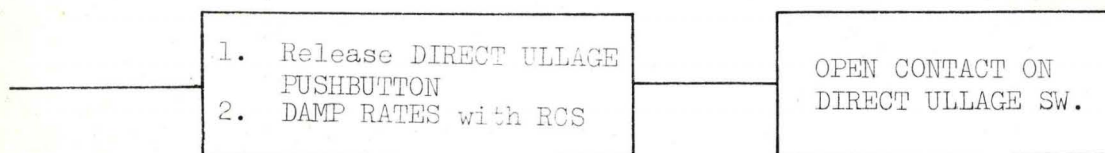
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SCS 23

PROCEDURE



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REMARKS

YES

THRUST CONTROL SW -
OFF

1. If direct ullage is needed use the abort position of the THC to command direct ullage through the sequence.

PROCEDURES ENTRY SHEET

SECTION 9.1.2

SPS MALFUNCTION PROCEDURES

SYMPTOM	SYMPTOM NUMBER	STEP	PAGE
SPS ROUGH ECO DURING MISSION CRITICAL BURN	1	1	2
SPS ROUGH ECO DURING NON-MISSION CRITICAL BURN	2	1	3
PITCH OR YAW GMBL DR FAIL C & W LIGHT ILLUMINATES DURING MISSION CRITICAL BURN	3	1	4
PITCH OR YAW GMBL DR FAIL C & W LIGHT ILLUMINATES DURING NON-MISSION CRITICAL BURN	4	1	5
SPS PRESS C & W LIGHT ILLUMINATES DURING THRUSTING	5	1	6
FUEL AND/OR OX TANK PRESS LOW DURING THRUSTING	5	2	6
FUEL AND/OR OX TANK PRESS HIGH DURING THRUSTING	5	7	7
SPS PRESS C & W LIGHT ILLUMINATES DURING NON- THRUSTING	6	1	8
FUEL AND/OR OX TANK PRESS LOW DURING NON-THRUSTING	6	2	8
FUEL AND/OR OX TANK PRESS HIGH DURING NON-THRUSTING	6	6	9
SPS WALL TEMP HI C & W LIGHT ILLUMINATES	7	1	10
PROPELLANT HEATERS FAIL TO RAISE TEMPERATURE	8	1	10
PROPELLANT TEMPERATURE READING ABNORMAL	9	1	11
NO RESPONSE OF OX FLOW FLAGS TO OX FLOW ADJUSTMENT	10	1	11
ABNORMAL PROPELLANT QUANTITY READOUT	11	1	11
UN BALANCE METER IS ERRATIC OR PEGGED	12	1	13
LOSS OF SPS HELIUM TANK PRESSURE	13	1	13
ABNORMAL SPS HELIUM VALVE TB INDICATION	14	1	14

PROCEDURES ENTRY SHEET

SECTION 9.1.3

RCS MALFUNCTION PROCEDURES

SYMPTOM	SYMPTOM NUMBER	STEP	PAGE
<u>S/M RCS</u>			
S/M RCS C&W LIGHT ILLUMINATES	1	1	2
S/M RCS TEMP PKG LOW	1	4	2
S/M RCS TEMP PKG HIGH	1	/ 10	3
S/M RCS PRESS MANF LOW	1	19	5
S/M RCS PRESS MANF HIGH	1	22	5
S/M RCS PRESS He LOW OR DECREASING	2	1	7
<u>C/M RCS</u>			
C/M RCS ENGINE TEMP FAILS TO INCREASE WITH HEATERS ON	3	1	9
C/M RCS C&W LIGHT ILLUMINATES	4	1	10
C/M RCS PRESS F OR OX HIGH	4	3	11
C/M RCS PRESS F OR OX LOW	4	4	11
C/M RCS PRESS He LOW	5	1	12

SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1 SPS ROUGH ECO DURING MISSION CRITICAL BURN				Light illuminates if 70 ± 20 msec at a vibration level of 180g's peak-to-peak or 30-70 msec at a vibration level of 360g's peak-to-peak. Light is extinguished when FCSCM circuitry is reset. THRUST SW-ON overrides the FCSCM monitors. Monitor PRESS ENG INLET FUEL and OX for decreased pressure or unbalanced pressure and flow.	Excessive engine vibration due to combustion instability.
	1	FCSCM G&N or SCS SW-OVERRIDE/ <u>RESET</u>	2	1. If in G&N ΔV , automatic restart of the engine will occur if <10 sec has elapsed since shutdown. If >10 sec V50N11 will flash, and the ENTER must be depressed for automatic restart.	
	2	FCSCM G&N SCS SW-G&N or SCS a. G&N b. SCS	4 3	2a. OVERRIDE/RESET has restarted engine. Interruption of engine "ON" command occurs during switching transient.	
	3	THRUST ON - <u>DEPRESS</u>	4		/
	4	Monitor SPS ROUGH ECO light a. Re-illuminates b. Remains extinguished	5 →		4b. Transient vibration level sensed in SPS engine.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
	5	FCSM G&N or SCS SW- <u>VERRIDE/RE-SET</u> a. G&N b. SCS	→ 6	5a. Automatic restart of the engine will occur if <10 sec has elapsed since shutdown. If >10 sec V50N11 will flash, and the ENTER must be depressed for automatic restart. 6. Continue normal procedures	
2. SPS ROUGH ECO DURING NON-MISSION CRITICAL BURN	1	THRUST SW- <u>OFF</u>	2	Light illuminates if 70 ± 20 msec at a vibration level of 180g's peak-to-peak or 30-70 msec at vibration level of 360g's peak-to-peak. THRUST SW- <u>ON</u> overrides the FCSM monitors. SPS is operable but FCSM may terminate subsequent burns.	Excessive engine vibration due to combustion instability.
	2	Terminate ullage.	3		
	3	Reset FCSM logic with any of the following switches: a. FCSM G&N or SCS SW- <u>VERRIDE/RESET</u> b. ΔV SW- <u>OFF</u> c. ATTITUDE/MONITOR/ENTRY SW- <u>MONITOR</u> or <u>ENTRY</u> .	→ → →	3. The SPS ROUGH ECO light is also reset.	/
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
3. PITCH OR YAW GMBL DR FAIL LIGHT ILLUMINATES DURING MISSION CRITICAL BURN	1	Monitor FDAI and GIMBAL POSITION INDICATOR for divergence from burn heading.		1. SPS is now operating on secondary gimbal motor. If this motor fails, the SPS must be shutdown.	Over or under current to primary drive motor.
	2	If divergence occurs; <u>THC-CW</u> .	3	2. This action initiates MTVC operation	
	3	Damp rates using MTVC.	4		
	4	THRUST SW-OFF:	5		
	5	THC-CENTER	6		
	6	With the RCS reorient the S/C to burn attitude.	7		
	7	THRUST SW- <u>NORMAL</u>	8		
		a. G&N	→	7a. Auto restart of the engine will occur if <10 sec has elapsed since shutdown. If >10 sec, V5ON11 will flash, and the ENTER must be depressed for automatic restart.	
		b. SCS	8		
	8	THRUST ON - <u>DEPRESS</u>	9		
	9	If divergence OCCURS, THRUST SW- <u>OFF</u>	→	9. SPS inoperative as gimbal control is lost in an axis	9. GIMBAL FAILURE IN ONE AXIS
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
4. PITCH or YAW GMBL OR FAIL LIGHT ILLUMINATES DURING NON-MISSION CRITICAL BURN.	1.	THRUST sw - <u>OFF</u>	2	Both GIMBAL MOTORS for PITCH or YAW have been turned on.	Over or undercurrent to primary drive motor. 6a. PITCH or YAW GMBL or FAIL light has failed on. 6b. Over or under-current to primary drive motor.
	2.	Damp any rates with the RCS.	3.		
	3.	Gimbal motors PITCH or YAW 1 sw-START; release to <u>ON</u> .			
	4.	Monitor PITCH or YAW GMBL or FAIL light.			
	a.	Re-illuminated	5.		
	b.	Extinguished	7.		
	5.	GIMBAL MOTORS PITCH or YAW 2 sw- <u>OFF</u>	6.		
	6.	Rotate PITCH or YAW GIMBAL POSITION thumbwheels			
	a.	Needle deflects	→	6a. For any subsequent burns, the GIMBAL POSITION indicator must be monitored with the FDAI for divergence from planned heading as these are the only means of monitoring the status of the gimbal motors.	
	b.	Needle doesn't deflect	→	6b. SPS now functional on secondary gimbal drive motor. Any subsequent burns must be monitored for gimbal motor failure on the GIMBAL POSITION indicator and the FDAI.	
	7.	SPS GIMBAL MOTORS PITCH or YAW 2 sw - OFF	8.		
	8.	Rotate PITCH or YAW GIMBAL POSITION thumbwheels.			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE	
		a. Needle deflects		8a. SPS functional, but gimbal switchover may occur at any time during thrusting.	8a. Transient over or under current.	
		b. Needle doesn't deflect		8b. GMBL DR FAIL light should also have re-illuminated. Motor is unable to assume the load and drops off the line.	8b. Over or under current to primary motor.	
5 SPS PRESS LIGHT ILLUMINATES DURING THRUSTING				Light illuminates if FUEL or OX TANK PRESS is >200 psia or <160 psia. Normal operating pressure is 171-179 psia.		
		WARNING - IF Pc INDICATOR ≤70 PSIA: THRUST sw - OFF				
	1.	Monitor FUEL and/or OX TANK PRESS				
FUEL AND/OR OX TANK PRESS LOW DURING THRUSTING	a.	High	7			
	b.	Low	2			
	c.	Normal	2			
	2.	Monitor PRESS ENG INLET FUEL and/or OX				
	a.	Low	3	2a. If FUEL and/or OX TANK PRESS NORMAL; FUEL and/or OX TANK PRESS INDICATORS ARE INACCURATE	2a. FUEL AND/OR OX indicator failed.	
	b.	Normal		2b. Monitoring of SPS pressure gages is required for all subsequent burns		
	c.	High		2c. If FUEL and/or OX TANK PRESS NORMAL FUEL and/or OX TANK PRESS INDICATORS ARE INACCURATE.	2c. FUEL AND/OR OX INDICATOR FAILED.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
FUEL AND/OR OX TANK PRESS HIGH DURING THRUSTING.	3	If non-critical burn: THRUST sw- <u>OFF</u> .	4.		
	4	Monitor FUEL and OX TANK PRES- SURES a. If continues to decrease b. If pressure low, but steady	4.	4. Use inlet pressures if TANK PRESSURE indicator failed 4a. SPS not operable. Sub- sequent repressurization may re- sult in tank rupture.	4a. Leak in propel- lant system.
	5.	He VLV sws (2) - <u>ON</u>	5 6	Tanks are manually repressurized for subsequent burns. Burns are not to exceed 20 sec if propel- lant tank pressure cannot be raised during manual repressuri- zation; SPS not operable due to propellant tank pressure <160 psia.	
	7.6	Monitor PRESS ENG INLET FUEL and/ or OX a. High b. Normal	8.7	7b. If indicator failure, inlet pressure should remain normal however inlet pressures should be monitored to see if a time delay may have given inaccurate normal reading.	7a. One regulator assembly failure oper 7b. Indicator failure
	8.7	SPS HELIUM sws (2) - <u>OFF</u>	9.8	8a With helium supply shut off, propellant tank ullage pressures are sufficient to provide 20 sec- onds of operation. After 20 sec- onds, O/F ratio becomes too high and engine operation may become rough. SPS will not be operable after this 20 seconds.	
	9.8	If non-mission critical, THRUST sw - <u>OFF</u>			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
6 SPS PRESS LIGHT ILLUMINATES DURING NON-THRUSTING PERIOD FUEL AND/OR OX TANK PRESS LOW DURING NON-THRUSTING	1.	Monitor FUEL and OX (TANK)PRESS		Light illuminates if fuel and/or oxidizer pressure is >200 psia or <160 psia. Normal operating pressures are 171-179 psia.	
		a. High	2		
		b. Low	2		
		c. Normal	2		
	2	Confirm FUEL and OX PRESS with ENG INLET PRESS.		<i>High & Low values refer to deviations from past stabilized conditions</i>	
		a. High	6	2a. If FUEL and/or OX TANK PRESS were normal: FUEL and/or OX TANK pressure indicators are inaccurate.	2a. FUEL and/or OX TANK PRESS INDICATOR FAILED.
		b. Low	3	2b. If FUEL and/or OX TANK PRESS were normal: FUEL and/or OX TANK pressure indicators are inaccurate.	2b. FUEL and/or OX TANK PRESS INDICATOR FAILED.
		c. Normal	→	2c. Monitor of SPS press gauges will be required.	2c. C/W circuitry failed.
	3	Monitor FUEL and OX PRESS			
		a. Stable	4		
		b. Decreasing	→	WARNING:- Subsequent repressurization considered dangerous due to possibility of tank rupture.	3b. Propellant system leak.
	4.	SPS HELIUM sws (2)- <u>ON/OFF</u> when press ≥ 175 psia.		4a. Tanks are manually repressurized for next burn if 175 psia is not obtainable: SPS HELIUM sws (2) - <u>OFF</u> . Major leak in pressurization systems SPS not operable for tank pressures <160 psia.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
FUEL AND/OR OX TANK PRESS HIGH DURING NON-THRUSTING	5.	Monitor FUEL AND/OR OX TANK PRESS a. Stable b. Decreasing		5a. SPS is functional <u>WARNING</u> :- Subsequent repressurization considered dangerous due to possibility of tank rupture.	5a. Apparent heat leak from SPS system. 5b. PROPELLANT SYSTEM LEAK
	6.	NONE	→		6. Heat leak into SPS system.

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
7. SPS WALL TEMP HI LIGHT ILLUMINATES				Light illuminates when throat surface temperature is 380°F or greater. Ablation rates will be so severe that loss of chamber may be expected at any-time, resulting in catastrophic failure. Maximum temperature should occur \approx 30 min after shut-down.	
MISSION CRITICAL: CONTINUE BURN - COMPLETE LOSS OF THE SPS SHOULD BE EXPECTED					
	1	If thrusting, THRUST sw - <u>OFF</u>	→	1. MSFN can confirm wall temperature over 380°F. Loss of entire chamber very possible upon refiring of SPS	1. Excess throat chamber ablation rates or instrumentation failure.
8. PROPELLANT HEATERS FAIL TO RAISE PROPELLANT TEMPERATURE	1	A/OFF/AB sw - <u>AB</u>	2	In the A position, the 26 electrical strip heaters receive 28V; in AB position an additional 26 heaters receive 28V.	
	2	Monitor PROP TEMP gage a. Propellant temperature increases b. Propellant temperature decreases		2a. Double heater operation is required for temperature control. 2b. If A/B not maintaining temperature above 45°F, attitude constraints must be observed or SPS may become non-operational. SPS not operable if Fuel temp < 25°F.	2a. System A heaters failed OFF. 2b. Both heater systems have failed, or SW failure, or instrumentation failure.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
9. PROP TEMP READING ABNORMAL	1	Revert to 5 hr-ON, 6 hr-OFF SPS LINE HEATER duty cycle.		<p>1. MSFN will provide back-up by monitoring propellant temperatures. If telemented FUEL TEMP abnormal, MSFN must monitor OX TEMP and provide back-up to crew for SPS LINE HEATER on-off control:</p> <p>HEATERS ON $T < 45^{\circ}\text{F}$ HEATERS OFF $T > 55^{\circ}\text{F}$</p> <p>Also, HEATERS ON if any OX line temp less than 20°F: HEATERS ON if any FUEL line temp, or if VALVE BODY temp, less than 25°F.</p>	
10. NO RESPONSE OF OX FLOW FLAGS TO OX FLOW ADJUSTMENT (PRI VALVE)	1	Valve sw - <u>SEC</u>	2	<p>Secondary valve has sufficient range to compensate for PRIMARY VALVE failure in any position and still provide valve openings for INCREASE, NORMAL or DECREASE OX FLOW.</p> <p>NOTE: Operation of OX FLOW valve is not critical to mission AS-204</p>	PRI OX FLOW VALVE failed
	2	Use OX FLOW switch as desired to adjust flow rate.			
11. ABNORMAL PROPELLANT QUANTITY READOUT	1	SENSOR sw - <u>PRI</u>	2	Complete any thrusting activity prior to check of quantity readout.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
	2	TEST/AUTO/TEST sw - <u>TEST</u> (upper) for 10 sec and monitor quantities:	3	In TEST mode the display will not move for the first 4.5 sec. Next it will race for ≈ 1 sec, and then will roll steadily at 2 to 4 digits per sec. If display reacts as above after primary system failure, then failure is in a tank probe. If tank probe is not failed, then random or bogey readings will be displayed.	
	3	a. Random reading	4		
		b. Correct reading	4	One or more tank probes has failed	Primary gauging failed
	4	SENSOR sw - <u>AUX</u>	5		
	5	TEST/AUTO/TEST sw - <u>TEST</u> (upper) for 10 sec, then sw - <u>TEST</u> (lower) for 10 sec. Read quantities:		In TEST mode the display will not move for the first 4.5 sec. Next it will race for ≈ 1 sec, and then will roll steadily at 2 to 4 digits per sec. If display reacts as above after primary system failure, then failure is in a tank probe. If tank probe is not failed, then random or bogey readings will be displayed.	
		a. Random reading	→	MSFN must now supply any propellant quantity data.	Display failed
		b. Correct reading	→	Continue in AUX mode. Telemetry will provide total quantities from auxiliary system, and sump tank quantities from PRI system.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
12. UNBALANCE METER IS ERRATIC OR PEGGED.	1	SENSOR switch - <u>AUX</u>	2	Complete any thrusting activity prior to checking unbalance meter.	UNBALANCE meter failed. PRIMARY UNBALANCE failed
	2	TEST/AUTO/TEST sw - <u>TEST</u> (upper) for 10 sec. Monitor unbalance meter. SW - <u>TEST</u> (lower) for 10 sec. Monitor unbalance indicator			
		a. Bogey Reading	3		
		b. Normal reading	→	Use AUX mode for operation of quality guaging system	
	3	SENSOR sw - <u>PRI</u>	4		
	4	TEST/AUTO/TEST sw - <u>TEST</u> (upper) for 10 sec; then sw - <u>TEST</u> (lower) for 10 sec.	5	Actuation of TEST switch here will realign digital display to PRIMARY system setting.	
	5	SENSOR sw - <u>NORM</u>			
13. LOSS OF SPS HELIUM TANK PRESSURE	1	Monitor He PRESS indicator		MSFN will correlate He temperature data with He press.	1a LEAK IN HELIUM SUPPLY
		a. He temperature drops concurrently with pressure	→	1a. Helium depletion imminent. Leak in helium supply.	
		b. He temperature does not reflect drop concurrent with pressure.	2	Leak cannot be verified until a SPS burn is performed.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. S/M RCS A (B,C,D) Light illuminates	1.	S/M RCS A(B,C,D) Helium 1 & 2 sws <u>OFF</u>	2.	Light illuminates if TEMP PKG is >175° or <63°; or if PRESS MANF is <155 psia or >215 psia.	
	2.	RCS INDICATOR sw - <u>S/M A(B,C,D)</u>	3.		
	3.	Monitor S/M RCS TEMP PKG		3. Normal operating range: 115 - 175°F	
	a. LOW		4.		
	b. HIGH		10.	3b. Boost heating may cause the temperature to rise above 200°F, but it should drop during the first rev. Prolonged RCS firing and solar heat soak orientation may result in a high TEMP PKG.	
	c. NORMAL		18.		
S/M RCS TEMP PKG LOW	4.	If TEMP PKG <45°F: SCS CHANNEL sws A&C ROLL (B&D ROLL) and PITCH (YAW)-OFF	5.	4. Two SCS CHANNEL sws and DIRECT RCS must be disabled to electrically isolate the affected quad, however the opposite quad on the S/M is also disabled.	
	5.	DIRECT RCS - <u>OFF</u>	6.	Actuation at temperatures lower than 63°F can result in incomplete combustion and dangerous pressure spikes.	
WARNING: If there was probable engine valve actuation while the quad's PKG TEMP was below 45°F: S/M RCS A(B,C,D) PROPELLANT SW - <u>OFF</u> ; SCS CHANNEL sws (2) - <u>ON</u> . Reactivate the quad only in an emergency; S/M RCS A(B,C,D) HELIUM 1 & 2 sws - <u>ON</u> . If the quad is reactivated, the first pulse on each jet of the quad should be a minimum of one second in duration in order to attempt disipation of possible residue.					
	6.	S/M RCS A(B,C,D) HELIUM 1&2 sws- <u>ON</u>	7.		
	7.	If possible, reorient S/C with quad A(B,C,D) in sunlight and monitor S/M RCS TEMP PKG			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. (continued)	13.	DIRECT RCS - <u>OFF</u>	14.	If the engine valves are actuated above 220°F, deformation of the valve seats can occur with possible leakage of propellants.	
	14.	S/M RCS A(B,C,D) HELIUM 1& 2 sws- <u>ON</u> (if applicable)	15.		
	15.	If possible, orient the S/C to position the affected quad away from the sun to effect cooling monitor S/M RCS TEMP PKG			
	a.	TEMP DECREASES	16.	15a. Use the C/B to manually maintain the TEMP PKG within limits of 70°F-210°F CAUTION: If temp falls below 63°F go to RCS 1 step 4	15a. S/M HEATER FAILED ON
	b.	TEMP DOES NOT DECREASE	17.	15b. If indicator failed, S/M RCS A(B,C,D) light will not be illuminated. If the sensor failed, the light will be on. Use the temperatures of the other quads to estimate the temp. of the affected quad. Continuous monitoring of the quad is advised	15b. PKG TEMP INDICATOR OR SENSOR FAILED.
	16.	When RCS A(B,C,D) TEMP PKG falls below 200°F.	17.		
	17.	SCS CHANNEL sws - <u>ON</u>	→	17. Use system normally	
	18.	MONITOR S/M RCS PRESS MANF		18. Normal Helium operating pressure: 177 psia - 185 psia. In addition to helium manifold pressures MSFN can read out FUEL MANIFOLD PRESSURES on all quads and OXIDIZER MANIFOLD PRESSURES on quads A&D.	
	a.	LOW	19		
	b.	HIGH	22		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. (continued)		c. NORMAL	→	18c. RCS SELECTOR sw should be left in the affected quad position after every system status checks.	18c. C/W circuitry to S/M RCS light or instrumentation failure.
S/M RCS PRESS MANF LOW	19.	S/M RCS A(B,C,D) HELIUM 1&2 sws- <u>ON</u>	20.		
	20.	Operate the quad until RCS press manf drops below 100 psia.	21.		
	21.	S/M RCS A(B,C,D) propellant sw - <u>OFF</u> (Verify striped display)	→	21. Firing jets at pressures lower than 100 psia may cause engine wall burn-through due to inadequate film cooling. Refer to S/M RCS 2 (S/M RCS PRESS He LOW or DECREASING) Reactivation of the quad should only be accomplished in an emergency.	21. LEAK IN HELIUM PRESSURIZATION SYSTEM OR INSTRUMENTATION FAILURE.
	22.	When practical, operate the thrusters on the affected quad, monitor S/M RCS A(B,C,D) press MANF		22. Burst disks receptive at 220 - 236 psia. Relief valves open at 225-248 psia and reseal at about 220 psia. Some loss of helium is to be expected throughout these ranges.	
		a. DECREASES b. REMAINS CONSTANT	24.		
S/M RCS PRESS MANF HIGH	23.	S/M RCS A(B,C,D) HELIUM 1&2 sws- <u>ON</u>	→	23. Continue normal operation.	
	24.	When S/M RCS PRESS MANF < 170 psia: S/M RCS A(B,C,D) HELIUM 1 sw - <u>ON</u> (Verify gray display) MONITOR S/M RCS PRESS MANF			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
		a. RETURNS HIGH b. NORMAL	25. →	24b. Quad is fully functional on redundant regulator assembly. If pressure was between 185-194 psia the primary regulator has failed and the secondary regulator was controlling Redundancy in the affected leg lost and should be used only as a last resort in case of failure closed in the other leg. If second set of regulators fail cycle S/M RCS HELIUM 1 or 2 sw to maintain adequate manifold pressure.	24b. S/M RCS A(B,C,D) HELIUM 2 REGULATOR ASSEMBLY FAILED.
	25.	S/M RCS A(B,C,D) HELIUM 1 sw - OFF (Verify striped display)	26.		
	26.	S/M RCS A(B,C,D) HELIUM 2 sw -ON (Verify gray display)	→	26. Pressure will decrease with use of the quad and the light (if on) will extinguish when pressure drops below 215 psia. Quad is fully functional on redundant regulator assembly. If pressure was between 185-194 psia the primary regulator has failed and the secondary regulator was controlling Redundancy in the affected leg lost and should be used only as a last resort in case of failure closed in the other leg. If second set of regulators fail cycle S/M RCS HELIUM 1 or 2 sw to maintain adequate manifold pressure.	26. # S/M RCS A(B,C,D) He Reg # 1 Assy Failed.
	27	S/M RCS PRESS MANF a) Returns high b) Normal	→		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE	
2. S/M RCS PRESS He LOW OR DECREASING.	1	SCS CHANNEL SWS A & C ROLL (B & D ROLL) AND PITCH (YAW) - <u>OFF</u>	2	1. TWO SCS CHANNELS AND DIRECT RCS MUST BE DISABLED TO ISOLATE THE AFFECTED QUAD.		
	2	DIRECT RCS - <u>OFF</u>	3	<u>CAUTION</u> : Propellant quantity gauging using PV is inaccurate.		
	3	S/M RCS A(B,C,D) HELIUM 1 & 2 SWS - <u>OFF</u> (VERIFY STRIPED DISPLAY)	4			
	4	S/M RCS A(B,C,D) PROPELLANT SW- <u>OFF</u> (VERIFY STRIPED DISPLAY)	5			
	5	MONITOR S/M RCS PRESS He				
		a. REMAINS CONSTANT b. DECREASING	6 →	5b. Configure to original conditions and NORMAL USE OF THE QUAD UNTIL S/M RCS PRESS MANF DROPS BELOW 100 PSIA THEN PLACE S/M RCS A(B,C,D) PROPELLANT SW - <u>OFF</u> DO NOT OPERATE QUAD IF PRESS MANF IS LESS THAN 100 PSIA EXCEPT IN AN EMERGENCY.		5b. HELIUM LEAK UP-STREAM OF HELIUM ISOLATION
	6	MONITOR S/M RCS PRESS MANF				
		a. REMAINS CONSTANT b. DECREASES	→ 7	6a. Use quad for emergency or separation only by: S/M RCS A(B,C,D) PROPELLANT Sw - <u>ON</u>		6a. PROPELLANT LEAK DOWNSTREAM OF PROPELLANT ISOLATION VALVES.
	7	WHEN IN RANGE OF MSFN, S/M RCS A(B,C,D) PROPELLANT SW - <u>ON</u>	8			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
	8	MONITOR OX AND/OR FUEL MANIFOLD PRESSURE THROUGH MSFN		8. OX measurements on quads B & C are not available.	
		a. REMAINS CONSTANT	→	8a. Use only for emergency or separation by SCS CHANNEL sws - <u>ON</u> . PLACE S/M RCS A (B,C,D) HELIUM 1 & 2 sws - <u>ON</u>	8a. HELIUM LEAK BETWEEN THE HELIUM ISOLATION VALVES AND THE CHECK VALVES.
		b. DECREASES	→	8b. THE LEAK COULD BE EITHER GAS OR LIQUID. USE ONLY FOR EMERGENCY OR SEPARATION BY PLACING THE SCS CHANNEL SWS AND THE S/M RCS A(B,C,D) HELIUM SWS TO <u>ON</u> .	8b. LEAK BETWEEN THE HELIUM ISOLATION VALVES AND PROPELLANT ISOLATION VALVES.

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
3. C/M RCS ENGINE TEMP FAILS TO INCREASE WITH HEATERS ON	1	PLACE TEST SELECTOR SW TO THE OTHER THRUSTER TEMP POSITIONS (1,2,3,4,11,12)	2		
	2	CYCLE FUNCTION SELECT SW FROM C/M RCS HTRS TO OFF AND BACK AND MONITOR DC AMMETER.			
		a. DC AMPS CHANGE MORE THAN 5 AMPS	3		
		b. DC AMPS CHANGE LESS THAN 5 AMPS	3		2b. C/M HEATER NOT FUNCTIONING
	3	MONITOR DC VOLT METER (ENGINE TEMP)		3. INDICATES THRUSTER TEMP.	
		a. ANY TEMP INCREASING	→	3a. USE ONE OF OTHER ENGINE TEMPS FOR THAT OF AFFECTED ENGINE.	3a. TEMP SENSOR FAILURE.
		b. ALL TEMPS CONSTANT. BUT ANY BELOW 64°F (1.8 VDC)	4		
	4	MESC PYRO SW - <u>SAFE</u> <i>Pyro Arm pull C/B</i>	5		
	5	C/M PROP JETT DUMP SW - ON	6	5. All engines will be heated with the exception of the two + pitch engines.	
	6	WHEN COLDEST ENGINE REACHES 100°F (2.5 VDC) OR for 13 minutes whichever comes first:	7		
	7	C/M PROP JETT DUMP SW - <u>OFF</u>			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
4. C/M RCS A OR B LIGHT ILLUMINATES	1	RCS INDICATOR SW - <u>CM RCS A OR B</u>	2	1. ILLUMINATES IF FUEL OR OXIDIZER PRESSURE IS <265 PSIA OR >325 PSIA.	
	2	MONITOR C/M RCS PRESS F AND OX a. HIGH b. LOW c. NORMAL	3 4 →	2. NORMAL 287-308 PSIA 2c. CONTINUE NORMAL OPERATION.	2c. C/W CIRCUITRY TO C/M RCS A OR B LIGHT FAILED ON.
	3	NONE		3. CONTINUE USING THE AFFECTED SYSTEM TO DEPLETION. BURST DISC RUPTURES AT 332-348 PSID. THE RELIEF VALVE CRACKS AT 332-360 PSIA AND RESEATS AT 327 PSIA. THERE WILL BE A LOSS OF HELIUM DUE TO VENTING.	3. REGULATOR ASSEMBLY FAILED OPEN
	4	NONE		4. CONTINUE USING THE AFFECTED SYSTEM UNTIL HELIUM DEPLETION OCCURS. IF THE REMAINING SYSTEM IS SERIOUSLY DEGRADED THE HELIUM SYSTEMS MAY BE INTERCONNECTED BY PLACING THE C/M PROP DUMP SW - <u>DUMP</u> (MOMENTARILY) AND THEN RETURNING IT TO THE <u>OFF</u> POSITION. THIS SHOULD BE DONE AS A LAST RESORT ONLY AS HELIUM FROM THE GOOD SYSTEM IS BEING SUPPLIED TO A MALFUNCTIONING SYSTEM AND COULD BE LOST. ONCE THE SYSTEMS ARE INTERCONNECTED, THEY CANNOT BE ISOLATED.	4. REGULATOR ASSEMBLIES FAILED CLOSED OR LEAK IN SYSTEM.
C/M RCS PRESS F OR OX - HIGH					
C/M RCS PRESS F OR OX - LOW					
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
5. C/M RCS PRESS He LOW OR DECREASING	1.	HAS THE C/M RCS BEEN PRESSURIZED			
		a. YES	→	1a. NORMALLY LOADED AT 4100-4200 PSIA. CONTINUE USING THE AFFECTED SYSTEM UNTIL HELIUM DEPLETION OCCURS. IF THE REMAINING SYSTEM IS SERIOUSLY DEGRADED, THE HELIUM SYSTEMS MAY BE INTERCONNECTED BY PLACING THE C/M PROP DUMP SW - <u>DUMP</u> MOMENTARILY AND THEN RETURNING IT TO THE <u>OFF</u> POSITION. THIS SHOULD BE <u>DONE</u> AS A LAST RESORT ONLY AS HELIUM FROM THE GOOD SYSTEM IS BEING SUPPLIED TO A MALFUNCTIONING SYSTEM AND COULD BE LOST. ONCE THE SYSTEMS ARE INTERCONNECTED, THEY CANNOT BE ISOLATED.	
		b. NO	2.		
	2.	WHEN PRESS He = 600 psia	3.		
	3.	C/B MESC ARM A BATT A - <u>CLOSED</u>	4.		
	4.	C/B MESC ARM B BATT B - <u>CLOSED</u>	5.		
	5.	MESC PYRO ARM SWS(2) - <u>ARM</u>	6.		
	6.	RCS C/M PRESS - <u>ON/OFF</u>	7.	6. THIS PRESSURIZES THE C/M RCS IN ORDER TO TRAP ENOUGH	6. LEAK IN HELIUM SUPPLY
	7.	MESC PYRO ARM SWS(2) - <u>SAFE</u>	8.	HELIUM DOWNSTREAM FOR USE OF	
	8.	C/B MESC ARM A BATT A - <u>OPEN</u>	9.	SYSTEM. IF THE OTHER SYSTEM IS SERIOUSLY DEGRADED, THE HELIUM SYSTEMS MAY BE INTERCONNECTED	
9.	C/B MESC ARM B BATT B - <u>OPEN</u>	→	BY PLACING THE C/M PROP DUMP SW - <u>DUMP</u> MOMENTARILY AND THEN		
PREPARED BY: <i>MA</i>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
DATE: Jan. 27, 1967		RCS MALFUNCTION PROCEDURES		S/C	REV FINAL
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
				<p>RETURNING IT TO THE OFF POSITION. THIS SHOULD BE DONE AS A LAST RESORT ONLY AS HELIUM FROM THE GOOD SYSTEM IS BEING SUPPLIED TO A MALFUNCTIONING SYSTEM AND COULD BE LOST. ONCE THE SYSTEMS ARE INTERCONNECTED, THEY CANNOT BE ISOLATED.</p>	

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Where is this procedure

SECTION	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
3. BATTERY CHARGER OUTPUT CURRENT indicates greater than <u>1.4</u> ampere above data point after normal recharge time.	1	Record time & charge current on affected Battery	2	(1) Normal recharge time is mission dependent.	
	2	Charge to and/or verify proper DC AMPS - Charge Status		(2) Data indicating -1 AH & -2 AH respective charger output current is included in flight data pkg.	
		a. Proper charge current level indicated	3		Single battery degradation or inadvertant loading.
		b. Improper charge level indicated	6		Extra-nominal loading.
	3	Initiate an additional 2 hour charge on affected battery(ies) with time starting at final charge current recorded in Step 1.	4	(3) If, during these 2 hours of additional charging, the current indicates 1.0 amp above 1 AH data point-record time and continue the 2 hour re-charge time. A data sheet is provided which will meet needs of this procedure & normal charging.	
	4	Monitor (& record time start) DC AMPS - Battery Charger DC VOLTS - Battery only		(4) DC VOLTS should be at least 38.5 volts after this amount of charging.	
		a. DC VOLTS (Battery) < 38.5v	10		(4b) Inadvertant leading
		b. DC AMPS - Charger \leq 1 amp data point after 2 additional hours of charge.	9		(4c) Inadvertant loading
		c. 1 amp < DC AMPS - Charger \leq 1.5 amp above 1 AH data point after 2 hours additional charge	3		(4d) Circuit failure or load shorting.
		d. DC AMPS > 1.5 amp above 1 AH data point after 2 hours additional charge.	5		
Prepared by <i>J. Radcliffe</i> <i>R. E. Dalry</i>		Flight Crew Support Division Date		EPS BATTERIES	Apollo Operations Handbook S/C 204 Rev Section 3.3

SYNOPSIS	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
	5	Monitor DC AMPS - Charger DC VOLTS (While accomplishing step 6)	6		
	6	Open Circuit breakers BAT RELAY BUS BAT A(B) COMPRESSOR NO. 1(2) SPS GIMBAL MOTOR-YAW-1(2) - BAT A(B) SPS GIMBAL MOTOR-PITCH -1(2) - BAT A(B) ELS A(B) - BAT A(B) EDS 1(3) - BAT A(B) a. Sharp decrease in current corresponding to opening a single breaker b. No change in voltage or current	8 7	Voltage step increase may be noticeable also. In either case the DC-AMPS should approach normal.	(6a) Load failure.
	7	Verify normal Bat CASE TEMP with MSFN (Temp > 60°F)	→	MSFN-Crew option to continue charging of affected battery at this time based on 1. Charged capacity of remaining batteries. 2. Performance of F/C's 3. Mission schedule. If choice is to charge go to step 9 of this procedure.	(6b) Intermittant or terminal current short.
	8	Leave faulty load circuit breaker OPEN - RESET remaining breakers (indicated in step 6)	9	Refer to respective system procedure for loss of power to the particular component.	
	9	Determine time remaining prior to next burn and initiate charging so that at least 2 batteries		Record charging times and adjust subsequent cycles accordingly. Charge to 2 ampr calibration	
Prepared by <i>[Signature]</i> <i>R. L. Daly</i>	Flight Crew Support Division Date		EPS BATTERIES		Apollo Operations Handbook S/C 204 Rev Section 3.4

PROCEDURES ENTRY SHEET

SECTION 9.1.4

EPS MALFUNCTION PROCEDURES

<u>SYMPTOMS</u>	<u>NO.</u>	<u>STEP</u>	<u>PAGE</u>
<u>CRYOGENICS</u>			
O ₂ (H ₂) PRESS LIGHT ILLUMINATES	1	1	2
O ₂ (H ₂) TANK 1 (AND/OR 2) PRESSURE LOW	1	2	2
O ₂ (H ₂) TANK 1 (AND/OR 2) PRESSURE HIGH	1	20	6
O₂ (H₂) TANK 1 (AND/OR 2) PRESSURE HIGH	1	20	6
<u>FUEL CELLS</u>			
F/C 1 (2 OR 3) LIGHT ILLUMINATES	1	1	10
FUEL CELL MODULE TEMP CON EXH HIGH	1a	1.00	11
FUEL CELL MODULE TEMP CONT EXH LOW	1b	2.00	14
FUEL CELL 1 (2 or 3) CIR & SEP MOTORS (AC) C/B OPEN	1c	3.00	16
FUEL CELL FLOW - O ₂ (H ₂) - HIGH	1d	4.00	17
FUEL CELL FLOW - O ₂ (H ₂) - LOW	1e	5.00	18
F/C 1 (2 OR 3) PH - HIGH - FLAG STRIPED	1f	6.00	20
O ₂ REG OUT PRESS HIGH - FLAG STRIPED	1g	7.00	22
H ₂ REG OUT PRESS HIGH - FLAG STRIPED	1h	8.00	24
<i>Both</i> O ₂ & H ₂ REG OUT PRESS - HIGH OR			
O ₂ & H ₂ & N ₂ REG OUT PRESS HIGH	1i	9.00	25
F/C 1 (2 or 3) RAD OUT TEMP - LOW	1j.	10.00	26
FUEL CELL 1 (2 OR 3) MODULE SKIN TEMP LOW (<375°F)	1k	11.00	27
FUEL CELL 1 (2 or 3) MODULE SKIN TEMP HIGH (>450°F)	1l	12.00	29

PROCEDURES ENTRY SHEET

(CONTINUED)

<u>SYMPTOMS</u>	<u>NO.</u>	<u>STEP</u>	<u>PAGE</u>
<u>POWER DISTRIBUTION</u>			
MN BUS A (B) UNDERVOLT LIGHT-ON DC VOLTS > 26V	1	1	30
DC VOLTS METER INDICATES PYRO BATTERY A(B) BELOW 35 VOLTS	2	1	31
BATTERY CHGR OUTPUT CURRENT DROPS TO ZERO & CIRCUIT BREAKERS BATTERY CHARGER MN A&B OPEN <i>both</i>	3	1	32
BATT CHGR OUTPUT CURRENT ZERO (IN ALL SWITCH POSITION)	4	1	33
DC INDICATORS - BAT BUS A(B), DC VOLTS 27-30 & DC AMPS > ZERO WITH BUS SWS OFF	5	1	34
BATT CHGR VOLTAGE 40 VDC AND CURRENT ZERO WHEN CHARGING BATTERY A(B,C)	6	1	36
INV 1 (2 or 3) TEMP $\geq 190^{\circ}\text{F}$ (MSFN MONITORING CAPABILITY)	7	1	37
AC BUS FAIL LIGHT ILLUMINATED	8	1	40
AC BUS FAIL LIGHT & AC BUS 1 (2) OVERLOAD LIGHT ILLUMINATED	9	1	42
AC BUS 1 & 2 FREQUENCY INDICATES < 393 CPS OR > 407 CPS (SINGLE INVERTER OPERATION)	10	1	45
AC BUS FAIL LIGHT ILLUMINATED & AC BUS 1 (2) VOLTAGE < 90v (DUAL INVERTER)	11	1	46
AC BUS FAIL LIGHT ON AFTER AC INVERTER 2 (1) IS APPLIED TO AC BUS 2(1)	12	1	47
MN BUS A & B UNDERVOLT LIGHT, AC BUS 1 & 2, & F/C BUS DISCONNECT LIGHTS ILLUMINATE (DUAL INVERTER CONFIGURATION)	13	1	49
MN BUS A&B UNDERVOLT LIGHT, AC BUS 1&2 & F/C BUS DISCONNECT LIGHTS ILLUMINATE (SINGLE INVERTER CONFIGURATION)	14	1	50

SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. O ₂ (H ₂) PRESS light illuminates. O ₂ (H ₂) Tank 1 (and/or 2) pressure low				C/W low pressure limits: O ₂ : TANK 1 & 2 = 800 psia H ₂ : Tank 1 & 2 = 220 psia C/W upper pressure limits O ₂ : Tank 1 & 2 = 950 psia H ₂ : Tank 1 & 2 = 270 psia	
	1	Monitor TANK PRESSURE - O ₂ (H ₂) - 1 & 2			
		a. Pressure low	2		
		b. Pressure high	20		
	2	O ₂ (H ₂) HEATERS Sw - 1 (and/or 2) - <u>OFF</u> (off limit tank(s))	3	(2) Low O ₂ (H ₂) pressure in one tank is not time critical and should be verified with MSFN to determine possible indicator failure. The surge tank should be isolated when marked decreasing trend in both O ₂ tank pressures is noticeable.	
	3	O ₂ (H ₂) FANS - 1 (and/or 2) - <u>OFF</u> (off limit tank(s))	4		
	4	Monitor Flow - O ₂ (ECS)			
		a. Flow >.45 lbs/hr	→	(4a.) Reference ECS symptom No. 1 (O ₂ Flow High)	(4a.) Leak in ECS
		b. Flow <.45 lbs/hr	5		
	5	Monitor CABIN PRESS			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
		a. Pressure \geq 5.6 psia	→	(5a.) Reference ECS symptom No. 21 (Cabin Pressure high)	(5a.) Leak in ECS
		b. Pressure \geq 5.6 psia	6		
	6	Monitor TANK PRESSURE O ₂ (H ₂) - 1 (and/or 2) & F/C FLOW - F/C 1, 2, & 3			
		a. Press steady or gradual decrease & F/C flow rates equivalent.	8.	(6a.) Pressure changes will be more evident with H ₂ gauge scale than with O ₂ gauge scale. F/C flow rate comparisons will reveal purge valve open.	(6a.) Motor or pressure switch failure or leak prior to flow sensor.
		b. Flow high in one fuel cell, pressure continues to drop	11		(6b.) Purge valve seat leak or plumbing leak.
		c. Fuel cell flow rates equivalent & pressure indicates marked drop in one tank	7	(6c.) Tank vent valve being open necessitates a previously high pressure or failure of relief valve. O ₂ tank relief vents at 983 psig and reseats at 970 psig. H ₂ relief valves vent at 273 psig & reseats at 268 psig.	(6c.) Tank vent valve open or plumbing leak.
	7	Leave both tank heaters & fans OFF.	→	(7) Surge tank should be isolated when marked decreasing trend in both O ₂ tank pressures is noticeable. Sufficient flow may be obtained in a pressure decay mode of operation.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
				Minimum cryo systems pressures are: O ₂ : 500 psi (required for worst case cabin repress) H ₂ : 150 psi Management constraints are: a. Quantity remaining in both tanks. b. Rate of depletion of faulty tanks.	
	8	O ₂ (H ₂) HEATERS Sw - 1 (and/or 2) <u>ON</u>	9		
	9	O ₂ (H ₂) FANS Sw - 1 (and/or 2) - <u>ON</u>	10		
	10	Monitor TANK PRESSURE - O ₂ (H ₂) - 1 (and/or 2) a. Pressure increases steadily b. Pressure continues to gradually decrease		(10a) Single switch failure results in loss of automatic pressure control in both tanks. Manual control is required. (10b) Tank pressure will decay and is effectively lost for rest of mission.	(10a) Motor or pressure switch failure. (10b) Leak prior to flow sensor.
	11	Cycle FUEL CELL 1 (2 or 3) - O ₂ (H ₂) - PURGE 3 to 5 times consecutively & return to <u>OFF</u>	12		
	12	Monitor - FLOW - O ₂ (H ₂) meter			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
	12	a. Flow returns to normal	13	(12a.) Normal purge maximum flow increases are: O ₂ : 0.6 lb/hr H ₂ : 0.75 lb/hr	(12a.) Purge valve seat open temporarily.
		b. Flow remains high	15	(12b) A plumbing leak in the area involved here is very remote.	(12b.) Plumbing leak down stream of fuel cell or purge valve.
	13	O ₂ (H ₂) HEATERS sw - 1 (and/or 2) - <u>AUTO</u>	14		
	14	O ₂ (H ₂) FANS sw - 1 (and/or 2) - <u>AUTO</u>	→		
	15	Repeat Step 13 11			
		a. Flow remains high	16	(15a) See statement of step 12a.	
	16	O ₂ (H ₂) HEATERS sw - 1 (and/or 2) - <u>AUTO</u>	17		
	17	O ₂ (H ₂) FANS sw - 1 (and/or 2) - <u>AUTO</u>	→ 18	(17) Fuel cell purge valve being open may give a critical operational mode if purge cycle is initiated during low pressure condition of tank. Consumption data & mission length should be adjusted accordingly. If flow rate exceeds flow rate of remark 12a, crew - MSFN option to shutdown fuel cell.	Purge valve failed open
	18	Monitor TANK PRESSURE - O ₂ (H ₂) - 1 & 2			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
O ₂ (H ₂) TANK 1 (and/or 2) PRESS HIGH	18	a. Pressure returns to normal	→		
		b. Pressure decreases	19		
	19	Use manual pressure control		<i>manual use of Headers & fans to control pressure.</i>	
	20	O ₂ (H ₂) HEATERS - 1 (and/or 2) - <u>OFF</u>	21	20. Note: Purge would normally be initiated when the tank pressures trigger the C/W. C/W upper pressure limits are: O ₂ : TANK #1 - 950 psia TANK #2 - 950 psia H ₂ : TANK #1 - 270 psia TANK #2 - 270 psia Tank relief valve crack pressures: O ₂ : Tank #1 - 983 psig Tank #2 - 983 psig H ₂ : Tank #1 - 270 psig Tank #2 - 270 psig	
	21	O ₂ (H ₂) FANS - 1 (and/or 2) - <u>OFF</u>	22		
	22	Monitor O ₂ (H ₂) Tank pressure			
		a. O ₂ high	23		
		b. H ₂ high	27		
	23	Monitor cryogenic & surge tank pressures			
		a. Surge tank = 900 \pm 35 and << highest cryo tank	24	(23a) Loss of sensor capability necessitates coordination with MSFN.	(23a) O ₂ Sensor circuit failure in tank with highest indicated pressure.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
		b. Surge tank \approx highest cryo tank	28'		
	24	PRESS IND SW-SURGE TANK	25		
	25	O ₂ HEATERS SW-1(&/or 2) - AUTO	26		
	26	O ₂ FANS SW-1(&/or 2) - AUTO	→	(26) Normal configuration is mission time dependent	
	27	Verify with MSFN H ₂ tank pressure			
		(a) Normal	→		(27a) H ₂ sensor circuit failure
		(b) One or two tanks high	28		
	28	FUEL CELL 1,2, & 3-O ₂ (H ₂) PURGE (normal duration) ²	29	(28) H ₂ purge line heater should be on at least 10 minutes (no more than 20 minutes should be required) prior to purge. Immediate purge may be initiated if vent valve crack pressures are imminent.	
	29	Monitor: TANK PRESSURE-O ₂ (H ₂)-1 & 2 TANK QUANTITY- O ₂ (H ₂)-1 & 2			
		(a) Pressure decreases in 1 tank	→	(29a) Mission constraint is quantity remaining in normal tank.	(29a) Tank outlet line blocked.
		(b) Press decreases in both tanks &			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
		(1) $O_2(H_2) > 950$ psia (270 psia)	30		(29.b.1) Cryogenic control circuitry or insulation degradation, or a combination of high heat leak influence and low demand.
		(2) 800 psia (210 psia) $< O_2(H_2) < 950$ psia (270 psia)		(29.b.2) The minimum dQ/dM region may be defined as the region of tank densities where in design pressures may be maintained by tank heat leak only. The following tank densities correspond approximately to entry of min. dQ/dM region. H_2 <u>15</u> lbs/tank O_2 <u>135</u> lbs/tank	
		(a) In min. dQ/dM region	27		
		(b) Outside min dQ/dM region	32		
	30	Repeat purge if required	29	(30) If normal purging of fuel cells does not sufficiently decrease pressure, continuous purging is an option or increasing cabin pressure (O_2 only)	
		(a) Pressure decreases			
		(b) Pressure high	30 →		(30b) Insulation degradation
	31	Power up ($\approx 2.5\Delta$ amps per fuel cell) e.g. Two inverters, S-Band high mode, battery charger		(31) These indicated loads will probably provide sufficient increase in demand	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
		(a) Pressure stabilizes	→	(31a) Maintain present minimum load requirements until tank densities are approximately: O ₂ : 15 lbs/ft ³ H ₂ : 1.0 lbs/ft ³	(31a) Predominant heat leak influence
		(b) Pressure increases steadily	35 →		(31b) Excessive heat leak-possible insulation degradation
	32	Manually maintain normal pressure & quantity balance	33		
	33	Monitor - TANK PRESSURE - O ₂ (H ₂) - 1(&/or 2)			
		(a) Pressure remains normal	34	(33a) Loss of automatic pressure control necessitates use of normal control	(33a) Motor &/or pressure switch failure.
		(b) Pressure increases			
		(1) In one tank	34		(33.b.1) Insulation degradation
		(2) In both tanks	35	(34.b.2) Crew option to manually or automatically control tank pressure	(33.b.2) Combination of high heat leak & low demand
	34	Continue manual pressure control			
	35	Increase power &/or purge as required to control pressure below C/W upper limit			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
F/C 1 (2 or 3) Light Illuminates	1	FUEL CELL INDICATORS - 1(2 or 3)			
	2	Survey F/C meters & annunciators			
		a. FUEL CELL MODULE TEMP COND EXH - High	1.00	$T_{CE} \geq 175^{\circ}\text{F}$ (Spec)	
		b. FUEL CELL MODULE TEMP COND EXH - Low	2.00	$T_{CE} \leq 152^{\circ}\text{F}$ (Spec)	
		c. Fuel cell 1 (2 or 3) - CIR & SEP MOTORS (AC) - C/B - OPEN	3.00	May occur independent of F/C 1, 2, or 3 light.	
		d. FUEL CELL FLOW - $\text{O}_2(\text{H}_2)$ - High	4.00	Flow ≥ 1.276 lb/hr (.1606 lb/hr) (Spec)	
		e. FUEL CELL FLOW - $\text{O}_2(\text{H}_2)$ - Low	5.00	Flow $\leq .140$ lb/hr (.018 lb/hr) (Spec)	
		f. PH HI-striped	6.00	C/W trigger values ph ≥ 9.0 (Spec)	
		g. O_2 REG OUT PRESS HI-Striped	7.00	O_2 press ≥ 75 psia (Spec)	
		h. H_2 REG OUT PRESS HI-Striped	8.00	H_2 press ≥ 75 psia (Spec)	
		i. O_2 REG OUT PRESS HI & H_2 REG OUT PRESS HI - STRIPED	9.00	N_2 Press ≥ 70 psia (Spec)	
		OR O_2 REG OUT PRESS HI & H_2 REG OUT PRESS HI & N_2 REG OUT PRESS HI - STRIPED			
		j. F/C RAD TEMP LOW - Striped	10.00	Temp $\leq -30^{\circ}\text{F}$ (Spec)	
		k. FUEL CELL MODULE TEMP SKIN Low	11.00	$T_{SKIN} \leq 360^{\circ}\text{F}$ (Spec)	
		l. FUEL CELL MODULE TEMP SKIN High	12.00	$T_{SKIN} \geq 500^{\circ}\text{F}$ (Spec)	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
(a) FUEL CELL MODULE TEMP-COND EXH HIGH	1.00				
	1.01	Monitor - FUEL CELL - 1, 2 & 3 - Module temp - COND EXH		C/W trigger value is 175° F. MSFN verification necessary for C/W failure.	
		a. 1 fuel cell affected	1.02		
		b. 3 fuel cell affected	1.03	(1.01b) $T_{CE} \geq 170^{\circ}\text{F}$ on fuel cells considered "high".	
CAUTION: DO NOT EXCEED $T_{CE} = 200^{\circ}\text{F}$ FOR ANY LENGTH OF TIME TO PREVENT H_2 PUMP FAILURE					
	1.02	Monitor - Fuel cell - 1 (2 or 3) Module temp - CONDEXH & skin			
		a. T_{CE} rises to 190° within approximately 10 to 15 min. T_{SKIN} increases after 15 minutes.	1.06	(1.02a) This set of symptom is indicative of limited, but serious flow restriction of coolant - some heat is still being transferred to the second- ary loop. When flow is com- pletely stopped, C/B may, in time, open. When flow is stopped & H_2 pump is operating, T_{CE} will rise sharply ($\approx 8^{\circ}/\text{min}$) followed by an increase in T_{SKIN} within 15 to 20 minutes.	(1.02a) Coolant flow restriction or leak- age or pump stalled.
		b. T_{CE} rises steadily for normal T_{SKIN} range.	1.03	(1.02b) Steadily rise defined as ($.5^{\circ}$ to $2^{\circ}/\text{min}$). There may be 15 minutes to an hour (at a steady power level) to detect a small but off - nominal increase in T_{SKIN} . The time interval is dependent upon the power level.	(1.02b) Secondary bypass valve or minor flow restriction.
	1.03	FUNCTION SELECT - <u>A</u>	1.04		
PREPARED BY: <i>J. Padelford</i> <i>H. K. Kelly</i> <i>R. E. Doherty</i>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
(a) continued	1.04	TEST SELECT - 10 (11 or 12)	1.05		
	1.05	Monitor EPS RAD OUT TEMP			
		(a) Normal	1.07 →	(1.05a) Normal operating boundaries: .6V (-10°F) to 2.0v (+90°F)	<i>Minor</i> (1.05a) Minor flow restriction.
		(b) High and increases with T_{CE}	1.07 →	(1.05b) The T_{CE} will follow any increase or decrease in RAD OUT TEMP if secondary bypass valve failed in 100% bypass position.	(1.05b) Secondary bypass valve failed in 100% bypass position.
	1.06	Monitor - FUEL CELL -1,2,&3 - Module temp - cond exh & skin			
		(a) T_{CE} rises rapidly & T_{SKIN} rising on 1 or more F/C's after 15 minutes.	→	(1.06a) Rapid rise of T_{CE} defined as 2 → 8°/minute. T_{SKIN} may rise within 20 minutes for a steady power level. This combination of symptoms is indicative of improper coolant flow stalling the three glycol pumps. The cause of the improper coolant flow is common to all three fuel cells. The mission constraint may consider faulty fuel cells useful for reentry burn or until T_{CE} meets the above constraints. After T_{CE} exceeds 299°F the H_2 pumps will seize (at same unpredictable time or temperature) but further use of fuel cells is available. An SPS deorbit could be supported with continuous purge & immediate entry into deorbit procedures.	(1.06a) Glycol pumps stalled.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
(a) continued		(b) T_{CE} high steady or slowly increasing (all fuel cells)	→	(1.06b) This combination of symptoms necessitates a powered up configuration. Symptom may be corrected by powering down when convenient.	(1.06b) Inadequate glycol to environment heat transfer, e.g. radiator sooting.
	1.07	Open circuit F/C or purge to control T_{CE} below 200°F.	1.08	(1.07) Control of T_{CE} may be accomplished by limited open circuit operation as required to restrain T_{CE} below 200°F.	
	1.08	Continue normal operation with appropriate monitoring.	→		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
(b) FUEL CELL - MODULE TEMP - COND EXH - LOW	2.00			C/W will trigger F/C 1, 2 or 3 light when $T_{CE} \approx 150^{\circ}\text{F}$. If T_{CE} remains low, a performance shift may occur.	
	2.01	Function Select - A TEST SELECT - <u>10, 11 & 12</u> (RAD OUT TEMP)	2.02		
	2.02	Monitor RAD OUT TEMP & FUEL CELL MODULE TEMP - SKIN			
		a. T_{SKIN} rises rapidly on 1 F/C.	2.03	(2.02a) RAD OUT TEMP will go to a stabilized temperature equivalent to the sector ambient. Circuit breaker CIR & SEP MOTORS (AC) should be OPEN or there exists an open circuit condition. T_{SKIN} rapid rise corresponds to 12° to 15° per hour at 1000 watt load on F/C.	<i>H₂ Pump Failure</i>
		b. RAD OUT TEMP low on 1 F/C.	2.05	(2.02b) This failure is detectable in a powered down configuration and T_{CE} is low. Normal operating RANGE: .38V = -20°F 2.0V = $+90^{\circ}\text{F}$ The cond exhaust temp will follow increase or decrease of RAD OUT TEMP in a 100% Bypass position (failure).	(2.02b) Coolant BYPASS valve failed in 100% bypass position.
		c. RAD OUT TEMP $\approx -30^{\circ}\text{F}$ <i>on cell 3 F/C</i>	2.05	(2.02c) Corresponding RAD OUT TEMP C/W limits may follow. Aux DC volts of .3 v corresponds to -30°F . (Note that a low T_{CE} is not necessarily indicative of a cold environment).	(2.02c) Cold environment.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
(b) continued	2.03	Monitor fuel cell performance (affected F/C)			
		a. F/C assuming load	2.04		
		b. F/C current ZERO	2.06		
	2.04	(option) Use continuous purge and/or open circuit to control temperatures until current decays.	2.06	2.04 The affected F/C's life may be extended 6 to 8 hours by controlling T_{CE} below 200°F. The lower the power level the more likely an 8 hour extension may be obtained.	
	2.05	Power up S/C as required to bring temperatures up.	→		
	2.06	Isolate F/C. Ref EPS Symp. No. (f) Step No. <u>6..07.</u>	→		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
✓ (c) FUEL CELL 1. (2 or 3) CIR & SEP MOTORS C/B - OPEN	3.00			Loss of pump will cause con- denser exit temperature to trigger C/W at $T_{CE} = 175^{\circ}\text{F}$	
	3.01	Attempt to reset C/B (a) C/B resets (b) C/B cannot be reset	→		(3.01a) Momentary H_2 pump stall
			3.02	(3.01b) NOTE: Glycol pump and pH sensor will be lost since their AC power to common to the H_2 pump.	(3.01b) Circulation separation pump failure caused by contamination or internal pump failure.
	3.02	Fuel cell pump 1 (2 or 3) - OFF	3.03		
	3.03	Place fuel cell 1 (2 or 3) on open cycle and/or open circuit if capable of supplying power. <i>Continuous purge.</i>		(3.03) Keep fuel cell in reserve. Plan to use with con- tinuous purge any time fuel cell is used. Fuel cell with con- tinuous purge can supply 563 watts indefinitely or 1000 watts for short periods.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
d. FUEL CELL FLOW -- O ₂ (H ₂) - Hi	4.00			<p>High flowrate C/W limits are:</p> <p>H₂: F/C 1 = .161 lb/hr F/C 2 = .162 lb/hr F/C 3 = .162 lb/hr</p> <p>O₂: F/C 1 = 1.32 lb/hr F/C 2 = 1.30 lb/hr F/C 3 = 1.32 lb/hr</p> <p>Procedure applicable to conditions of high flowrate independent of those occurring during purge. H₂ flow Hi C/W may come on during purge.</p>	
	4.01	Cycle FUEL CELL 1 (2 or 3) - O ₂ (H ₂) - <u>PURGE</u> , several times & return to <u>OFF</u>			
		<p>(a) Flowrate returns to normal</p> <p>(b) Flowrate remains high</p>	<p>→</p> <p>→</p>	<p>(4.01a) Subsequent purges may, again, result in valve seat remaining open.</p> <p>(4.01b) Crew - MSFN option to shutdown <u>generate</u> F/C based on:</p> <p>(1) Performance of remaining 2 F/C's, & condition of batteries.</p> <p>(2) Time required to complete mission vs. cryogenic quantity remaining</p>	<p>(4.01a) Purge valve seat open</p> <p>(4.01b) Faulty purge valve, or regulator vent valve, or fuel cell assembly leak. The latter is possible but remote.</p>
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
✓ (e) FUEL CELL 1 (2 or 3) FLOW O ₂ (H ₂ - LOW)	5.00			C/W trigger limits are (actual): F/C 1: .013 lb/hr H ₂ .14 lb/hr O ₂ F/C 2: .018 lb/hr H ₂ .11 lb/hr H ₂ F/C 3: .018 lb/hr H ₂ .14 lb/hr H ₂	
	5.01	Verify FUEL CELL 1 (2,3) REACTANTS SW - <u>ON</u>	5.02	Verify flag - gray.	
	5.02	FUNCTION SELECT - <u>A</u>	5.03		
	5.03	TEST SELECT - <u>4(5,6)</u> or <u>7(8,9)</u>	5.04		
	5.04	O ₂ (H ₂) REGULATOR OUTLET PRESSURE (a) Normal (b) Low	5.05	Normal regulator pressures: O ₂ : 62 PSIA (4.13V) <u>H</u> O ₂ : 60.5 PSIA (4.03V) → (5.04b) Imminent loss of fuel cell 1 (2,3) expected. If H ₂ regulator pressure is low, fuel cell should be shut down immediately to prevent flooding (possible KOH contamination.) Refer to EPS symptom (f) step 6.07 for fuel cell shutdown.	(.5.06b) Blocked supply line (from cryo tank).
CAUTION: DO NOT PURGE TO PREVENT PLUGGING OF COMMON VENT LINE					
	5.05	Monitor FUEL CELL 1 (2,3) performance		Reference V - I curve.	

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
✓ (e) (continued)		(a) Normal performance	→	(5.05a) System normal (correct flow may be estimated from: O ₂ FLOW = 7.9 H ₂ FLOW)	Failed flow indicator
		(b) Abnormal performance	→	(5.05b) Refer to normal procedure "FUEL CELL POWER PLANT PURGING" to attempt to restore normal operation.	Fuel cell degradation

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
(f) F/C 1(2 or 3) pH-Hi- Striped <i>Shut off potable tank inlet</i>	6.00				
	6.01	Monitor F/C performance (Refer to V1 curve)			
		a. Performance Normal	6.02		
		b. Decreasing trend in performance (steady state power)	6.03	(6.01b) Further F/C degradation can be anticipated. The rate will depend on extent of flooding.	(6.01b) Limited electrode flooding
		c. DC amps indicating zero	6.07		(6.01c) Complete fuel cell flooding.
	6.02	F/C performance over 1 hr.			
		a. No decrease	→	(6.02) If KOH (limited) is being transferred to H ₂ line without significant loss of performance then it will do so at unpredictable intervals. This is indicative of small quantities being transferred and it is not a critical situation as long as the ph of the water gun output does not exceed ~11 ph. If problem is transient, dilution will allow F/C 1(2 or 3) light to extinguish.	(6.01a) C/W failure.
		b. Decrease in performance	6.01b		
CAUTION: DO NOT PURGE F/C IF KOH FLOODING IS SUSPECTED. Plugging of common vent line may result.					
	6.03	FUNCTION SELECT-A	6.04		
	6.04	TEST SELECT - <u>7(8 or 9)</u>	6.05		
	6.05	Monitor H ₂ Reg out press			
		a. Reg out press normal	6.06	(6.05a) 4.2V corresponds to 63 psia regulated pressure.	(6.05a) Limited KOH flooding due to internal F/C rupture.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
(f) continued		b. Reg out PRESS LOW	6.06	(6.05b) This failure of regulator is extremely remote.	(6.05b) Limited KOH flooding due to LOW supply press (reg.)
	6.06	Continue use of F/C until F/C current zero.	→ (6.07)	(6.06) Note that step 6.01b expresses F/C output exist. In either case, (6.05a or 6.05b) there exists 1 to 2 hours of F/C use, depending on S/C power level. When F/C current zero continue to step 6.07.	
Loss of F/C output	6.07	MAIN BUS TIE - <u>BAT A & C</u> - <u>BAT B & C</u>	6.08	(6.07) Monitor PH - (Ref. ECS procedure No. <u>6.07</u>) The initial F/C - Bus configuration assumed is:	
	6.08	Tie two normal F/C's to parallel main buses A & B.	6.09	F/C 1 - MNA - ON F/C 2 - MNA - ON F/C 3 - MNA - OFF	
	6.09	Remove faulty F/C from main bus(es).	6.10	F/C 1 - MNB - OFF F/C 2 - MNB - ON F/C 3 - MNB - ON	
	6.10	Fuel cell 1 (2 or 3) H ₂ O ₂ Valve C/B - <u>CLOSED</u> .	6.11		
	6.11	F/C 1 (2 or 3) - (faulty F/C) H ₂ O ₂ REACTANTS - <u>OFF</u> .	6.12		
	6.12	FUEL CELL PUMP - 1 (2 or 3) - <u>OFF</u>	6.13		
	6.13	Open FUEL CELL 1 (2 or 3) - C/B's	6.14		
	6.14	Configure 1 fuel cell to MNA & 1 fuel cell to MNB.	6.15		
	6.15	(Option) MAIN BUS TIES - <u>OFF</u> .	→	(6.15) Batteries should be tied during high power levels.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
(g) O ₂ REG OUT PRESS Hi-Striped	7.00				
	7.01	DC INDICATOR sw - FUEL CELL	7.02	This symptom may be caused by either an actual O ₂ regulator failure or an N ₂ regulator failure. This is due to the fact that O ₂ press is referenced 11 psi above N ₂ press and the 75 psia O ₂ C/W trigger value is reached before the N ₂ C/W trigger value of 70 psia.	
	7.02	Monitor fuel cell performance (Ref. VI curves)			
		(a.) Performance Normal	7.04		
		(b.) Performance Abnormal (current decreasing rapidly or zero)	7.03 →		(7.02b) O ₂ regulator failure.
	7.03	Shutdown fuel cell (Ref EPS sym. (a) STEP 1.07)	→	(7.03) Loss of one fuel cell the C/W trip limit of 75 psi also corresponds approximately to the point where fuel cell flooding can be anticipated.	
	7.04	FUNCTION SELECT - <u>A</u>	7.05		
	7.05	TEST SELECT - <u>1</u> (2 or 3)	7.06		
	7.06	MONITOR N ₂ REG OUT PRESS			
		(a.) Normal	→	(7.06a) Normal N ₂ Reg out press- 53 psi (3.55V). Loss of O ₂ C/W flag (except sensor failure) necessitates use of aux DC volt-meter to monitor O ₂ regulator performance.	(7.06a) O ₂ C/W circuitry failure.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
(g) continued		(b.) High	→	(7.06b) Maximum pressure tolerance of fuel cell assembly permits N ₂ regulator failure with O ₂ & H ₂ pressures following. This fuel cell will subsequently run with higher than normal skin temp and consumption. Its efficiency will probably improve.	(7.06b) N ₂ regulator failure.

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
✓h. H ₂ REG OUT PRESS ² HI - Striped	8.00				
	8.01	DC INDICATORS SW - <u>FUEL CELL</u> <u>1(2 or 3)</u>			
	8.02	FUNCTION SELECT - <u>A</u>	8.03		
	8.03	TEST SELECT - <u>7, 8 or 9</u>	8.04		
	8.04	Monitor: DC AMPS meter & H ₂ regulator pressure			
		a. Regular pressure indicates high, DC AMPS indicating a rapid decrease in F/C output or zero.	8.05 →	(8.04a) Continued use of fuel cell will eventually cause its failure.	(8.04a) H ₂ regulator failure.
		b. Regular pressure indicates high, low or erratic, and no decrease in amperage.	→	(8.04b) Loss of C/W annunciator necessitates use of AUX DC VOLTS meter to monitor H ₂ regulator performance.	(8.04b) C/W circuit failure.
	8.05	Shutdown fuel cell (Ref. EPS symp. No.(f)Step 6.07	→		

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
i. O ₂ REG OUT PRESS Hi & H ₂ REG OUT PRESS Hi flags striped or O ₂ REG OUT PRESS Hi & H ₂ REG OUT PRESS Hi & N ₂ REG OUT PRESS Hi flags-striped	9.00				
	9.01	DC INDICATORS - <u>FUEL CELL 1(2or3)</u>	9.02	N ₂ REG OUT PRESS flag will follow an O ₂ flag actuation in a short time.	
	9.02	Monitor fuel cell performance (Ref. VI curves) a. Performance normal or improving.	→	(9.02a) N ₂ regulator failure will not fail fuel cell unless either the O ₂ or H ₂ regulator fails to follow the increase in reference pressure. The increased reference pressure may increase the efficiency of the F/C and therefore it will assume more load than it has previously. The load sharing and respective consumption data should be adjusted accordingly. The situation is not critical.	(9.02a) N ₂ regulator failure.
		b. Performance abnormal (current rapidly decreasing or zero)	9.03 →		(9.02b) Double or triple failure of N ₂ and either H ₂ or O ₂ regulators failed or all regulators failed
	9.03	Shut down fuel cell (Ref EPS symp. (f) step <u>16.07</u> .			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
j. F/C 1 (2 or 3) RAD OUT TEMP - LOW	10.00			Flag will trigger at -37°F, -39°F, and -42°F for F/C 1, 2, or 3 respectively. The condenser exhaust temp may trigger C/W (150°F) before the radiator glycol reaches the above trip valves.	
	10.01	Monitor T _{CE} & T _{SKIN}			
		(a) Normal	10.02		
		(b) Abnormal		(10.01b.1) Ref. EPS symptom No.	
		(1) T _{CE} & T _{SKIN} high	→	(a) FUEL CELL MODULE TEMP-COND EXH HIGH	
		(2) T _{CE} - low & T _{SKIN} - high	→	(10.01b.2) Ref EPS symptom No.	
	10.02	FUNCTION SELECT - <u>A</u> TEST SELECT - <u>10, 11, & 12</u>	10.03	(b) FUEL CELL MODULE TEMP-COND EXH LOW	
	10.03	Monitor Rad out temps			
		(a) 1 F/C indicates low Rad out temp	→	(10.03) 1 F/C low Rad out temp compared to remaining two and T _{CE} & T _{SKIN} normal is indicative of an indicator failure,	(10.03a) Indicator failure
		(b) 3 F/C's Rad out temp low	10.04		(10.03b) Cold environment
	10.04	Power up S/C as req'd to maintain temperatures.	→	(10.04) Positioning S/C with bay 4 towards sun is an option.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
✓ (k) FUEL CELL 1 (2 or 3) MODULE SKIN TEMP LOW (<375°F)				Inline heater maintains skin temp 375-395°F. Performance degrades significantly below this range.	
	11.01	Monitor fuel cell 1 (2 or 3) performance (ref. VI curves)			
		a. Performance normal for indicated skin temp.	11.02 →		(11.01a) Inline heater failure.
		b. Performance higher than normal for indicated skin temp.	→	(11.01b) Fuel cell normal skin temp may be estimated from VI curve.	(11.01b) Fuel cell 1 (2 or 3) skin temp indication failed.
	11.02	If desired: Reconfigure fuel cell bus ties so that fuel cell 1 (2 or 3) is shared between buses.	11.03	(11.02-11.03) Fuel cell recovery possible from skin temp as low as 330°F by increasing load on that fuel cell. MSFN-crew option based on: (1) Performance of remaining fuel cells and condition of batteries. (2) Time required to complete mission vs. cryogenic quantity remaining.	
	11.03	Power up spacecraft	11.04		
	11.04	Fuel cell 1 (2 or 3) module skin temp (a) Increases	→	(11.04a) Increase load allowing fuel cell to recover. Estimated load required to maintain that fuel cell skin temp above 375°F is 20 amps.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
(k) continued		(b) Does not increase & fuel cell 1, (2 or 3) performance does not improve.	→	(9.04b) Fuel cell recovery apparently not possible. Open circuiting by reverse current relay anticipated. Refer to EPS Malfunction Procedure for fuel cell shut down (Sym (f) step 6.07)	

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
(1) FUEL CELL 1(2,3) TEMP SKIN HIGH ($>450^{\circ}\text{F}$)	1200			Normal F/C operating temp. range is 375°F - 450°F , depending upon electrical load. C/W trip values are 360°F and 500°F . FCPP open circuit or continuous purge are options. Prolonged operations above 500°F will result in FCPP failure (time and/or temp. at which failure will occur are not predictable) a failure of this nature will have no adverse effect on other FCPPs or S/C systems.	
	12.01	Monitor F/C 1, (2,3) performance using V-I curve and temp-skin. a. Performance normal for indicated temp-skin, b. Performance lower than normal for indicated temp.-skin.	→ →	(12.01a) Fuel cell will perform satisfactorily up to C/W trip temp. of 500°F . (However, it is unlikely that 500°F will be reached during flight). (12.01b) Estimated temp-skin (from V-I curve) lower than indicated temp.	Temp-skin sensor failure
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. MN BUS A (B) UNDERVOLT LIGHT-ON DC VOLTS >26V	1	MN BUS A(B) RESET- <u>RESET</u> -(CENTER)			
		a. MN BUS A (B) UNDERVOLT LIGHT-OFF	→		1a. Transient under voltage
		b. MN BUS A (B) UNDERVOLT LIGHT-ON	2		
	2	MN BUS A(B) RESET- <u>RESET</u> -(CENTER) several times.			
		a. MN BUS A(B) UNDERVOLT LIGHT-OFF.	→		2a. Intermittant malfunction of DC undervoltage sensor
		b. MN BUS A(B) UNDERVOLT LIGHT-ON.	3		2b. DC Undervoltage sensor failure
	3	MN BUS A(B) RESET-OFF.			
		a. MN BUS A(B) UNDERVOLT LIGHT-OFF.	4	Loss of MN BUS A(B) C/W under-volt indication.	
	4	Normally maintain DC indicator in MN BUS A(B) position.			
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SYNPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
2. DC VOLTS meter indicates pyro battery A(B) below 35 volts		(When pyro batteries are required)		(Normal pyro open circuit voltage = 36.9 - 37.2 vdc)	Loss of pyro Bat A(B)
	1.	PYRO A(B) SEQ A(B) CIRCUIT breaker - <u>OPEN</u> .	2	(1) Malfunction detected at EPS verification prior to SIVB sep. or G&N. and/or SCS deorbit entry.	Loss of pyro Bat A(B) Internal: - Open circuit - Short circuit - Partial short
	2.	MAIN A(B) BAT BUS A(B) C/B - <u>OPEN</u> .	3	(2) Prepares circuit for BAT BUS A(B) isolation from MAIN BUS A(B) and reduced loading on BAT A(B) to assure voltage is maintained high enough to operate pyros.	
	3.	MAIN A(B) BAT C C/B - <u>CLOSED</u> .	4	(3) Prepares circuit for application of BAT C to MAIN BUS A(B)	
	4.	MAIN B(A) BAT C C/B - <u>OPEN</u> .	5	(4) Prepares circuit so that BAT C cannot be applied to MAIN BUS B(A). This will assure equal depletion of batteries B(A) & C	
	5.	PYRO A(B), BAT A(B) to PYRO BUS TIE C/B - <u>CLOSE</u> .	6	(5) Entry BAT A(B) powering PYRO BUS A(B)	
	6.	Monitor: DC VOLTS METER PYRO BAT A(B) Voltage a) normal >34V b) Low <34V	→	(6) Voltage reading of >34V should be indicated since pyro BUS A(B) power is now furnished by entry BAT A(B) with PYRO BAT A(B) isolated from PYRO BUS A(B).	6a confirms loss of pyro battery 6b Shows partial short on pyro bus
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
3. BATTERY CHGR OUTPUT CURRENT drops to ZERO & circuit breakers BATTERY CHARGER MN A & B - OPEN.	1.	(Attempt) Reset Breakers. (a) Breakers reset, (b) Breakers OPEN.	→ 2	(1b) Loss of Battery Charging capability.	(1a) Transient battery charger overload (1b) Distribution diode short to ground or Batt Chrgr internal short.
	2.	BATTERY CHARGER-OFF	→	(2) ΔV maneuver preparations should be adjusted to ensure F/C SKIN TEMP of approximately 430° F during gimbaling, (to conserve battery energy). Powering down unnecessary loads just prior to burn is an option. Note maximum loading of F/C's during preparations (4 to 6 hours) is necessary to achieve above SKIN TEMP.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
4. BATT CHGR out-put CURRENT ZERO (in all switch positions)	1.	BATTERY CHARGER-OFF,	→	(1) Loss of Battery Charging Capability. Δ V maneuver preparations should be adjusted to ensure F/C SKIN TEMP of 430° F during gimbaling, (to conserve battery energy). Powering down unnecessary loads just prior to burn is an option. Note maximum loading of F/C's during preparations (4 to 5 hours) is necessary to achieve the above SKIN TEMP.	(1) Control relay K4 failure.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
5. DC INDICATORS- BAT BUS A(B), DC VOLTS <u>27-30</u> & DC AMPS <u>>ZERO</u> WITH BUS SWS OFF				DC VOLTS should read <u>34-38</u> & DC AMPS should read <u>ZERO</u> .	
	1	MAIN A(B) BAT BUS A(B) CB <u>-OPEN</u> .			
		a. DC VOLTS meter - <u>34-38</u> & DC AMPS meter - ZERO.	2	(1a.) Indicates Bat A(B) was still connected to Main Bus A(B) via MAIN BUS TIE BAT A & C C(BAT B & C) motor switch closed contact; circuit breaker in series with contact has dis- connected Bat (A(B) from Main Bus A(B).	(1a) MAIN BUS TIE BAT A & C (BAT B & C motor switch.
	2	DC INDICATORS - BAT C.			
		a. DC VOLTS meter - <u>34-38</u> & DC AMPS meter - ZERO.	3	2a. Indicates Bat C not con- nected to either Main Bus A or B. This is a normal situa- tion since MAIN A BAT C & MAIN B BAT C CB's are normally open.	
	3	MAIN B(A) BAT C CB - <u>CLOSED</u> .			
		a. DC VOLTS meter - 27-30 DC AMPS meter - greater than ZERO,	4	3a. Indicates Bat C is con- nected to Main Bus B(A) via MAIN BUS TIE BAT A & C (BAT B & C) motor switch closed contact; circuit breaker in series with contact has connected Bat C to Main Bus B(A). This step verifies Bat C functional.	
	4	MAIN B(A) BAT C CB - <u>OPEN</u> . (see page 35)	→	4. This places circuit breaker back in standard configuration.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
<p><u>Warning:</u> Future connect or disconnect of Bat A(B) to Main Bus A(B) & Bat C to Main Bus B(A) will have to be accomplished with MAIN A(B) BAT BUS A(B) & MAIN B(A) BAT C circuit breakers. Batteries A(B) & C cannot be recharged since the failed motor switch now has an open pair auxiliary contacts which prevent the charger from feeding Batteries A(B) & C.</p>					
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
6. Battery Charger Voltage 40 vdc and Current 0 when charging Battery A(B,C)	1	Cycle BATTERY CHARGER SW-A,B, and C, and read DC VOLTS AND DC AMPS.		Voltage should be >32 but <40 and current should be >.4 but <2.8 amps Assumes DC INDICATOR SW-BAT CHARGER.	
		a. DC VOLTS 40 vdc and DC AMPS 0 for A, B, and C.	→	(1a.) Capability to charge Batteries and to check Battery charge lost.	(1a.) Battery charger circuit open circuited
		b. DC VOLTS 40 vdc and DC AMPS 0 Battery A,(B,C) only.	→	(1b.) Capability to charge bat- tery A(B,C) and the check Bat- tery A(B,C) charge lost.	1b. Charging circuit for Battery A(B,C) is open circuited.
		c. DC VOLTS 40 vdc and DC AMPS 0 for A and C(B and C).	2	1c. Capability to change Bat- teries A and C(B and C) and to check Battery A and C (B and C) charge lost.	(1c.) Motor switch failed.
	2	MAIN A-BAT BUS A (MAIN B BAT BUS B) CB - OPEN.	→	2. CB must be used to isolate Battery A(B) from Main DC bus	

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
7. INV 1 (2 or 3) TEMP. <u>2</u> 190°F (MSFN Monitoring Capability)	1	Set dual inverter configuration Ref EPS Norm. Proc No. _____	2	C/W Trip valves: Inv 1, 2, 3 Temp. = 241±30°F	
	2	Balance and hold loads steady for 10 minutes.	3	The thermal response time of Inverter heating from 155°F to 190°F is sufficient to ensure MSFN monitoring with the exception of rapid, total loss of coldplate cooling. Normal Inverter thermal response will be from ambient to 125°F in approximately 30 to 40 minutes. Setting a second inverter to load and its temperature increases to 125°F within 10 to 30 minutes is indicative of coldplate problems (assuming proper inverter voltage and frequency).	
	3	Record Mission Elapsed Time Approximate history of AC Load Switching during the 5 minutes prior to symptom activation. ECS RADIATOR OUTLET TEMP.			
		(a) ECS RADIATOR OUTLET TEMP above 97°F (Ref. ECS SYMPTOM NO. _____)		(3a) The Inverters may be rotated as required to keep temp. below the C/W trip values. If the above C/W trip valves are reached the inverter(s) will fail within 30 minutes if temperature cannot be decreased.	(3a) ECS Glycol Pump failure or extensive leakage.
		(b) ECS RADIATOR OUTLET TEMP Below 97°F.	4		(3b) Rapid AC Load Switching or internal inverter failure.
	4	At end of 10 minutes specified in step 2 - Communication loads and Battery charger to normal inverter's bus	5		

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
	5	MSFN INV 1, (2 or 3) Temp monitoring indicates (a) Inv 1(2 or 3) Temp $\leq 160^{\circ}\text{F}$ (b) Inv 1(2 or 3) Temp does not show gradual decreasing trend at end of 2 hours.	6 7	(5) Note there is no ΔP measurement across the Inverter Coldplate. If internal inverter failure were the cause then AC Volts & Freq would indicate abnormal before inverter could reach these temperatures.	(5b) Coolant flow restriction within single Inverters Coldplate.
	6	When MSFN indicates inverter temperature is approximately 160°F or less, <u>balance loads & hold steady for at least 1 hour</u> (a) Faulty inverter temperature stabilizes at a nearly equal temperature of normal inverter. (b) Faulty inverter temperature shows increasing trend.	→ →	(6) Temperature of both Inverters should stabilize between 125°F & 155°F . There is a high probability of failure of overheated inverter but it may be used with dual inverter configuration and with a minimum of load switching. (6a) Continue mission schedule using affected inverter as required for dual inverter configuration. (6b) Note the original symptom does NOT presume faulty voltage or frequency. This combination of symptoms is remote. MSFN-Crew option to shut-down and isolate faulty inverter depending on sensitivity of thermal control.	(6a) Rapid AC Load Switching at high power levels. (6b) Internal inverter problem dependent on load demand.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
	7	Shutdown & isolate faulty INVERTER.	→	Establish single or dual inverter configuration as required by mission schedule.	

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
8. ⁸ AC BUS FAIL LIGHT ILLUMINATED	1	AC BUS 1 (2) RESET - <u>RESET</u> (Center)		(IF AC BUS OVERLOAD LIGHT ILLUMINATES AT ANY TIME DURING THESE PROCEDURES, REVERT TO PROCEDURES UNDER AC SYMPTOM 3.)	
		(a) Symptoms extinguish	2		
		(b) Symptoms re-illuminate	3	<i>where is this?</i>	
	2	Survey for OPEN C/B			
		(a) C/B Open	→		(2a) Load short.
		(b) C/B NOT OPEN	→		(2b) Transient overload.
	3	AC Indicators Bus 1 (&/or 2) - Φ A, B, C	4		
	4	MONITOR: AC VOLTS AC FREQ			
		(a) AC VOLTS & AC FREQ Normal.	→	(4a) Option to set AC BUS RE- SET -- OFF. This will permit light to be extinguished but also removes capability of subsequent C/W indication and automatic disconnect of In- verter by Over & Under-Voltage Sensing Unit.	
		(b) AC VOLTS < 90 Vac AC FREQ < 380 cps	5		
		(c) AC VOLTS < 95 ±3 AC FREQ = 400 cps	6		(4a) Inverter Under- voltage.
	5	AC INDICATORS BUS 1 (or 2) - Φ A. AC BUS 1 (or 2) RESET - RESET. MONITOR AC VOLTS.		5. Monitor AC Volts with "Bus at Reset". CAUTION ONLY HOLD RESET SW IN RESET POSITION MOMENTARILY SINCE HIGH VOLTAGE MAY BE APPLIED TO AC LOADS.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
		(a) AC VOLTS >128 Vac	6		(5a) Inverter Over-voltage.
	6	Determine Inverter Configuration			
		a. Single Inverter Conf.	→	Ref EPS Norm. Proced. No.	
		b. Dual Inverter Conf.	→	Ref EPS Norm. Proced. No.	
		c. Inverter 3 Required.	→	Ref EPS Norm. Proced. No.	

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
9. AC BUS 1(2) FAIL LIGHT Illuminated AC BUS 1 (2) OVERLOAD light illuminated				Overload light could take 4 to 20 seconds to illuminate after illumination of AC Bus Fail Light.	
	1.	Monitor: -AC volts Frequency.		(1) Frequency should be 400 ± 2 cps with CTE; 400 ± 7 cps with internal oscillator. AC Volts should be $115 \pm 1, -1.5$ v.	
		a. AC volts & frequency normal.	21		(1a) Sensing unit failure.
		b. AC volts & frequency abnormal.	2		
	2.	AC BUS 1 (2) RESET - <u>RESET</u> (center).			
		a. Symptoms extinguished.	→	(2a) Proceed with mission schedule.	(2a) Transient overload condition.
		b. Reillumination of symptoms.	3	(2b) AC Bus 1 (2) FAIL light and AC Bus 1 (2) Overload light may or may not illuminate depending on magnitude and duration of overload on inverter.	
	3.	Survey AC Circuit breakers for OPEN breaker.			
		a. Breaker OPEN.	19 →	(3a) <u>Most probable occurrence</u> .	(3a) AC Load failure.
		b. C/B does not OPEN.	4		
	4.	AC BUS 2 (1) Reset - Reset(center)	5	(4) Continue Bus Reset as required to extinguish lamp. There will be a time delay after each reset before re-illumination.	
	5.	Transfer and verify AC loads to normal bus.			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
	13	AC BUS 1(2) RESET - <u>OFF</u>	14		
	14	TELCOM-NONESS - <u>OFF</u>	15		
	15	OPEN C/B's of faulty AC BUS	→	(15) Maintain faulty bus isolated.	
	16	CLOSE C/B GAS ANAL - AC1			
		(a) Symptoms Reilluminate	18		(16a) Gas Anal & C/B failure.
		(b) Symptoms remain extinguished	17		
	17	CLOSE C/B's CRYOGENIC FAN MOTORS 1(2) - AC1(2) A , B , C			
		(a) Symptoms Reilluminate	18		(17a) Cryogenic Fan motor & C/B failure
		(b) Symptoms remain extinguished	→		(17b) ECS RADIATORS VALVE CONTROL & C/B failure.
	18	Isolate faulty load	19	(18) If faulty load detected during load transfer (step isolate by opening respective C/B(s).	
	19	AC BUS 1(2) RESET - <u>RESET</u> (center)	20		
	20	Reconfigure AC loads to normal positions (if applicable)	→	(20) If faulty load detected in either step 16 or 17 then leave appropriate breaker open.	
	21	AC BUS 1(2) RESET - <u>OFF</u>	22		
	22	AC INDICATORS - BUS 1 (2) (affected bus)	→	(22) Mission schedule may be continued with use of Indicators to monitor AC BUS 1(2). The C/W capability & the automatic disconnect capability are lost with AC BUS RESET - OFF.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
10. AC BUS 1 & 2 FREQUENCY INDICATES <393 CPS OR >407 CPS SINGLE INVERTER OPERATION	1	PHASE LOCK SW - ON.		(1) Removes CTE signal to inverter. Inverter on internal oscillator.	
	2	Verify INV PHASE SYNC PWR CB'S - OPEN.			
		a. Freq within 393 to 407 cps.	→	Inverter is driven off 400 CPS by out of tolerance CTE signal. Replace INVERTER 1(2) with INVERTER 2(1).	2a. CTE malfunction.
		b. Freq 393 CPS or 407 CPS	3		
	3	PHASE LOCK SW - OFF.	4		
	4	AC BUS 1 & 2 RESET - <u>OFF</u>	5		
	5	AC INVERTER 2(1) - MAIN B(A) - <u>ON</u> .	6		
	6	AC INVERTER 1(2) - AC BUS 1 & 2 - <u>OFF</u> .	7		
	7	AC INVERTER 1(2) - MAIN BUS A(B) - <u>OFF</u> .	8		
	8	AC INVERTER 2(1) - AC BUS 1 & 2 - <u>ON</u> .	9		
	9	AC BUS 1 & 2 RESET - <u>ON</u> .	10		
	10	a. FREQ - 400 CPS.	→		9a. Inverter 1(2) oscillator failure.
		b. FREQ <393 CPS or >407 CPS.	11	Since second inverter indicates same symptoms, this is indicative of frequency meter failure. If voice communication available verify telemetry readings with MSFN.	9b. Frequency meter failure.
	11	MSFN to closely monitor frequency.			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
11. AC BUS 1(2) FAIL LIGHT illuminated AC BUS 1(2) Voltage <90v (Dual Inverter)	1	AC BUS 1(2) RESET - <u>RESET</u> (center).			((1a.) Transient, ((1b.) Inverter overvoltage. ? <i>(as is it under voltage)</i>
		a. Symptoms OUT.	→		
		b. Symptoms Light,	2		
	2	AC INVERTER 1(2) AC BUS 1(2)- <u>OFF</u> .	3		
	3	AC INVERTER 1(2) MNA(B) - <u>OFF</u> .	4		
	4	AC BUS 1(2) RESET - <u>OFF</u> .	5		
	5	CB INV SYNC PWR (3) - <u>CLOSE</u> .	6		
	6	PHASE LOCK - <u>ON</u> .	7		
	7	AC INV 3 - MNA (B).	8		
	8	AC INV 3 AC BUS 1(2) - <u>ON</u> .	9		
	9	AC BUS 1(2) RESET - RESET (Cntr).	10		
	10	Verify AC 1 & 2 Bus Voltages & Frequencies.	11		
11	PHASE Lock - <u>OFF</u> .	12			
12	CB INV SYNC PWR (3) - <u>OPEN</u> .	→			

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
12 AC BUS 2(1) FAIL Light ON after AC INVERTER 2(1) is applied to AC BUS 2(1).	1	AC BUS 2(1) RESET - <u>RESET</u> (Cntr) several times consecutively.		Single to dual switchover assumed from Inverter 1(2) on AC BUS 1 & 2 to Inverter 1 on AC BUS 1 and Inverter 2 on AC BUS 2.	
		a. AC BUS 2(1) FAIL light OUT.		(1a.) This failure is likely be occur again.	(1a.) Transient condition.
		b. AC BUS 2 (1) FAIL LIGHT ON;			
		1. AC BUS 2(1) volts normal.	13		(1b.1) Sensing Unit
		2. AC BUS 2(1) volts zero.	2		(1b.2) Motor Switch
	2	AC INVERTER MNB(A) - <u>OFF</u> .	3		
	3	AC INVERTER AC BUS 2(1) - <u>OFF</u> .	4		
	4	AC BUS 2(1) RESET - <u>OFF</u> .	5		
	5	CB INV SYNC PWR (3) - <u>CLOSE</u> .	6		
	6	PHASE LOCK - <u>ON</u> .	7		
	7	AC INVERTER 3 - MNB(A).	8		
	8	AC INVERTER 3 AC BUS 2(1) - <u>ON</u> .	9		
	9	AC BUS 2(1) RESET - <u>RESET</u> (Cntr).	10	10. Inverter 3 is now powering AC BUS 2(1).	
	10	Verify AC BUS 1 & 2 voltages and Frequencies.	11		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
12. (Cont)	11	PHASE LOCK - <u>OFF</u> ,	12	(14.) The C/W indication and automatic disconnect capability is not functional with AC BUS 2(1) RESET - OFF	
	12	CB INV SYNC PWR (3) - <u>OPEN</u> ,			
	13	AC BUS 2(1) RESET - <u>OFF</u> ,	14		
	14	AC INDICATORS - AC BUS 2(1),			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
13. MN BUS A & B UNDERVOLT light illuminates AC BUS 1 Fail light illuminates AC BUS 2 Fail light illuminates F/C BUS disconnect light illuminates SINGLE INVERTER CONFIGURATION CAUTION: Note that AC BUS OVERLOAD light is not illu- minated. Do not use this procedure if the overload light is illuminated	1	AC INVERTER 1(2) - MNA(B) - OFF	2	1. Removal of shorted inverter initially will prevent DC BUS problems. It will take 3 to 9 seconds for 70 amp power breaker to an inverter to open. MN BUS B(A) volts will recover in APPROX 1 SECOND after short. The following F/C to BUS configuration is assumed: F/C 1 - MNA - ON F/C 1 - MNB - OFF F/C 2 - MNA - ON F/C 2 - MNB - ON F/C 3 - MNA - OFF F/C 3 - MNB - ON	INVERTER DC INPUT shorted.
	2	AC INVERTER 2(1) - MNB(A) - ON	3		
	3	AC BUS 1 - RESET - OFF	4		
	4	AC INVERTER 1(2) - AC BUS 1-OFF	5		
	5	AC BUS 2 - RESET - OFF	6		
	6	AC INVERTER 1(2) - AC BUS 2-OFF	7		
	7	AC INVERTER 2(1) - AC BUS 1 - ON	8		
	8	AC INVERTER 2(1) - AC BUS 2 - ON	9		
	9	AC BUS 1 - RESET - RESET - (Center)	10		
	10	AC BUS 2 - RESET - RESET - (Center)	11		
	11	F/C 2 - MAIN B(A) - ON	12		
	12	MAIN BUS A(B) RESET - <u>RESET</u>	13		
	13	Verify normal systems operation.	→		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
14. MN BUS A & B UNDERVOLT light illuminates AC BUS 1(2) FAIL light illuminates F/C BUS DISCONNECT Light ON DUAL INVERTER CONFIGURATION Caution: Note that AC BUS OVERLOAD Light is not illuminated in this case.		CAUTION: <u>Total AC POWER LOSS</u> may occur in less than 5 seconds.			<i>Failures:</i> <i>DC Input to Inverter shorted.</i> <i>(bus short or ...)</i>
	1	AC BUS 1(2) RESET Sw - <u>RESET</u> (Centr).	2	This procedure assumes a two inverter configuration at time of failure and the following F/C to Bus configuration: F/C 1 - MNA - ON F/C 1 - MNB - OFF F/C 2 - MNA - ON F/C 2 - MNB - ON F/C 3 - MNA - OFF F/C 3 - MNB - ON	
	2	AC INVERTER 1(2) - MAIN A(B) - <u>OFF</u> .	3		
	3	AC INVERTER 1(2) - AC BUS 1(2)- <u>OFF</u> .	4		
	4	AC INVERTER 3 - MAIN A(B) - <u>ON</u> .	5		
	5	AC BUS 1(2) - <u>RESET</u> - <u>OFF</u> .	6		
	6	AC INVERTER 3 - AC BUS 1(2) - <u>ON</u> .	7		
	7	AC BUS 1(2) RESET Sw - <u>RESET</u> (Center).	8		
	8	F/C 2 - MAIN B(A) - <u>ON</u> .	9		
	9	MAIN BUS A & B RESET Sw - <u>RESET</u>	10		
	10	Verify normal systems operation	11		
11	If appropriate, MAIN BUS TIE - BAT A & C - <u>OFF</u> - BAT B & C - <u>OFF</u>				
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PROCEDURES ENTRY SHEET

9.1.5

TELECOMMUNICATIONS MALFUNCTION PROCEDURES

SYMPTOMS	SYMPTOM NUMBER	STEP	PAGE
ONE CREWMAN HAS DEGRADED OR NO INTERCOM CAPABILITY	1	1	2
ALL CREWMEN HAVE DEGRADED OR NO INTERCOM CAPABILITY	2	1	4
CONTINUOUS BACKGROUND NOISE IN ONE OR MORE CREWMEN'S HEADSET	3	1	4
ONE CREWMAN LOSS OF EITHER OF THE FOLLOWING TELE- COMMUNICATIONS: VHF-AM OR S- BAND	4	1	6
ALL CREWMEN LOSE VHF-AM OPERATION (IN-FLIGHT)	5	1	7
ALL CREWMEN LOSE USBE VOICE OPERATION (MODES A,B1,B2,OR C)	6	1	8
ALL CREWMEN LOSE USBE VOICE OPERATION (MODES D OR E)	7	1	10
MSFN REPORTS VHF-FM TELEMETRY POOR OR LOST	8	1	11
VHF UPDATA AND REAL-TIME COMMANDS NOT RECEIVED BY S/C	9	1	12
S-BAND UPDATA AND REAL-TIME COMMANDS NOT RECEIVED BY S/C (S-BAND VOICE NORMAL)	10	1	14
MSFN REPORTS PARTIAL OR COMPLETE LOSS OF C-BAND TRACKING	11	1	14
MSFN REPORTS TV RECEPTION LOST (OR POOR) (S-BAND) VOICE & DATA NORMAL)	12	1	15
NO VOICE RECORD FLAG INDICATION WHEN ATTEMPTING VOICE RECORDING (INTERCOM NORMAL)	13	1	15
VHF-AM POOR OR LOST AFTER SPLASHDOWN	14	1	17
HF VOICE POOR OR LOST AFTER SPLASHDOWN	15	1	18
MSFN REPORTS LOSS OF VHF-FM DATA AND C-BAND RANGING (VHF- AM AND S-BAND NORMAL)	16	1	19
MSFN REPORTS VHF-FM AND S-BAND PLAYBACK TIM POOR OR LOST	16	1	19

SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. One crewman has degraded or no intercom capability.	1	Audio Center (A/C) POWER sw - Alternate position - (<u>VOX</u> or <u>PTT</u>)			
		(a) Intercom normal - - After switching to PTT - After switching to VOX	→ 2	(1a) Crewman limited to PTT mode of keying. Loss of "hot mike" capability.	(1a) VOX circuit failure.
		(b) No intercom	3		
	2	Key intercom using translational controller PTT button (without speaking.)		(2) This step can be accomplished only by the CP and SP. P should go directly to step 6.	
		(a) No background noise	8 →	(2a) Crewman limited to VOX mode of keying. Loss of VHF-AM and S-Band voice capability.	(2a) A/C PTT circuit failure.
		(b) Background noise present	7 →		(2b) Cobra cable PTT circuit failure.
	3	VHF-AM sw - (A/C) - <u>T/R</u> , verify VHF sidetone.		(3) VHF sidetone can be verified regardless of VHF-AM (MDC-20) switch position.	
		(a) Sidetone normal	4 →		(3a) A/C intercom circuit failure.
		(b) No sidetone	5		

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. (Cont)	4	(a) Use VHF sidetone for intercom or,	→	(4a) All A/C VHF switches must be in T/R position.	
		(b) Cobra cable electrical connector - <u>EMER</u>	→	(4b) Two crewmen must share one A/C. (4a or b) Crewman may use whichever is more desirable.	
	5	Connect and utilize alternate headset		(5) Requires shirtsleeve environment.	
		(a) Intercom normal	→		
	6	(b) No intercom	6		
		Remove diode and filter assembly from cobra cable.			
	7	(a) Intercom normal	→	(6a) Removal of diode and filter assembly will result in increase background noise on intercom and down link voice.	
		(b) Intercom not normal	7		
	8	Connect and utilize spare cobra cable			
		(a) Intercom normal	→		
		(b) No intercom	8		
	8	Cobra cable electrical connector - <u>EMER</u>	→	(8) Two crewmen must share one audio center.	(8) Audio center module failure

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
2. All crewmen have degraded or no intercom capability.	1	INTERCOM sw (ALL) - <u>OFF</u>			
	2	VHF-AM sw (A/C) (ALL) - <u>T/R</u> Verify sidetone. (a) Normal (b) No sidetone	3 → →	<i>not written yet</i> (2b) Refer to EPS malfunction symptom No. _____ (3) Sidetone may be used regardless of VHF-AM sw (MDC-20) position. The use of VOX keying will provide a "hot mike" sidetone intercom and PTT VHF-AM keying.	(2a) Intercom bus shorted to ground (2b) Loss of Flight and Post Landing bus
	3	Use VHF sidetone for intercommunications.			
3. Continuous background noise in one or more crewmen's headset.	1	Verify: S-BAND sw (MDC-23) - <u>MUTE</u> (up)	2	(1) USBE receiver unlock results in similar symptom.	
	2	Individually cycle all PTT buttons (3 cobra cable and 2 hand controller buttons) in sequence. (a) Noise removed (b) Noise continues	3 → 4		(2a) Sticking PTT button
	3	If failure was on cobra cable use spare cobra cable. If failure was on Hand Controller discontinue use of that PTT button.			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE		
3. (Cont)	4	POWER sw (A/C) (All) - <u>PTT</u> (one at a time)					
		(a) Noise removed	→	(4a) Keying limited to PTT mode on failed A/C.	(4a) One A/C VOX circuitry failure (continuous key)		
	5	(b) Noise continues	5				
		All crewmen - all A/C T/R switches (except S-BAND) - <u>RCV</u>					
	6	(a) Single crewman retains noise	6		(5a) Ground in crewman's controller or cobra cable PTT circuitry; ground in A/C keying line		
		(b) All crewmen lose noise	9		(5b) Ground on HF or VHF-AM keying line		
	6	All A/C switches to original configuration (except failed A/C)	7				
	7	Failed A/C - Disconnect cobra cable and connect spare cobra cable.					
		(a) Noise removed	→		(7a) Cobra cable PTT circuit failure		
		(b) Noise not removed	8	(7b) Hand controller failure possible for CP & SP only.	(7b) Hand controller PTT failure, or audio center keying circuit failure		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
3. (Cont)	8	Cobra cable electrical connector - <u>EMER</u>	→	(8) Two crewmen must share one A/C module.	
	9	Any crewman - A/C HF sw - <u>T/R</u> (a) Noise returns	→	(9a) HF usable only in beacon mode. Receive capability lost. Voice recorder will run continuously until end of tape. <u>CAUTION</u> Disconnecting tape recorder connector under power may result in dangerous arcing.	(9a) Ground on HF keying line
		(b) No noise	10		
	10	Any crewman - A/C VHF-AM sw - <u>T/R</u> (a) Noise returns	→	(10a) VHF-AM usable only in duplex mode. (Notify MSFN). RF radiation is present any time that VHF-AM sw (MDC-20) is in <u>T/R</u> position.	(10a) Ground on VHF-AM keying line.
4. One crewman loss of either of the following communications: VHF-AM or S-Band	1	POWER sw - (A/C) - <u>PTT</u>		(1) VHF-AM keyed in PTT mode only.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
4. (Cont)	2	Verify normal intercom.			
		(a) Intercom normal	4		
		(b) No intercom	3		
	3	Follow Telecom procedure, "One crewman has degraded or no intercom" (Symptom No. 1).			
	4	Cobra cable electrical connector - <u>EMER</u>	→	(4) Two crewmen must share one A/C.	(4) A/C module failure
5. All crewmen lose VHF-AM operation (in-flight).	1	Energize USBE in mode A.	2	(1) Backup mode for VHF-AM voice	
	2	VHF-AM RCVR sw - <u>1</u>			
		(a) Signal regained	→	(2a) VHF-AM limited to the simplex mode.	(2a) VHF-AM front-end No. 2 failure
		(b) Signal not regained	3		
	3	VHF-AM RCVR sw - <u>2</u>			
		(a) Signal regained	→	(3a) When switching to No. 2 receiver, ground must be so informed. (MSFN requires a minimum of 5 min. to reconfigure.) MSFN will detect a continuous carrier if VHF keying relay has failed.	(3a) VHF-AM receiver No. 1 failure or VHF-AM keying relay failure (closed)
		(b) Signal not regained	4		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
5. (Cont)	4	VHF ANTENNA sw - Alternate position - (<u>UPPER</u> or <u>LOWER</u>)	5		
	5	Re-orient S/C for optimum antenna coverage, if necessary. (a) Signal regained	→	(5a) VHF voice, VHF-FM, and UHF data limited to one antenna & restricted S/C orientation.	(5a) Upper or lower VHF SCIN antenna failure
		(b) Signal not regained	→ 6	(5b) Voice limited to S-Band.	(5b) VHF-AM system failure
	6	VHF-AM sw (MDC-20) - <u>OFF</u>			
6. All crewmen lose USBE voice. operation (modes A, B1, B2, or C)	1	Verify that A/C S-BAND sw (MDC-23) is <u>not</u> in MUTE (up) position.	2	(1) <u>MUTE</u> (up) position disables S-Band reception.	
	2	Observe S-BAND ANT meter for phase lock. (a) << half scale (b) > half scale	6 3	(2) << half-scale indicates loss or near loss of lock. > half-scale indicates receiver phase lock.	
	3	S-BAND POWER AMPL sw - <u>LOW</u>	4		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
6. (Cont)	4	S-BAND sw - <u>XPONDER PWR AMPL</u>			
		(a) Voice regained	→	(4a) S-Band transmitter limited to operation with power amplifier only.	(4a) Power amplifier by-pass mode failure
		(b) Voice not regained	5		
	5	S-BAND VOICE/TV sw - <u>TV</u>			
		(a) Voice regained	→	(5a) S-Band limited to FM mode. S-Band ranging lost.	(5a) FM mode failure
		(b) Voice not regained	9		
	6	S-BAND ANTENNA sw - Alternate position (<u>UPPER</u> or <u>LOWER</u>)	7		
	7	Re-orient S/C for optimum antenna coverage, if necessary.	8		
	8	Observe S-BAND ANT meter for USBE phase lock.			
		(a) << half scale	10		
		(b) > half scale	→	(8b) S-Band operation limited to one antenna & restricted S/C orientation.	(8b) Upper or lower 2 KMC SCIN antenna failure
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
6. (Cont)	9	Verify CTE operation with MSFN via VHF-AM.			
		(a) CTE normal	10		
		(b) CTE not normal	→	(9b) TIM operation continues, via S-Band or VHF-FM, but may be degraded. Voice limited to VHF-AM.	(9b) CTE failure
	10	Manually change to alternate transponder unit.	11	(10) Refer to abbreviated check-list for transponder turn-around procedure.	
	11	Configure S-Band switches to original mode.			
		(a) Voice regained	→		(11a) USBE primary transponder failure
		(b) Voice not regained	→	(11b) Voice limited to VHF-AM. TV, TIM, and ranging still available on S-Band.	(11b) PMP (voice circuit) failure
7. All crewmen lose USBE voice operation (modes D or E)	1	Verify that A/C S-BAND sw (MDC-23) is <u>not</u> in <u>MUTE</u> (up) position.	2	(1) <u>MUTE</u> (up) position disables S-Band reception.	
	2	S-BAND PWR AMPL sw - <u>HIGH</u>			
		(a) Voice regained	→	(2a) Power amplifier operation limited to high mode.	(2a) Partial power amplifier failure (Low mode)
		(b) Voice not regained	3		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE	
7. (Cont)	3	Configure S-Band switches for mode A.				
		(a) Voice regained	→	(3a) Voice and R/T TIM limited to USBE FM mode or VHF. Playback TIM limited to VHF-FM. Loss of TV.	(3a) FM mode failure or total power amplifier failure.	
		(b) Voice not regained	4			
	4	Follow Telecom procedure, "All crewmen lose USBE voice operation, modes A, B1, B2, or C" (Symptom No. 6).				
8. MSFN reports VHF-FM telemetry poor or lost.	1	Energize USBE in mode A. (Notify MSFN).	2	(1) Enables R/T PCM via S-Band.		
	2	Verify normal VHF-AM voice operation.		(2) All VHF & UHF equipment share same antenna system (VHF SCIN antennas).		
		(a) Voice normal	5	(2a) Rules out antenna failure.		
		(b) No voice	3			
	3	VHF ANTENNA sw - Alternate position (<u>UPPER</u> or <u>LOWER</u>)	4			
	4	Re-orient S/C for optimum antenna coverage, if necessary.				
		(a) VHF-FM TIM regained	→	(4a) VHF & UHF operation limited to one antenna & restricted S/C orientation.	(4a) Upper or lower VHF SCIN antenna failure	
		(b) VHF-FM TIM not regained	5			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
8. (Cont)	5	TIM INPUTS PCM sw - Alternate position (<u>HIGH</u> or <u>LOW</u>)			
		(a) VHF-FM TIM regained	→	(5a) Limits telemetry to one bit rate mode. If limited to low bit rate, many G&N TIM parameters are lost. If limited to high bit rate, long data dumps are required.	(5a) PCM TLM mode failure (High or Low)
		(b) VHF-FM TIM not regained	6		
	6	Check status of S-Band telemetry with MSFN			
		(a) Normal	→ 7	(6a) USBE must be used for all down data.	(6a) VHF-FM system failure
		(b) Not normal	→	(6b) MSFN may elect to use VHF-FM or S-Band telemetry if some data is salvageable.	(6b) PCM telemetry equipment failure or PMP (TIM circuit) failure
	7	VHF-FM sw - <u>OFF</u>			
9. UHF Updata and Real-time commands not received by S/C	1	Energize USBE in mode A.	2	(1) Enables updata backup mode.	
	2	Verify normal VHF-AM voice operation.		(2) All VHF & UHF equipment share same antenna system (VHF SCIN antennas).	
		(a) Normal	5	(2a) Rules out antenna failure.	
		(b) Not normal	3		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
9. (Cont)	3	VHF ANTENNA sw - Alternate position (<u>UPPER</u> or <u>LOWER</u>)	4		
	4	Re-orient S/C for optimum antenna coverage, if necessary			
		(a) Voice and updata regained	→	(4a) VHF & UHF operation limited to one antenna & restricted S/C orientation.	(4a) Upper or lower VHF SCIN antenna failure
		(b) Updata not regained (Voice normal)	5		
	5	UPDATA sw - <u>S-BAND</u>	6		
	6	Request MSFN to retransmit update.	7		
	7	Verify S-Band updata normal.			
		(a) Normal	→	(7a) Updata limited to S-Band only. Some stations not equipped for S-Band updata	(7a) UHF receiver failure
		(b) Not normal	8		
	8	Repeat procedure over another ground station			
		(a) Normal	→		
		(b) Not normal	9	(8b) All updata capability lost. Voice updating required.	(8b) UDL equipment failure
	9	UPDATA sw - <u>OFF</u>			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
10. S-Band Updata and real-time commands not received by S/C. (S-Band voice normal).	1	UPDATA sw - <u>UHF</u>	2	(1) Coordinate with MSFN.	(2a) 70KC updata demodulator failure
	2	Verify UHF updata normal. (a) Normal (b) Not normal	→ 3	(2a) Updata limited to UHF.	
	3	Repeat procedure over another ground station. (a) Normal (b) Not normal	→ 4	(3b) All updata capability lost. Voice updating required.	
	4	UPDATA sw - <u>OFF</u>			
11. MSFN reports partial or complete loss of C-Band tracking.	1	Energize USBE in mode B1. (Notify MSFN).	2	(1) Enables backup ranging mode.	(2a) 1 or 2 pulse mode failure
	2	C-BAND sw - Alternate position - (1 <u>PULSE</u> or 2 <u>PULSE</u>) (a) C-Band tracking required (b) Not regained	→ 3	(2) Coordinate with MSFN. Some stations are not equipped with 2 pulse mode capability.	
	3	Orient S/C to illuminate a different C-Band antenna. (a) C-Band tracking regained	→	(3) Coordinate with MSFN. (3a) Partial S/C attitude constraint due to loss of one antenna/receiver.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE	
11. (Cont)		(b) Not regained	4 →	(3b) Ranging limited to S-Band and "skin track."	(3b) C-Band transponder failure	
	4	C-BAND sw - <u>OFF</u>				
12. MSFN reports TV reception lost (or poor) (S-Band voice & data normal).	1	S-BAND PWR AMPL sw - Alternate position (<u>HIGH</u> or <u>LOW</u>)				
		(a) TV regained	→	(1a) Power amplifier operation limited to one mode.	(1a) Partial power amplifier failure (High or Low)	
		(b) TV not regained	2			
	2	Connect TV cable to No. 1 TV receptacle.				
		(a) TV regained	→	(2a) Discontinue use of failed receptacle.	(2a) TV cabling or receptacle failure	
		(b) TV not regained	3 →	(2b) Loss of TV capability	(2b) TV system failure or total power amplifier failure	
	3	S-BAND-VOICE-TV sw - <u>OFF</u>				
13. No VOICE RECORD flag indication when attempting voice recording (intercom normal).				NOTE Absence of audio on track 1 (in excess of 4 seconds) will cause flag drop-out. If portions of track 1 were recorded in a PTT mode rather than a VOX mode, erratic or intermittent flag indications may appear on all other tracks.		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
13. (Cont)	1	Verify instruments RCDR NON ESS C/B - <u>CLOSED</u>	2	(1) C/B powers flag mechanism.	
	2	If recorder not in use has tape available, transfer connector to that recorder.			
		(a) Flag indicates properly	→	(2a) Any recording time remaining on failed recorder is lost.	(2a) Failure of one voice recorder or recorder end of tape
		(b) No flag indication	3		
	3	Place hand on recorder. Push PTT button and note vibration from drive motor.			
		(a) Vibration	→ 4		(3a) Flag indicator failure or drive belt failure
		(b) No vibration	→ 5	(3b) Voice recording capa- bility lost.	(3b) Voice recorder cable or connector failure
	4	Continue using recorder and check periodically for end of tape.		(4) Flag indicator failure is assumed (providing first recorder was not out of tape).	
	5	All A/C HF sw - <u>OFF</u>		(5) Switches may be energized post landing for HF operation.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE	
14. VHF-AM poor or lost after splash-down.	1	Verify VHF ANTENNA sw - <u>RECOVERY</u>	2			
	2	VHF-AM RCVR sw - Alternate position (<u>1</u> or <u>2</u>)		(2) Recovery forces must be informed via HF of change to duplex.		
		(a) Signal regained	→	(2a) VHF-AM limited to one mode (Simplex or duplex).	(2a) One receiver front-end inoperative.	
		(b) Signal not regained	3			
	3	VHF-AM RCVR sw - <u>1</u>	4	(3) Notify recovery forces of change to simplex mode via HF.		
	4	Coax connectors (MDC-9) - Reverse connectors.				
		(a) Signal regained	→	(4a) VHF Recovery beacon & VHF-AM must share antenna No. 1 (white) & cannot be used simultaneously.	(4a) VHF Recovery antenna No. 2 (black) failure	
		(b) Signal not regained	5	(4b) Recovery communications systems limited to VHF beacon & HF transceiver.	(4b) VHF-AM transmitter/receiver failure	
	5	If VHF-AM is unusable, VHF-AM sw (MDC-20) - <u>OFF</u>	6			
	6	Restore coax connectors to original configuration.		(6) S/C VHF recovery antenna No. 2 (black) available for use with survival transceiver, if desired.		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
15. HF voice poor or lost after splashdown.	1	Verify POSTLANDING ANTENNA - A & B sw - <u>DEPLOY</u>	2	NOTE HF propagation is relatively unpredictable. Weak signals may be a result of adverse propagation phenomena rather than equipment failure.	
	2	Verify visually HF antenna fully deployed.			
		(a) Fully deployed	3	(2a) Fully deployed HF antenna is approximately 14 feet in length.	
		(b) Not fully deployed	6	(2b) Continuous operation of transmitter in excess of 5 minutes results in probable transmitter damage. Avoid BCN mode.	(2b) HF antenna failure
	3	RECOVERY - HF sw - Alternate position (<u>SSB</u> or <u>AM</u>)			
		(a) Voice regained		(3a) HF limited to one mode of operation (SSB or AM). Loss of SSB limits comm distance. If AM available, BCN probably available.	(3a) HF mode failure
		(b) Not regained	4		
	4	RECOVERY - HF sw - <u>BCN</u>	5	(4) Voice recorder will not run due to absence of AC power.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE	
15. (Cont)	5	On VHF-AM verify with recovery forces that HF beacon received. (a) Received (b) Not received	→ 6	(5a) HF operation limited to Beacon only. (5b) Recovery communications limited to VHF.	(5a) HF voice section failure (5b) HF system failure	
	6	RECOVERY HF sw - <u>OFF</u>				
16. MSFN reports loss of VHF-FM data and C-Band ranging (VHF-AM and S-Band normal)	1	TELCOM NON ESS sw - Alternate position (<u>AC1</u> or <u>AC2</u>)		(1) Flight qual recorder, voice recorder, and DSE will also be lost. Tripping of telecom GROUP 1 CB will have the same symptom.	(1) Probable loss of one AC power source to telcom nonessential switch or switch failure.	
17. MSFN reports VHF-FM and S-Band playback TIM poor or lost.	1	Attempt subsequent recordings at different recording speeds and/or in the reverse tape direction. Coordinate any deviations from normal procedures with MSFN.		(1) Diagnostic tests for DSE malfunctions are quite limited.	(1) Some possible failures are: DSE drive failure, erase or record head failure, speed assurance failure, TIM input failure, or DSE system failure.	
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PROCEDURES ENTRY SHEET

SECTION 9.1.6
ECS MALFUNCTION PROCEDURES

SYMPTOM	SYMPTOM NUMBER	STEP	PAGE
<u>OXYGEN SUPPLY SUBSYSTEM</u>			
O ₂ FLOW Hi C&W Lite - ON	1	1	3
FLOW O ₂ indicator - HIGH	1	4	3
FLOW O ₂ indicator - LOW	2	1	11
SURGE TANK PRESSURE HIGH	3	1	13
SURGE TANK PRESSURE LOW	4	1	14
100 psig O ₂ circuit pressure HIGH	5	1	15
100 psig O ₂ circuit pressure LOW	6	1	16
20 psig O ₂ circuit pressure HIGH	7	1	17
20 psig O ₂ circuit pressure LOW	8	1	18
<u>PRESSURE SUIT CIRCUIT SUBSYSTEM</u>			
CO ₂ PP Hi C&W Lite - ON	11	1	20
PART PRESS CO ₂ indicator - HIGH	11	2	20
LITHIUM HYDROXIDE CARTRIDGE SEIZURE	12	1	24
Ballooned P.G.A.	13	1	25
Clinging P.G.A.	14	1	28
LOW SUIT FLOW	15	1	31
Suit temperature HIGH	16	1	34
Suit humidity HIGH	17	1	36
<u>CABIN PRESS & TEMP CONTROL SUBSYSTEM</u>			
CABIN PRESS - HIGH	21	1	39
CABIN PRESS - LOW	22	1	45
CABIN TEMP - HIGH	23	1	47
CABIN TEMP - LOW	24	1	48

Cabin humidity HIGH	25	1	49
<u>WATER/GLYCOL COOLANT SUBSYSTEM</u>			
GLYCOL TEMP Low C&W Lite - ON	31	1	50
ECS RAD OUTLET TEMP - LOW	31	2	50
ECS RADIATOR TEMP 1 or 2 - LOW	31	21	53
ECS RAD OUTLET TEMP - HIGH	32	1	55
Glycol evaporator outlet temp - HIGH	33	1	56
Glycol evaporator outlet temp - LOW	34	1	61
PRESS GLY DISCH - LOW	37	1	64
GLY ACCUM QUANTITY - LOW	37	2	64
GLY ACCUM QUANTITY - HIGH	39	1	68
<u>WATER SUPPLY SUBSYSTEM</u>			
Potable HOT H ₂ O temperature LOW	41	1	69
H ₂ O transfer failure	42	1	70
WATER quantity decrease rate HIGH	43	1	71
Gas leakage into H ₂ O subsystem	44	1	72
Potable and Waste water pressure HIGH	45	1	74
<u>WASTE MANAGEMENT SUBSYSTEM</u>			
Unable to dump urine	51	1	76
Low vacuum suction	52	1	77
Fecal canister vacuum LOW	53	1	78
<u>POST LANDING SUBSYSTEM</u>			
Inadequate ventilation after landing	61	1	78
Water inflow	62	1	81

SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. O ₂ FLOW HI C & W Lite - ON				Trigger Valve: Flow > 1.0 lbs/hr for more than 16 sec. FLOW > 1.0 lb/hr may occur for short periods during normal operations. Flow > 1.0 lbs/hr for longer than 10-15 seconds indicates probable malfunction.	
	1	FLOW O ₂ :			
		a. NORMAL: < 0.45 lbs/hr	2		
		b. HIGH: > 0.45 lbs/hr	4		
	2	CABIN REPRESS or DIRECT O ₂ VALVE - OPEN/OFF	3	2. Monitor FLOW O ₂	
	3	FLOW O ₂			
		a. INCREASES	→		3a. O ₂ FLOW HI C & W circuitry failure.
		b. NO INCREASE	4		3b. FLOW O ₂ gage/ circuitry failure.
FLOW O ₂ - HIGH: > 0.45 lbs/hr	4	CABIN PRESS:			
		a. NORMAL or above: > 4.8 psia	5		
		b. LOW: < 4.8 psia	→		4b. Possible C/M puncture.
	5	DIRECT O ₂ - CLOSED	6	5-7. Verify inadvertently opened valves haven't caused increased O ₂ flow.	
	6	CABIN REPRESS - CLOSED	7		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. (Cont)	7	WASTE MANAGEMENT SELECTOR VALVE - OFF	8		
	8	FLOW O ₂ :			
		a. Remains HIGH: >0.45 lbs/hr	9		
		b. NORMAL: <0.45 lbs/hr	→	8b. Corrected by steps 5-7.	
	9	EMERGENCY CABIN PRESS REG SELECT - OFF	10		
	10	FLOW O ₂			
		a. Remains HIGH: >0.45 lbs/hr	11		
		b. NORMAL: <0.45 lbs/hr	12		
	11	EMERGENCY CABIN PRESS REG SELECT - NORMAL	18		
	12	EMERGENCY CABIN PRESS REG SELECT - NO. 1	13		
	13	FLOW O ₂ :			
		a. HIGH: >0.45 lbs/hr	14		13a. No. 1 Emergency cabin pressure regulator failure
		b. NORMAL: <0.45 lbs/hr	15		
	14	EMERGENCY CABIN PRESS REG SELECT - NO. 2	→	14. Loss of redundancy regulator capability.	

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. (Cont)	15	EMERGENCY CABIN PRESS REG SELECT - NO. 2	16		
	16	FLOW O ₂			
		a. HIGH: >0.45 lbs/hr	17		16a. NO. 2 Emergency Cabin Pressure regulator failure.
		b. NORMAL: <0.45 lbs/hr	→	16b. Probable transient condition.	
	17	EMERGENCY CABIN PRESS REG SELECT - NO. 1	→	17. Loss of redundancy regulator capability	
	18	SUIT DEMAND REG SELECTOR - OFF	19		
	19	FLOW O ₂			
		a. Remains HIGH: >0.45 lbs/hr	27		
		b. NORMAL: <0.45 lbs/hr	20		
	20	SUIT DEMAND REG SELECTOR - NO. 1	21	20. Assumes initial 1 & 2 Regulator position.	
	21	FLOW O ₂			
		a. NORMAL: <0.45 lbs/hr	23		
		b. HIGH: >0.45 lbs/hr	22		21b. Suit Demand Regulator No. 1 failure.
	22	SUIT DEMAND REG SELECTOR - NO. 2	→	22. Loss of suit pressure regulation redundancy.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. (Cont)	23	SUIT DEMAND REG SELECTOR - NO. 2	24		
	24	FLOW O ₂			
		a. NORMAL: <0.45 lbs/hr	26	24. Possible transient condition	
		b. HIGH: >0.45 lbs/hr	25		24b. Suit Demand Regulator NO.2 failure
	25	SUIT DEMAND REG SELECTOR - NO. 1	→	25. Loss of suit pressure regulation redundancy.	
	26	SUIT DEMAND REG SELECTOR - 1 & 2	→	26. Possible transient condition.	
	27	SUIT DEMAND REG SELECTOR - 1 & 2	28		
	28	Pull Suit Hose Return Port Plug	29		
	29	FLOW O ₂			
		a. NORMAL: <0.45 lbs/hr	30		
		b. Remains HIGH: >0.45 lbs/hr	34		
	30	Re-install Suit Hose Return Port Plug	31		
	31	Vacuum SUIT CIRCUIT AIR RETURN CHECK VALVE SCREEN (Suit compressors off while vacuuming screen)	32		
	32	FLOW O ₂			
		a. NORMAL: 0.45 lbs/hr			32a. Dirty screen.

PREPARED BY:

J. B. BUREA

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. (Cont)		b. Remains HIGH: >0.45 lbs/hr	33	32b. Open suit operation requires air return through suit hose. Closed suit operation normal.	
	33	Pull Suit Hose Return Port Plug	→		33. Suit circuit Return Check valve Restricted or failed closed.
	34	Re-install Suit Hose Return Port Plug	35		
	35	H ₂ O ACCUM - AUTO 2 (alternate)	36	35. Assumes initial AUTO - 1 position.	
	36	FLOW O ₂			
		a. Remains HIGH: >0.45 lbs/hr	37		
		b. NORMAL: <0.45 lbs/hr	→		36b. H ₂ O ACCUM NO. 1 auto cycle control failure
	37	H ₂ O ACCUM - MAN	38	37. Shuts off power to accumulator O ₂ solenoids.	
	38	FLOW O ₂			
		a. Remains HIGH: >0.45 lbs/hr	39		
	b. NORMAL: <0.45 lbs/hr	→	38b. Loss of auto cyclic H ₂ O ACCUM control.	38b. Probable central timer failure, giving false signal to auto cycle control units.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE	
1. (Cont)	39	H ₂ O ACCUMULATOR 1 - OFF	40	39&40. Manual valves.	41b. Possible failure of both cyclic O ₂ inflow solenoid valves in open position.	
	40	H ₂ O ACCUMULATOR 2 - OFF	41			
	41	FLOW O ₂				
		a. Remains HIGH: >0.45 lbs/hr	42	→ 41b. Loss of electrical cyclic control of H ₂ O accumulators.		
		b. NORMAL: <0.45 lbs/hr	→			
	42	Return H ₂ O accumulators to normal operation	43			
	43	WATER & GLYCOL TANKS PRESSURE INLET SELECT - OFF	44	43. Assumes NORMAL initial position		
	44	FLOW O ₂				
		a. Remains HIGH: >0.45 lbs/hr	52			
		b. NORMAL: <0.45 lbs/hr	45			
	45	WATER & GLYCOL TANKS PRESSURE INLET SELECT - NORMAL	46			
	46	WATER & GLYCOL TANKS PRESSURE OUTLET SELECT - OFF	47			
	47	FLOW O ₂				
	a. Remains NORMAL: <0.45 lbs/hr	→	47a. Loss of pressure to glycol & water tanks.	47a. Glycol & water system O ₂ leak downstream of pressure relief valves.		
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T.C. McHenry		DATE: JAN 27, 1967		MALFUNCTION PROCEDURES		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. (Cont)		a. LOW: <865 psia	→	53a. LARGE LEAK. Unable to identify or isolate. Will result in loss of all O ₂ regulator control.	53a. Probable CABIN PRESS REGS leaking or 100 psi line leakage downstream of flow sensor.
		b. Pressure: NORMAL	→	53b. Leak present - leakage rate < supply rate therefore pressure regulation capability satisfactory; however, usage rate above normal. Monitor O ₂ usage to verify FLOW O ₂ indication.	
<p>NOTE: If leak is not isolated and the high O₂ flow rate continues to deplete O₂ supply - mission time may be extended by shutting off the main O₂ regulators and only opening valve as required to maintain cabin pressure and CO₂ level. Isolate Water & Glycol Tanks pressure to retain system operation. Open Water & Glycol tanks valve as required to maintain pressure.</p>					
PREPARED BY: <i>J. Baker</i> <i>T.C. Mortimer</i> <i>R. B. Buehler</i>		FLIGHT CREW SUPPORT DIVISION DATE: JAN 27. 1967		ENVIRONMENTAL CONTROL SYSTEM MALFUNCTION PROCEDURES	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
2. FLOW O ₂ - LOW				FLOW O ₂ pegged at 0.2 lb/hr. Normal flow rate is >0.2 <0.45 lb/hr. FLOW O ₂ indicator cannot indicate <0.2 lb/hr.	
	1	Verify MAIN O ₂ REGULATOR - NORMAL	2	1. Unless in 1 or 2 due to previous failure.	
	2	FLOW O ₂ :			
		a. Increases	→	3a. If reg. valve was OFF, resume normal ops. If was positioned to 1 or 2, redundant reg. capability lost.	3a. Incorrect reg. valve position and/or single reg. failed closed.
		b. No change in status	3		
	3	O ₂ PRESS IND - SURGE TANK	4		
	4	TANK PRESSURE O ₂ - 1: (SURGE TANK)		4. Normal surge tank pressure 900 ±35 psia. Inlet pressure to MAIN REG <150 psia will result in loss of control of 100 psia O ₂ circuit.	
		a. LOW: <150 psia	→	4a. Refer to ECS Malfunction Procedure NO. 4	
		b. >150 psia	5		
NOTE: In step 5 monitor both the FLOW O ₂ gage and SURGE TANK (assumes surge tank on-line) pressure indications to isolate failure when DIRECT O ₂ valve is opened. If no flow indication with DIRECT O ₂ exercise EMER O ₂ INFLOW, DEMAND REG SUIT FLOW and EMER RETPRESS.					
	5	DIRECT O ₂ - OPEN/OFF			
		a. FLOW O ₂ - increases	6	5a. Verifies FLOW O ₂ indicator function.	
		SURGE TANK PRESSURE - decreases			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
2. (Cont)		b. FLOW O ₂ - No change SURGE TANK PRESSURE - DECREASES	→	5b. FLOW O ₂ indication lost.	5b. FLOW O ₂ sensor/circuitry failure.
		c. FLOW O ₂ - No change SURGE TANK PRESSURE - No change	7		
	6	CABIN PRESSURE			
		a. LOW (or decreasing)	→	6a. Refer to ECS malfunction Procedure NO. 22.	
		b. Normal	→	6b. FLOW O ₂ indications invalid	6b. FLOW O ₂ meter out of calibration.
	7	PLSS O ₂ SUPPLY S/O VALVE CAP - REMOVED	8	7. Remove cap carefully to preclude blowing off if PLSS valve has leaked pressure.	
	8	PLSS O ₂ SUPPLY S/O VALVE - OPEN/OFF	9	8. Note O ₂ flow from valve.	
	9	TANK PRESSURE O ₂ 1 (SURGE TANK)			
		a. Decreases (and flow from PLSS valve)	→	9a. <u>PLSS valve only O₂ source to cabin. Monitor CABIN PRESSURE for flow control.</u>	9a. Both <u>MAIN REGS failed or line blockage</u>
		b. No change in status (and no flow from PLSS valve)	→	9b. CM O ₂ SUPPLY LOST with 0.25 lbs/hr cabin leakage and 5.0 psia cabin pressure aprox. 3 hrs remaining until 3.5 psia cabin pressure.	9b. O ₂ supply line blockage upstream of PLSS valve.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
3. SURGE TANK PRESSURE HIGH				TANK PRESSURE O ₂ - 1 > 935 psia with O ₂ PRESS IND TO SURGE TANK	
	1	O ₂ PRESS IND - TK 1	2		
	2	TANK PRESSURE 1 - O ₂			
		a. HIGH	→	2a. See EPS CRYO malfunction procedures NO. 1 step 20, O ₂ TK1 (and/or 2) pressure high.	2a. CRYO O ₂ Storage Failure
		b. NORMAL	3		
	3	TANK PRESSURE 2 - O ₂			
		a. NORMAL	→	3a. Continue operation in TK 1 position.	3a. Surge tk pres- sure sensor & sig cond failure.
		b. HIGH	→	3b. See EPS CRYO malfunction procedures. NO. 1 step 20, O ₂ TK1 (and/or 2) pressure high.	3b. Cryo O ₂ storage failure.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
4. SURGE TANK PRESSURE LOW	1	PRESS - CABIN a. >5.2 psia (High) b. >4.8 <5.2 psia (Normal)	→ →	TANK PRESSURE O ₂ - 1 <865 psia with PRESS IND - SURGE TANK 1a. Surge tank pressure <865 psia may result (other than cabin repress mode) in increased cabin pressure. Refer to PRESS - CABIN ECS malfunction NO. 21. 1b. See EPS CRYO Malfunction Proc. NO. 1 step 2, O ₂ TK 1 (and/or 2) pressure low.	1b. Probable cryo subsystem failure.

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
5. MSFN CF0036P > 110 psig. Over-pressurization of 100 psig O ₂ circuit				Normal system pressurization 100 ± 10 psig. Only direct pressure readout is by MSFN CF0036P	
	1.	CF0036P > 110 psig	2		
	2.	O ₂ PRESS IND - SURGE TANK	3		
	3.	TANK PRESS O ₂ - 1 (SURGE TANK)			
		a. Normal: 900 ± 35 psig	4		
		b. HIGH: > 935 psig	→	Refer to ECS Malfunction Procedures No. 3.	
	4.	MAIN REGULATOR - # 1	5	4. Assumes NORMAL initial position	
	5.	CF0036P			
		a. Normal: > 90 < 110 psig	→	5a. Main reg. redundancy lost. Continue operation on Reg. NO. 1.	5a. MAIN REG NO. 2 failed OPEN
		b. HIGH: > 110 psig	6		
	6.	MAIN REGULATOR - # 2	7		
	7.	CF0036P			
		a. Normal	→	7a. Main regulator redundancy lost. Continue operation on Reg. NO. 2.	7a. MAIN REG NO. 1 failed OPEN
		b. Remains HIGH	8		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
5. (Cont)	8	CABIN PRESS			
		a. HIGH: > 5.2 psia	→	8a. Refer to ECS Malfunction procedure No. 21	
		b. NORMAL	→		8b. Probable press ducer failure.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
6. MSFN CF0036P < 90 psig. Under-pressurization of 100 psig O ₂ circuit				Normal system pressurization 100 ± 10 psig. Only direct press readout is by MSFN CF0036P	
	1.	CF0036P < 90 psig	2		
	2.	O ₂ PRESS IND - SURGE TANK	3		
	3.	TANK PRESS O ₂ - 1 (SURGE TANK)			
	a.	Normal: 900 ± 35 psia	4		
	b.	Low: < 865 psia	→	3b. Refer to ECS Malfunction Procedures NO. 4.	
	4.	FLOW O ₂			
	a.	NORMAL: /0.2-0.45 lb/hr.	→		4a. Reg. calibration shift of both regs. or transducer shift.
	b.	LOW: < 0.2 lb/hr.	→	Refer to ECS Malfunction Procedure NO. 2	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
7. CF0120P TM>27 psig. over- pressurization of 20 psig O ₂ circuit				Normal regulator pressure 20 [±] 2 psig. Normal system pressure 18-27 psig (relief valve setting 25 ± 2 psig). Only direct pres- sure readout is MSFN (FQ) CF0120P.	
	1.	Verify WATER & GLYCOL TANKS PRESSURE OUTLET SELECT VALVE - NORMAL	2.	1. Assumes no previous failure	
	2.	CF0120P			
	a.	NORMAL: ≤27 psig	→	2a. Relief valve redundancy lost if selector was in posi- tion 1 or 2.	2a. Selector was OFF or single relief valve failure.
	b.	Remains HIGH: >27 psig	3.		
	3.	POT WATER QUANTITY	4		
	a.	100%	5		
	b.	<100%			
	4.	Use water gun until POT WATER QUANTITY <100%	5		
	5.	CF0326P	6		
	a.	HIGH			5a. Both relief valves failed closed or line blockages.
	b.	NORMAL	→		
	6.	Use water gun for system pressure relief.	→	6 Monitor MSFN	5b. CF0120P sensor failure.

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
8. CF0120P TM <18 psig. Underpressurization of 20 psig O ₂ circuit				Normal system pressurization 20 ± 2 psig. Only direct pressure readout is MSFN (FQ) CF0120P. Relief valve setting 25 ± 2 psig.	
	1	CF0120P <18 psig	2		
	2	CF0326P & CF0327P		2. PRESS POTABLE H ₂ O DRAIN and PRESS WASTE H ₂ O TANK DRAIN.	
		a. Normal :> 18 <27 psig	→	2a. CF0326P & CF0327P only other indication of pressure in 20 psig circuit	2a. CF0120P Sensor Failure
		b. LOW	3		
	3	CF0036P		3. 100 psig O ₂ circuit pressure	
		a. Normal: 100 ± 10 psig	4		
		b. LOW: <90 psig	→	3b. Refer to ECS Malfunction Procedure No. 6	
	4	WATER & GLYCOL TANKS PRESS REGULATOR SELECTOR - INLET AND OUTLET # 1 (or 2) alternate	5	4. Assumes initial position of one required.	
	5	CF0120P			
		a. Normal: >18 <27 psig	→	5. Loss of redundant pressure reg. and relief. Use No. 1 positions.	5a. Failure of No. 2 relief valve
		b. LOW: <18 psig	6		
	6	WATER & GLYCOL TANKS PRESS REGULATOR SELECTOR - INLET and OUTLET No. 2 (or 1) alternate.	7		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
8. (Cont)	7	CF0120P a. Normal: > 18 < 27 psig b. LOW: < 18 psig	→ →	7a. Loss of redundant reg. & relief. Use No. 2 positions 7b. Failure to maintain adequate positive pressure in water system will result in loss of water inflow to suit and glycol evaporators. Positive expulsion of glycol from glycol reservoir will also be lost.	7a. Failure of No.2 relief valve 7b. Failure of both regs to control tank pressure to 20 ± 2 psig

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
11. CO ₂ PP HI C & W lite - ON				Trigger value: CO ₂ PP >7.6 mm Hg.	
NOTE: CO ₂ PP level will vary with crew activity; short periods of high CO ₂ PP may trigger C & W lite briefly, but not necessarily indicate a dangerous situation.					
PART PRESS CO ₂ HIGH	1	PART PRESS CO ₂			
		a. NORMAL: <7.6 mm Hg.	16		
		b. HIGH: >7.6 mm Hg.	2		
	2	SUIT FLOW			
		a. LOW:	→	2a. Insufficient flow in suit loop can cause excessive CO ₂ PP buildup. Accomplish ECS ² Malfunction Procedure 15.	
		b. NORMAL:	3		
	3	Check LiOH cartridge replacement log to determine time since last canister change:			
		a. If recent cartridge change:	6		
		b. If near time for replacement:	4		
	4	Change LiOH cartridge	5	4. Oldest cartridge.	
	5	PART PRESS CO ₂			
		a. NORMAL	→	5a. Resume normal operation; normal saturation of cartridge caused increase in CO ₂ PP.	
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11. (Cont)		b. Remains HIGH	6	5b. Should begin decrease within one minute.	
	6	DIRECT O ₂ - FULL OPEN (ccw) for 10 seconds.	7	6. Purge CO ₂ PP sensor with O ₂ to clear possible stagnant CO ₂ near sensor.	
	7	PART PRESS CO ₂			
		a. NORMAL	→	7a. Resume normal operations	
		b. Drops to normal then increases >7.6 mm Hg.	8	7b. Confirms High CO ₂ partial pressure.	
		c. Remains - HIGH	17		
	8	Change LiOH cartridge	9	8. Change oldest cartridge.	
	9	PART PRESS CO ₂			
		a. NORMAL	→	9a. Resume normal operation. Loss of 12 hr. CO ₂ & odor removal capability.	9a. PROBABLE FAULTY LiOH cartridge
		b. Remains - HIGH	10		
CAUTION: Possible LiOH cartridge supply faulty.					
	10	Monitor crew comfort			
		a. Crew Comfortable	17	10a. LiOH cartridge working properly.	
		b. Crew Uncomfortable	11	10b. Possible loss of CO ₂ removal capability for suit loop and cabin using LiOH canister assy.	10b. PROBABLE FAULTY LiOH cartridge supply
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
11. (Cont)	11	Check all LiOH cartridges for possible uncontaminated cartridges.			
		a. Partial Contamination	→	11a. CO ₂ removal capability unknown.	11a. CO ₂ removal capability degraded.
		b. If all contaminated	12		
MANUAL CO ₂ PP CONTROL	12	Don PGA's, get on suit loop	13		
	13	SUIT CIRCUIT RETURN AIR CHECK VALVE - CLOSED	14	13. Isolate suit loop from cabin.	
NOTE: Periodic flowing of fresh O ₂ into suit loop purging it into cabin, and periodic relieving of cabin to space will control CO ₂ PP level in suit loop.					
	14	DIRECT O ₂ - OPEN (ccw) as required ²	15	14. Open direct O ₂ valve to maintain CO ₂ PP < 7.6 mm Hg. O ₂ FLOW HI C & W lite may come on.	
	15.	CABIN PRESSURE RELIEF - Verify NORMAL	→	15. Cabin Pressure relief valve will relieve at 5.6 - 6.2 psia automatically. Manual dump available.	
CO ₂ PP INDICATOR SENSOR MALFUNCTION ISOLATION	16	IF:	→	16. Loss of CO ₂ PP level high C & W capability. Use PART PRESS CO ₂ meter.	16. PROBABLE C & W CIRCUIT FAILURE
		a. CO ₂ PP HI lite - ON			
		b. PART PRESS CO ₂ - < 7.6 mm Hg.			
		c. Crew Comfortable			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
11. (Cont) CO ₂ PP HI C & W lite failure	17	IF: a. CO ₂ PP HI lite - ON after LiOH cartridge change and sensor purge. b. PART PRESS CO ₂ - >7.6 mm Hg after LiOH cartridge change and sensor purge. c. Crew Comfortable after a & b have existed for several minutes	→	17. Loss of all CO ₂ PP monitor capability, except crew physical senses. Gas chromograph can be turned on to verify CO ₂ PP with ground.	17. PROBABLE CO ₂ PP SENSOR FAILURE
	18	IF: a. CO ₂ PP HI lite - OFF b. PART PRESS CO ₂ >7.6 mm Hg and no change with LiOH cartridge change and sensor purge with O ₂ .	→	18. Loss of CO ₂ PP meter indication for monitoring CO ₂ PP level.	18. PROBABLE CO ₂ PP meter failure.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
12. Lithium Hydroxide cartridge seizure within canister.		1. Pull on LiOH cartridge removal strap -- or apply mechanical advantage as required to remove the faulty cartridge.		1. LiOH is hygroscopic & cartridge swelling results due to water absorption. In addition H_2O is produced by $2LiOH + CO_2 = Li_2CO_3 + H_2O$.	1. Excessive swelling of LiOH cartridge.
<p>NOTE: Any delay in removing a seized cartridge will result in water saturation of the cartridge, increased pressure drop across seized cartridge with resulting reduced suit flow.</p> <p>CAUTION: Immediately following replacement of a LiOH cartridge -- the opposite canister should be momentarily opened & cartridge canister clearance be noted. Immediately replace a cartridge suspected of swelling.</p> <p>CAUTION: Continued use of a seized cartridge will aggravate situation. Establish single canister operation by positioning diverter valve to route suit flow thru good canister. Flow may be diverted thru seized cartridge momentarily when replacement of operational cartridge is required.</p>					
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
13. Ballooned P.G.A. (Closed Suit Loop)				Cabin-to-suit ΔP maintained at 2.5 to 3.5 in H_2O . Suit Pressure maintained at $3.75 \pm .25$ psia when Cabin Pressure ≤ 3.5 psia.	
	1	PRESS CABIN			
		a. Low: < 3.5 psia	→	1a. Refer to ECS Malfunction Procedure No. 22.	
		b. Normal	2		
	2	FLOW O_2			
		a. HIGH: > 0.45 lb/hr	→	2a. Refer to ECS Malfunction Procedure No. 1.	
		b. NORMAL: < 0.45 lb/hr	3		
	3	Verify DIRECT O_2 valve - CLOSED	4		
	4	Verify SUIT TEST SELECTOR - OFF	5		
	5	Suit Status			
		a. Remains ballooned	6		
		b. Normal	→	5b. Corrected by 3-4.	
	6	SUIT DEMAND REG SELECTOR - cycle OFF/1 & 2	7	6. Monitor suit status while OFF.	
	7	Suit Status		7. While SUIT DEMAND REG SELECTOR - OFF	
		a. Remains ballooned	13		
		c. NORMAL	8		

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
13. (Cont)	8	SUIT DEMAND REG SELECTOR - 1	9		
	9	Suit Status			
		a. Ballooned	10		
		b. Normal	→	9b. Regulator redundancy lost.	9b. Suit Demand Regulator NO. 2 failed open.
	10	SUIT DEMAND REG SELECTOR - 2	11		
	11	Suit Status			
		a. Remains Ballooned	12		11a. Both Suit Demand Regulators failed open.
		b. Normal	→	11b. Regulator redundancy lost.	11b. Suit Demand Regulator NO. 1 failed open.
	12	SUIT DEMAND REG SELECTOR -- OFF	13		
	13	SUIT CONFIGURATION -- OPEN	14		
	14	Verify SUIT CIRCUIT AIR RETURN CK VALVE SCREEN clean & flow path obstructed	15		
	15	Monitor CABIN HUMIDITY & CO ₂ PARTIAL PRESSURE			
		a. INCREASES	→	15a. Humidity CO ₂ & Odor removal capability lost. Closed suit configuration impossible.	15a. Clogged DEBRIS TRAP or plumbing downstream of DEBRIS TRAP
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
13. (Cont)		b. Remains NORMAL	→	15b. Closed suit configuration not possible.	15b. Clogged suit outlet manifold or plumbing obstruction upstream of debris trap.

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
14. PRESS-SUIT LOW (Closed Suit Loop). Evidenced by PGA clinging.				Normal Cabin to suit ΔP is 0.09 to 0.13 psia.	
NOTE: Other than periods of fault isolation DIRECT O_2 metering valve may be opened for suit purging.					
	1	PRESS-CABIN			
		a. High: > 5.2 psia	2	1a. Suit loop leakage into cabin.	
		b. Normal: 5.0 ± 0.2 psia	5		
		c. Low: 4.8 psia	→	1c. See ECS Malfunction Pro- cedure NO. 22.	
	2	Verify SUIT FLOW CONTROL Valves - SUIT FLOW	3		
	3	Verify suit hose connector integ- rity at PGAs & SUIT FLOW CONTROL VALVES.	4		
	4	Suit Status			
		a. Clinging	→	4a. Unable to isolate SUIT loop leakage into cabin. Unable to maintain suit loop press.	4a. Suit loop plumb- ing or Demand Reg. relief valve failed open.
		b. Not clinging	→	4b. Corrected by step 2 & 3.	
	5	Verify SUIT CIRCUIT RETURN AIR CK VALVE - CLOSED	6		

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
14. (Cont)	6	PGA Status			
		a. Clinging	7		
		b. Not Clinging	→	6b. Corrected by step 5	
	7	AP SUIT COMP			
		a. Normal	10		
		b. < Normal	8		
	8	Check alternate bus & compressor with suit compressor selector & CB'S.	9		
	9	AP SUIT COMP			
		a. Normal 0.4 to 0.3	→	9a. If single compressor failure - redundancy lost.	9a. Circuitry or Compressor Failure.
		b. < Normal < 0.4	10		
	10	Suit Demand Regulator Selector			
		a. If in 1 & 2	13		
		b. If in 1 (or 2)	11		
	11	SUIT DEMAND REG - Alternate reg.	12		
	12	AP SUIT COMP			

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
14. (Cont.)		a. Normal	→	12a. Eliminates SUIT DEMAND REG redundancy. Continue operation on selected regulator.	12a. SUIT DEMAND REGULATOR 1 (or 2) failed CLOSED.
		b. < Normal	13		
	13	Verify SUIT FLOW RELIEF VALVE - CLOSED	14		
	14	PGA Status			
		a. Not Clinging	→	14a. Resume ops. with SUIT FLOW RELIEF Valve manually CLOSED.	14a. SUIT FLOW RELIEF valve was OPEN & relief function failed.
		b. Clinging	→	14b. Small leak not isolated Maintain positive suit by opening DIRECT O ₂ metering valve.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
15. LOW SUIT FLOW				Normal Suit Flowrate 35 cfm with 10 in H ₂ O pressure rise across suit fan.	
NOTE: For periods of high crew activity additional cooling may be required. Switch COMPR SELECTOR to AC 1/2					
	1	Verify Suit O ₂ Umbilical connections	2		
	2	Verify SUIT FLOW CONTROL VALVES (3) - SUIT FLOW	3		
	3	Verify SUIT TEST - OFF	4		
	4	Verify SUIT DEMAND PRESS REGULATOR - 1 & 2	5		
	5	Verify SUIT FLOW RELIEF VALVE - OFF	6		
	6	If open suit loop verify SUIT CIRCUIT RETURN AIR CHECK VALVE OPEN, screen clean & unobstructed flowpath	7	6. Suit compressors must be off while vacuuming return air screen.	
	7	SUIT FLOW a. Normal	→	7a. Continue normal operations. Corrected by steps 1 - 6.	
		b. Remains low	8		
	8	ΔP SUIT COMPR a. Normal: <0.4 >0.3 psi b. Low: <0.3 psi	12 9		

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
15. (Cont)	9	Check alternate bus & compressor with suit compressor selector & CB's	10		
	10	ΔP COMPR			
		a. Normal	12	10a. If single compressor failure compressor redundancy lost.	10a. Electrical or Compressor Failure.
		b. Remains Low: <0.3 ΔP	11		10b. Probable both suit compressors and/or circuitry failure.
	11	Go to open suit	→	11. Normal suit loop functions are lost.	
	12	SUIT FLOW			
		a. Normal	→	12a. Suit Compressor redundancy lost.	12a. Single Suit Compressor failure.
		b. Remains Low	15		
	13	SUIT COMPRESSOR SELECTOR -AC 1/2	14		
	14	SUIT FLOW			
		a. Normal	→	14a. Two compressor operation required for crew comfort.	
		b. Remains Low	15		
	15	PGA status			
		a. Clinging	→	15a. DIRECT O ₂ metering valve may be opened (short duration) for additional suit flow. Suit doffing may be required for crew comfort. Suit loop functions may be lost. Monitor	15a. Obstruction between compressor outlet and suit inlet.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
15. (Cont)				cabin humidity & CO ₂ partial pressure.	
		b. Ballooned	→	15b. Monitor PGA CUFF PRESSURE INDICATORS (3). DIRECT O ₂ metering valve should not be opened while closed suit. Suit loop press relief capability probably lost.	15b. Obstruction between suit outlet and compressor inlet
		c. Normal	→	15c. Suit Flowrate degraded - but functional.	15c. Small suit loop obstruction.

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
16. TEMP SUIT HIGH ($>55^{\circ}\text{F}$ $<60^{\circ}\text{F}$)				NORMAL SUIT TEMP $51-55^{\circ}\text{F}$	
	1	Crew Comfort			
		a. TEMP COMFORTABLE	→		1a. Suit Temp sensor /circuitry failure.
		b. HIGH TEMP, crew discomfort.	2		
	2	Verify:	3		
		a. SUIT EVAP GLYCOL - ON			
		b. SUIT HT/EXCH - GLY/EVAP			
		c. SUIT EVAP SW - MANUAL			
		d. SUIT EVAP VALVE - OFF			
	3	TEMP SUIT			
		a. Returns to NORMAL	→	3a. Corrected by step 2	3a. Control mis- position.
		b. Remains HIGH: $>55^{\circ}\text{F}$	4		
	4	GLYCOL EVAP OUTLET TEMP			
		a. NORMAL ($40-43^{\circ}\text{F}$)	5		
		b. HIGH $>43^{\circ}\text{F}$	→	Refer to ECS Malfunction Pro- cedure NO. 33.	
	5	TEMP SUIT			
		a. $<60^{\circ}\text{F}$	→	6a. Possible transient over- temperature condition due to crew activity, equipment operation or S/C attitude.	
		b. $>60^{\circ}\text{F}$	7		
TEMP SUIT HIGH ($>60^{\circ}\text{F}$)	6	DOFF SUIT			
WARNING: Only if cabin temp cannot be controlled, Don suits and proceed to step 7.					
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
16. (Cont)	7	SUIT HT/EXCH - EVAP SUIT EVAP SW - AUTO SUIT EVAP VALVE - AUTO	8	7. Initiates SUIT HX evaporative mode	
	8	TEMP SUIT			
		a. Returns to NORMAL (51-55°F)	→	8a. Continue evaporative mode.	8a. Loss of auto temp control of SUIT HX outlet or diverter valve failure.
		b. Remains HIGH	9		
	9	Isolate surge tank	10		
	10	Open direct O ₂ valve, as required for suit cooling	→		10. Loss of SUIT HX evaporative & glycol cooling modes.

NOTE: Open surge tank after CM/SM separation

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
17. HIGH SUIT HUMIDITY (closed Suit Loop with SUIT FLOW & TEMP NORMAL)				High humidity evidenced by fogged visors and crew discomfort.	
	1	H ₂ O ACCUM Switch - MAN	2		
	2	H ₂ O ACCUM 1 and then 2 - ON 10 sec/OFF	3	2. Monitor FLOW O ₂ meter for increased flow while cyclic accumulator 1 and 2 solenoid valves are operated with ON/OFF switch	
	3	FLOW O ₂			
		a. Both increase Flow O ₂	4		
		b. NO. 1 or 2 increases (alternate) FLOW O ₂	8	3b. Auto and electrical control of NO. 1 or 2 lost.	3b. Electrical circuit failure of one accumulator
		c. No change in FLOW O ₂	12	3c. All auto and electrical control lost.	3c. Electrical circuit failure both accumulators
	4	H ₂ O ACCUM - AUTO 1 or 2 (alternate)	5		
	5	Suit Humidity			
		a. Decreases	→	5a. Use alternate accumulator in auto. Other accumulator useable with manual switch.	5a. Automatic control circuit 1 (or 2) accumulator failed.
		b. Remains HIGH	6		5b. Automatic control circuit of both accumulators lost.

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17. (Cont)	6	H ₂ O ACCUM Switch - MAN	7		
	7	H ₂ O ACCUM 1 or 2 - ON 10 sec/OFF (as required to maintain humidity control.)	→		
	8	H ₂ O ACCUM - AUTO 1 or 2 (alternate)	9		
	9	Suit Humidity			
		a. Decreases	→	9a. Use alternate accumulator in auto.	9a. Automatic control circuit 1 (or 2) accumulator failed
		b. Remains HIGH	10		9b. Automatic control circuit of both accumulators lost.
	10	H ₂ O ACCUM Switch - MAN	11		
	11	H ₂ O ACCUM 1 or 2 - ON 10 sec/OFF (as required for humidity control)	→	11. Alternate accumulator.	
	12	H ₂ O ACCUMULATOR manual valve - MAN 1 (and then MAN 2) for 10 sec then OFF	13	12. Monitor FLOW O ₂ while valves open.	
	13	FLOW O ₂			
		a. Both increase FLOW O ₂	14		
		b. NO. 1 or 2 increase (alternate) FLOW O ₂	14	13b. Accumulator redundancy lost.	13b. Loss of cyclic accumulator NO. 1 or 2.

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
17. (Cont)		c. No change in FLOW O ₂	18	13c. Moisture removal capability lost.	13c. Loss of both cyclic accumulators
	14	Manually cycle alternate accumulator as required for humidity control.	15		
	15	Suit humidity			
		a. Decreases	→	15a. Manual humidity control possible.	
		b. Remains HIGH	16		15b. Probable diaphragm rupture.
	16	Manually cycle original accumulator (if both gave FLOW O ₂ increase in step 13)	17		
	17	Suit humidity			
		a. Decreases	→	17a. Manual humidity control possible with one accumulator only.	
		b. No change	18	17b. Moisture removal capability lost.	17b. Probable rupture both diaphragms.
	18	Use DIRECT O ₂ to maintain crew comfort.	→		

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
21. (Cont)	4	TANK PRESSURE - 1.O ₂ : SURGE TANK		4. Normal surge tank pressure 900 ± 35 psia.	
		a. NORMAL	23	4a. Leak within supply limits.	
		b. LOW	8	4b. Large leak	
		c. HIGH	5	4c. Surge Tank relief valve setting 1045 ± 25 psia.	
	5	O ₂ PRESS IND Switch - TANK 1	6		
	6	TANK PRESSURE 1 - O ₂ (TANK 1)			
		a. HIGH	→	6a. Refer to EPS CRYO malfunctions procedures NO. 1 step 20, O ₂ TK 1 (and/or 2) pressure high.	
		b. NORMAL	7		
	7	TANK PRESSURE 2 - O ₂			
		a. HIGH	→	7a. High O ₂ Cryo supply pressure Refer to EPS CRYO malfunction procedures. NO. 1 step 20, TK1 (and/or 2) pressure high.	
		b. NORMAL	23	7b. Probable Surge Tank sensor/circuitry failure. Use TANK 1 & 2 for SURGE TANK PRESSURE.	
	8	MAIN O ₂ REG - 1	9		
	9	TANK PRESSURE 1 - O ₂ (Surge tank)			
		a. Pressure increases	→	9a. Regulator redundancy lost. Use regulator # 1.	9a. No. 2 Main regulator.
		b. No change in status	10		

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
21. (Cont)	10	MAIN O ₂ REG - 2	11		
	11	TANK PRESSURE 1 - O ₂ (Surge tank)			
		a. Pressure increases	→	11a. Regulator redundancy lost. Use regulator # 2.	11a. No. 1 Main regulator.
		b. No change in status	12		
	12	MAIN O ₂ REG - NORMAL	13		
	13	SURGE TANK PRESSURE RELIEF - OFF	14		
	14	TANK PRESSURE 1 - O ₂ (Surge tank)			
		a. Pressure increases	→	14a. Surge tank pressure relief lost. Requires monitoring of Surge TK pressure if surge TK isolated.	14a. Surge tank pressure relief valve leaking.
		b. No change in status	15		
	15	SURGE TANK PRESSURE RELIEF - NORMAL	16		
	16	SURGE TANK - OFF	17		
	17	TANK PRESSURE 1 - O ₂ (Surge tank)			
		a. Continues to decrease	→	17a. Gross leak protection and primary source of O ₂ after CSM separation eliminates or degrades. Entry tank will supply 1 lb O ₂ after CSM separation for reentry.	17a. Leak in surge tank.
		b. Steady readout	18		
	18	SURGE TANK - ON	19		

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
21. (Cont)	19	Verify PLSS FILL valve - CLOSED and CAP - INSTALLED	20	19. Normally closed and capped	
	20	TANK PRESSURE 1 - O ₂ (Surge tank)			
		a. Pressure increases	→	20a. Resume normal operation.	20a. PLSS FILL valve was not closed or was leaking through cap.
		b. No change in status	21		
	21	Verify ENTRY O ₂ valve - OFF	22	21. Normally OFF.	
	22	TANK PRESSURE 1 - O ₂ (Surge tank)			
		a. Pressure increases	→	22a. Redundant O ₂ supply lost after CSM separation.	22a. ENTRY FILL valve not OFF and leak in entry tank assembly.
		b. No change in status	→	22b. Monitor O ₂ supply usage rate to determine mission status.	22b. Leaking O ₂ supply subsystem line upstream of oxygen flow transducer.

NOTE: If leak is not isolated and continues to deplete O₂ supply - mission time may be extended by shutting off the main O₂ regulators (or SM O₂ SUPPLY CONTROL if leak upstream of main regulator) and only opening valve as required. If SM O₂ SUPPLY CONTROL is turned OFF; isolate surge tank to maintain SURGE TANK PRESSURE. If main O₂ regulators are shut off; isolate Water & Glycol Tanks pressure to retain system operation. Cycle open each time O₂ cycled ON.

NOTE: Due to large cabin volume cabin pressure changes for the following steps will require time to be detectable.

	23	MAIN O ₂ REG - 1	24		
	24	CABIN PRESS			
		a. Decreases	→	24a. Regulator redundancy lost.	24a. No. 1 main regulator.
		b. No change in status	25		

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
21. (Cont)	25	MAIN O ₂ REG - 2	26		
	26	CABIN PRESS			
		a. Decreases	→	26a. Regulator redundancy lost.	26a. No. 1 main regulator. 2
		b. No change in status	27		
	27	MAIN O ₂ REG - NORMAL	28		
	28	SURGE TANK PRESS RELIEF - OFF	29		
	29	CABIN PRESS			
		a. Decreases	→	29a. Surge tank pressure relief lost.	29a. Surge tank pressure relief valve leaking.
		b. No change in status	30		
	30	SURGE TANK PRESSURE RELIEF - NORMAL	31		
	31	SURGE TANK - OFF	32		
	32	CABIN PRESS			
		a. Decreases	→	32a. Gross leak protection and primary source of O ₂ after CSM separation eliminated or degraded. Entry tank will supply 1 lb O ₂ after CSM separation.	32a. Leak in surge tank.
		b. No change in status	33		
	33	SURGE TANK - ON	34		
	34	Verify PLSS FILL valve - CLOSED and CAP - INSTALLED	35		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
21. (Cont)	35	CABIN PRESS			
		a. Decreases	→	35a. Resume normal operations.	35a. PLSS FILL valve was not closed or was leaking through cap.
		b. No change in status	36		
	36	Verify ENTRY O ₂ TANK - OFF	37	36. Normally OFF	
	37	CABIN PRESS			
		a. Decreases	→	37a. Redundant O ₂ supply lost after CSM separation.	37a. ENTRY FILL valve not OFF and leak in entry tank assembly.
		b. No change in status	→	37b. Monitor O ₂ supply rate to determine mission status.	37b. Leaking O ₂ supply subsystem line upstream of oxygen flow transducer.

WARNING: If the leak is not isolated, but CABIN PRESSURE returns to normal, the ENTRY O₂ TANK could have leaked to zero. To check the ENTRY O₂ TANK, monitor the surge tank O₂ pressure and place the ENTRY O₂ TANK valve to FILL. A decrease in surge tank pressure indicates the entry tank had leaked. Place ENTRY O₂ TANK valve OFF. If leak excessive SURGE TANK only supply after CSM separation.

NOTE: If leak is not isolated and continues to deplete O₂ supply - mission time may be extended by shutting off the main O₂ regulators (or SM O₂ SUPPLY CONTROL if leak upstream of main regulator) and only opening valve as required. If SM O₂ SUPPLY CONTROL is turned OFF; isolate surge tank to maintain SURGE TANK PRESSURE. If main O₂ regulators are shut off; isolate Water & Glycol Tanks pressure to retain system operation (cycle open each time O₂ cycled on).

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
22. PRESS CABIN LOW (< 4.8 psia)				Normal cabin pressure $> 4.8 < 5.2$ psia.	
WARNING: Maintain full suited mode if cabin pressure ≤ 4.8 psia and decreasing.					
	1.	Verify both CABIN PRESS RELIEF valves - NORMAL	2		
	2.	Verify WMS OVBD DRAIN-OFF	3		
	3.	PRESS-CABIN			
	a.	Increases		3a. Corrected by valve verification.	
	b.	Still decreasing	4		
	c.	Stabilized < 4.8 psia	→		3c. Reg-colibration shift
	4.	Suit Pressure		4. MDC or cuff pressure indicator	
	a.	Normal	→		4a. Cabin Pressure sensor/indicator failure
	b.	Low	5	4b. Approximately same as cabin pressure	

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
22 (continued)	5	L. H. CABIN PRESS RELIEF VALVE - CLOSE	6		
	6	PRESS CABIN			
		a. Increases	→	6a. Maintain CLOSE position on L. H. Cabin Pressure Relief Valve and maintain auto cabin press. control by R. H. cabin press relief valve. Redundancy lost.	6a. L. H. Cabin Pressure Relief Valve failed open.
		b. Low and decreasing	7		
	7	L. H. CABIN PRESS RELIEF VALVE - NORMAL	8		
	8	R. H. CABIN PRESS RELIEF VALVE - CLOSED	9		
	9	PRESS CABIN			
		a. Increases	→	9a. Maintain CLOSE position on R. H. cabin pressure relief valve and maintain auto cabin press control by L. H. cabin press. relief valve. Redundancy lost.	9a. R. H. Cabin Pressure Relief Valve failed open
		b. Low and decreasing	→	9b. Maintain cabin pressure as required by opening DIRECT O ₂ valve.	9b. Both cabin pressure Regs and both emergency inflow valves failed or excessive cabin leakage.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
23. TEMP CABIN HIGH				NORMAL CABIN TEMP 70-80° F	
	1	Verify: a. CABIN HX exhaust flowpath unobstructed b. Verify individual operation of each CABIN AIR FAN. c. CABIN TEMP SWITCH - AUTO d. CABIN TEMP THUMBWHEEL - FULL DECREASE		1b. If one fan is inoperative, place fan closure over inlet of disabled fan.	
	2	CABIN TEMP a. Decreases to NORMAL b. Remains HIGH	→ 3	2. Check at outlet with hand held psychrometer 2a. Corrected by step 1	2a. Control misposition
	3	Crew Comfort a. Comfortable b. HIGH temp - Crew uncomfortable	→ 4	3. Unsited 3a. Crew comfort, or hand held psychrometer dry bulb reading used for cabin temp indications	3a. Cabin temp sensor/circuitry failure
	4	CABIN TEMP SWITCH - MAN	5		
	5	CABIN TEMP VALVE - FULL COOL	6	5. Manual valve	
	6	TEMP CABIN a. Decreases to NORMAL b. Remains HIGH	→ →	6a. Reposition manual valve as required (S/C coolant thermal change) to maintain cabin temp 6b. If uncomfortable Don PGA's for temp control.	6a. Auto control of cabin temp. 6b. All cabin temp control lost.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
24. Cabin Temperature low.	1.	Verify: a. CABIN HX exhaust flowpath unobstructed b. Verify individual operation of each CABIN AIR FAN c. CABIN TEMP SWITCH - AUTO d. CABIN TEMP THUMBWHEEL-FULL INCREASE	2	Normal cabin temp. 70-80°F 1b. If one fan is inoperative place fan closure over inlet of disabled fan.	
	2.	Cabin temperature a. Increases to NORMAL b. Remains LOW	→ 3	2a. Corrected by step 1	
	3.	Crew comfort a. LOW TEMP (Crew discomfort) b. Comfortable	4.	3. Unsuit	
	4.	CABIN TEMP SWITCH - MANUAL	5.	→ 3b. Crew comfort, or handheld psychrometer dry bulb reading used for cabin temp. indication.	3b. Cabin temp. sensor/circuitry failure.
	5.	CABIN TEMP VALVE-FULL HOT	6	5. Manual valve	
	6.	TEMP CABIN a. Increases to NORMAL b. Remains low	→	6a. Reposition manual valve as required (S/C coolant thermal change) to maintain cabin temp. 6b. If uncomfortable don PGAS for temperature control.	6b. Cabin temp. control lost.
<p>NOTE: Cabin temperature may be increased by powering up equipment and S/C orientation. Condensation will be evident with cabin temperature below 50°F.</p>					
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
25. HIGH CABIN HUMIDITY				High humidity noted by crew discomfort or condensation with in the C/M - probably on Cabin HX louvers. Determine relative humidity or dew point by using hand held pshchrometer.	
NOTE: Examine CABIN INTERIOR FOR WATER LEAKS & ISOLATE LEAKS					
	1.	Verify SUIT CIRCUIT RETURN AIR CHECK VALVE - OPEN & intake screen clean and flow-path unobstructed.	2	1. Suit compressors must be off while vacuuming return air screen.	
	2.	HUMIDITY			
	a.	No Decrease	→	2a. Refer to ECS Malfunction Procedure No. 17	
	b.	Decreases	→	2b. Corrected by Step 1.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
31. GLYCOL TEMP LOW C & W Lite - ON ECS RAD OUT TEMP LOW 30°F				Lite trigger: -30° F. Glycol becomes slyshy @ <-30°F; if temp is not increased radiator freezing is probable with resulting loss of radiator cooling capability. However, radiator outlet temp should not be maintained <30°F for extended periods to preclude slow recovery response and progressively poorer performance.	
	1	ECS RAD OUTLET TEMP:			
		a. NORMAL: >30°F	30		
		b. LOW: <30°F	2		
	2	ECS RADIATOR TEMP 1+2		2. Try to ascertain which radiator may be causing problem	
		a. BOTH NORMAL	29		
		b. ONE LOW	21		
		c. BOTH LOW	3		
	3	Verify ECS RAD #1 (A) - OFF	4	3-6. Verify valve positions for condition of radiator outlet temp <35° F	
	4	Verify ECS RAD #1 (B) - Open	5		
	5	Verify ECS RAD #2 (A) - OFF	6		
	6	Verify ECS RAD #2 (B) - Open	7		
	7	ECS RAD OUTLET TEMP			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
31. GLYCOL TEMP LOW C & W Lite - ON				Lite trigger: -30° F. Glycol becomes slyshy @ <-30°F; if temp is not increased radiator freezing is probable with resulting loss of radiator cooling capability. However, radiator outlet temp should not be maintained <30°F for extended periods to preclude slow recovery response and progressively poorer performance.	
	1	ECS RAD OUTLET TEMP:			
		a. NORMAL: >30°F	30		
		b. LOW: <30°F	2		
ECS RAD OUT TEMP LOW 30°F	2	ECS RADIATOR TEMP 1+2		2. Try to ascertain which radiator may be causing problem	
		a. BOTH NORMAL	29		
		b. ONE LOW	21		
		c. BOTH LOW	3		
	3	Verify ECS RAD #1 (A) - OFF	4	3-6. Verify valve positions for condition of radiator outlet temp <35° F	
	4	Verify ECS RAD #1 (B) - Open	5		
	5	Verify ECS RAD #2 (A) - OFF	6		
	6	Verify ECS RAD #2 (B) - Open	7		
	7	ECS RAD OUTLET TEMP			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
		a. LOW: < 30°F b. NORMAL: > 30°F	8 →	7b. Exercising radiator isolation valves has alleviated problem.	
<p>NOTE: Radiator temp can be increased by diverting a portion of the hot glycol from the pumps to the radiators by manually overriding the GLYCOL EVAP TEMP IN valve. However, caution should be used to maintain 40-48° F evaporator outlet temperature.</p> <p>NOTE: Normal evaporator outlet temperature varies with mode of operation 40-43° F in evap mode, 42-48° F in mixing mode until Glycol temp in (mixing) valve full closed, and then to 49-50.5° F before the evap mode is initiated.</p>					
	8	GLYCOL EVAP TEMP IN (sw) - MAN	9		
	9	GLYCOL EVAP TEMP IN - max. cool (CCW)	10	9. Divert max. hot glycol flow to radiators.	
	10	GLY EVAP OUTLET TEMP:		10. Allow time for max. hot glycol flow to circulate through ECS radiators.	
		a. NORMAL: > 40°, < 48° F	12		
		b. LOW: < 40° F	11		
	11	GLYCOL EVAP TEMP IN - to HEAT (CW)	10	11. Divert some hot glycol flow to evaporator to maintain EVAP outlet temp > 40° F < 48° F	
	12	ECS RAD OUTLET TEMP			
		a. NORMAL: > 30° F	13		
		b. LOW: < 30° F	9	12b. If ECS RAD OUTLET TEMP does not increase after several attempts, proceed to step 17.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
	13	GLYCOL EVAP TEMP IN (sw) - AUTO	14	13. Reestablishes auto control	
	14	ECS EVAP OUTLET TEMP			
		a. NORMAL: $>40^{\circ}$ F	17		
		b. LOW: $<40^{\circ}$ F	15		
	15	Switch electrical plug from J38 to J39.	16	15. Switch to spare glycol inlet sensor that controls GLY EVAP TEMP IN (mixing) valve.	
	16	ECS EVAP OUTLET TEMP			
		a. NORMAL	→	16a. Loss of redundant sensor to Glycol Temp Control Unit.	16a. Glycol sensor that inputs to Glycol Temp Control Unit failure.
		b. LOW	→		16b. Probable GLYCOL EVAP TEMP IN valve or Glycol Temp Control Unit failure.

NOTE: Loss of auto inlet glycol temp. control to glycol evap. Manual override of GLY EVAP TEMP IN valve can maintain evap. outlet temp $>40^{\circ}$ F, but will require constant crew attention. Powering up S/C Electronics and initiating S/C "slow roll" to increase radiator outlet temp. will alleviate crew attention to GLYCOL EVAP TEMP IN valve. However, increased water usage will result due to glycol evap. operation to maintain glycol evap. outlet temp to $40-43^{\circ}$ F.

	17	ECS RAD OUTLET TEMP.			
		a. LOW: $<30^{\circ}$ F	18		
		b. NORMAL: $>30^{\circ}$ F	→	17b. Transient condition.	
	18	When possible: Slow roll S/C to maximize Sun, Moon, and/or Earth heating on both radiator surfaces.	19	18. Add external heat to radiator surfaces.	
	19	Power S/C to maximize heat into coldplates.	20	19. Add heat to glycol loop.	

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
31. (Cont) ECS RADIATOR TEMP 1 (or 2) LOW	20	ECS RAD OUTLET TEMP. a. NORMAL: > 30°F b. LOW: < 30° F		20a. Monitor ECS radiator temperatures until stable condition established. 20b. Loss of radiator cooling capability should be expected. Glycol evaporator only cooling means available. If required, S/C can be oriented so one of the radiators receives maximum external heat from Sun, Moon or Earth.	
	21	ECS RAD #1 (or 2) A - OFF	22	21-23. Check for proper RAD configuration for one RAD outlet temp low. (A circuit closed and B circuit open)	
	22	ECS RAD #1 (or 2) B - Open	23		
	23	ECS RAD OUT TEMP 1 (or 2) a. NORMAL: > 30°F b. LOW: < 30° F	24 25		
	24	ECS RAD OUTLET TEMP: a. LOW: < 30° F b. NORMAL: > 30° F	25	31b. Exercising radiator isolation valves has alleviated	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
31. (Cont) CAUTION: Monitor the other radiator to avoid loss due to being on the cold side and freezing completely. RAD TEMP INDICATOR/ SENSOR MALFUNCTION ISOLATION.				problem.	
	25	Orient S/C with cold radiator towards heat source.	26	25. Maximize Sun, Moon, Earth heating on radiator surface.	
	26	Power up S/C	27	26. Maximize heat input to cold plates.	
	27	ECS RAD OUTLET TEMP: a. NORMAL: >30°F b. LOW: <30°F	→ 27a.	27a. Problem alleviated.	
			28	27b. Loss of 50% of radiator cooling capability.	27b. Probable frozen radiator #1 (or #2)
	28	Periodically monitor for indication of recovery	→		
	29	IF: a. GLYCOL TEMP LOW C & W lite ON b. ECS RAD OUTLET TEMP. LOW: <-30°F c. ECS RAD OUT TEMP 1 & 2: NORMAL: >-30°F	→	29. Loss of glycol temp C & W and combined ECS Rad outlet temp indication. Use ECS RAD OUT TEMP 1, 2 meter to monitor radiator outlet temperature.	29. PROBABLE FAILURE OF TEMP SENSOR driving C & W lite and ECS RAD OUTLET TEMP meter.
	30	IF: a. GLYCOL TEMP LOW C & W lite ON b. ECS RAD OUTLET TEMP: NORMAL: >-30°F c. ECS RAD OUT TEMP 1 & 2: NORMAL: >-30°F	→	30. Loss of radiator glycol outlet temp. low C & W indication. Use meters to monitor temp.	30. Probable C & W circuitry failure.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
32. HIGH ECS RAD OUTLET TEMP >97° F				With ECS RAD OUTLET TEMP >97° F the evaporator will be unable to maintain normal EVAP OUTLET TEMP (40-43° F)	
	1	ECS RADIATOR OUTLET TEMP. <i>192</i>			
		a. BOTH NORMAL: <97° F	→		1a. RAD OUTLET TEMP SENSOR/CIRCUITRY FAILURE.
		b. BOTH HIGH: >97° F	2.		
		c. 1 or 2 HIGH: >97° F	5.		
	2	ECS RAD INLET TEMP			
		a. <97° F	3.		
		b. >97° F	4.		
	3	GLYCOL TO RAD VALVE - CLOSE	→	3. Serious heating in S/M. Possible fire or RCS firing on RAD.	3. Excessive heating in S/M. <i>most prob cause of high inlet temp is high elect load - shorted inverter</i>
	4	Power down	→	4. Refer to EPS Malfunction Procedure NO. 7 section 9.1.4.3 (Inverter 1, 2, or 3 ≥ 190° F)	
	5	Verify RAD isolation valves (4) open	6.		
	6	Orient S/C with hot RAD away from heat source.	→	6. Monitor temps for recovery	6. Probable single radiator restriction or S/C orientation
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33.

Glycol evaporator
outlet temp - HIGH

17505

TO BE DETERMINED

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
33. (Cont)	7	Maintain $45 \pm 3^{\circ}\text{F}$ at GLY EVAP OUTLET TEMP with GLYCOL EVAP TEMP IN valve.	→	7. Manual control of GLY EVAP TEMP IN (MIXING) VALVE required.	7. Sensor or controller failure
	8	GLYCOL EVAP OUTLET TEMP a. $<60^{\circ}\text{F}$ b. $>60^{\circ}\text{F}$	→	8a. Acceptable temperature 9 8b. Temperature too high	
	9	Power down to maintain GLYCOL EVAP OUTLET $<60^{\circ}\text{F}$	→		
	NOTE: If unable to reduce temperature $<60^{\circ}\text{F}$ or power up required, manually operate evaporator to control EVAP OUTLET TEMP.				
	10	Switch EVAP SMSRS plug to redundant receptacle (J38 or J39)	11	10. Check alternate set of sensors for evaporator control	11a. J38 or J39 sensors failed
	11	GLYCOL EVAP OUTLET TEMP a. Decreases to NORMAL: $40-43^{\circ}\text{F}$ b. No change	→	11a. Sensor redundancy lost	
	12	GLYCOL EVAP STEAM PRESS - MAN	12		
	13	GLYCOL EVAP STEAM PRESS switch - DECR	13		
	14	GLYCOL EVAP STEAM PRESS a. Decreases b. No change	14		
			15	14a. Possible loss of automatic back pressure control	
			31	14b. Steam duct blocked	

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
33. (Cont)	15	GLYCOL EVAP OUTLET TEMP			
		a. Decreases	16		
		b. No change	17		
	16	Manipulate GLY EVAP STEAM PRESS- INCR/DECR switch	→	16. Maintain Glycol Evapora- tor outlet temperature 40-43°F	16. Glycol Evap con- troller failure.
	17	Plug EVAP TEMP SENSOR UNIT into EVAP SNSRS J38 or J39	18		
	18	EVAP TEMP SENSOR UNIT switch - WICK	19		
	19	WICK temp			
		a. < 40°F	20		19a. EVAP Frozen
		b. > 40°F	23		
	20	GLY EVAP STEAM PRESS switch - increase until WICK temp > 40°F	21		
	21	GLY EVAP STEAM PRESS switch - AUTO	22		
	22	GLYCOL EVAP OUTLET TEMP			
		a. 40-43°F	→	22a. Frozen evap probably caused by transient condition	
		b. > 43°F	24		
	23	GLYCOL EVAP STEAM PRESS switch - AUTO	24		
	24	EVAP TEMP SENSOR UNIT - NULL	25		

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
33. (Cont)	25	Manipulate GLY EVAP H ₂ O switch between ON and OFF.	26	25. Manual control of water to wick.	
	26	GLY EVAP OUTLET TEMP a. 40-43°F	→	26a. Automatic EVAP control lost (water only). Manual control possible when required using NULL position of EVAP TEMP SENSOR UNIT to control water flow with switch.	26a. GLY EVAP controller (water section) controller failure.
		b. >43°F	27		
	27	EVAP H ₂ O valve - OFF	28		
	28	Manipulate GLY EVAP WATER CONTROL BYPOSS valve between ON and OFF	29	28. Manual control of water to wick	
	29	GLY EVAP OUTLET TEMP a. 40-43°F	→	29a. Manual bypass only water control to evap wick. Continue manual operation as required. Requires crewman at LHEB.	29a. EVAP WATER valve electrical failure.
		b. >43°F	30		29b. EVAP failure
	30	Power down to maintain EVAP OUTLET TEMP <60°F	→	30. Evaporator unusable.	
	31	Cycle STEAM/URINE DUCT HTR CB's MN A & MN B.	32		
	32	GLY EVAP STEAM PRESS switch - AUTO	33		

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
33. (Cont)	33	GLY EVAP H ₂ O switch - OFF	34	33. Prevents added water in-flow to evaporator.	
	34	Orient S/C with steam duct outlet to heatsource.	35	34. Attempt to thaw frozen duct outlet. Time required may be excessive.	
	35	Monitor GLY EVAP OUTLET TEMP	36	35a. Duct clear and boiling resumed.	
		a. Decreases			
	b. No decrease	37			
36	GLY EVAP H ₂ O switch - AUTO	→	36. EVAP operation restabilished.		
	37	Power down to maintain EVAP OUTLET TEMP 60°F	→	37. Evaporator unusable as long as steam duct blocked.	37. Blocked steam duct.
<p><u>WARNING:</u> CABIN PRESSURE RELIEF may not be possible through steam duct.</p>					

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Glycol evaporator
outlet temp - LOW
($<40^{\circ}\text{F}$)

SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
		TO BE DETERMINED			

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
34. LOW GLYCOL EVAPORATOR OUTLET TEMPERATURE: < 40°F.				Normal temperature range 40-50.5°F depending on operation mode.	
	1	ECS RAD OUTLET TEMP a. > 48-50.5°F b. < 42°F	12 2	1a. Evaporator operating with excessive boiling 1b. GLY EVAP TEMP IN (MIXING) VALVE not allowing adequate Glycol bypass	
	2	Switch EVAP SENSOR plug to redundant jack (J38 or J39)	3		
	3	GLY EVAP OUTLET TEMP a. Increases to normal (42-48°F) b. No change	→ 4	3a. Loss of redundant sensors.	3a. Sensor failure.
	4	GLYCOL EVAP TEMP IN switch - MAN	5		
	5	GLYCOL EVAP TEMP IN valve - CW (HEAT)	6		
	6	GLY EVAP OUTLET TEMP a. Increases to normal (42-48°F) b. No change	7 8	7a. Automatic Glycol mixing control lost. 6b. Possible indicator failure	
	7	Adjust for 45° + 3°F at GLYCOL EVAP OUTLET TEMP.	→	7. Manual control of mixing valve required when ECS RAD OUTLET TEMP 38°F to prevent wick freezing	

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
34. (Cont)	8	GLYCOL EVAP TEMP IN switch - AUTO	9		
	9	Plug EVAP TEMP SENSOR UNIT into EVAP SNSRS J38 or J39	10		
	10	EVAP TEMP SENSOR UNIT - INLET	11		
	11	Evaporator INLET TEMP a. $45^{\circ}\text{F} \pm 3^{\circ}\text{F}$ b. $<42^{\circ}\text{F}$	→		11a. GLY EVAP OUTLET TEMP indicator failure
			→	11b. Glycol bypass lost. Radiator outlet temperature must be maintained $>38^{\circ}$ to prevent evaporator wick freezing	11b. GLYCOL EVAP TEMP IN (MIXING) valve failed closed.
	12	Switch EVAP SENSOR plug to redundant jack (J38 or J39)	13		
	13	GLY EVAP OUTLET TEMP a. $40^{\circ}-43^{\circ}\text{F}$ b. No change	→	13a. Normal temperature. Loss of redundant sensor.	13a. Sensor failure.
			14		
	14	GLYCOL EVAP STEAM PRESS - MAN	15		
	15	GLYCOL EVAP STEAM PRESS switch - INCR (Monitor STEAM PRESS gage)	16		
	16	GLY EVAP STEAM PRESS a. Increases b. No change	17 23	16a. Loss of automatic back pressure control	16a. Glycol Evap controller failed

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
34. (Cont)	17	Manipulate GLY EVAP STEAM PRESS INCR/DECR switch to control outlet temp.	18	17. Manual control of back pressure.	
	18	GLY EVAP OUTLET TEMP a. 40°-43°F b. <40°F	→ 19	18a. Continue manual control as required 18b. Possible indicator failure	
	19	Plug EVAP TEMP SENSOR UNIT into EVAP SNSRS J38 or J39.	20		
	20	EVAP TEMP SENSOR UNIT - WICK	21		
	21	WICK TEMP a. >40°F b. <40°F	22 23		21a. GLY EVAP OUTLET TEMP indicator failure.
	22	GLYCOL EVAP STEAM PRESS - AUTO	→	22. Automatic operation of evaporator re-established.	
	23	GLYCOL EVAP H ₂ O FLOW switch - OFF	→	23. De-energizes Glycol Evaporator operation.	23. Back pressure controller failed.
NOTE: Maintain Radiator outlet temperature <60°F. For high load conditions and entry the glycol evaporator can be used, but not recommended for normal operation due to probable freezing and inefficient H ₂ O usage.					
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
37 PRESS GLY DISCH - LOW 434		TO BE DETERMINED			
GLY ACCUM QUANTITY - HIGH LOW		TO BE DETERMINED			

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
37. PRESS GLY DISCH - LOW: <34 PSIA or decreasing					
	1	GLY ACCUM QUANTITY:			
		a. NORMAL: 30-60% (and steady)	18		
		b. LOW: < 30% (and/or decreasing)	2	1b. System leakage.	
GLY ACCUM QUANTITY LOW: < 30%	2	GLYCOL ACCUMULATOR valve - OFF (CW)	3	2. Isolates accumulator	
	3	GLY ACCUM QUANTITY			
		a. Decreasing	4		3a. Glycol accumulator leaking
		b. Stabilized	5	3b. Glycol accum not leaking.	
	4	GLYCOL RESERVOIR INLET valve-ON	→	4. Reservoir replaces accumulator for remainder of mission.	
	5	GLYCOL ACCUMULATOR valve-ON (CCW)	6		
	6	GLY TO RAD valve - CLOSE	7	6. Assumes GLYCOL PRESS RELIEF BYPASS valves - OPEN. Bypasses all glycol flow around radiator. Not to exceed 30 minutes to avoid radiator freezing.	
	7	PRESS GLY DISCH:			
		a. Remains LOW	14		
		b. NORMAL: > 34 psia	8	7b. Probable leak in ECS radiators.	
	9	GLY TO RAD valve - OPEN	9		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
37. (Cont)	15	SUIT EVAP GLYCOL valve - OFF	16	15. Directs glycol flow around suit heat exchanger <i>Verify Water valve closed</i> <i>Suit Evap Sw - manual</i>	16a. Glycol system leakage.
	16	PRESS-GLY DISCH a. Remains LOW:	17	16a. Unable to isolate glycol system leakage. Eventual loss of entire glycol supply with resulting loss of total space-craft thermal control	
		b. NORMAL:	→	16b. Loss of suit cooling capability with suit heat exchanger Suit evap. only means available for suit circuit cooling.	16b. Glycol leak internal to suit heat exchanger.
	17	SUIT EVAP GLYCOL valve - ON	→		
	18	ECS GLYCOL PUMP SELECTOR SWITCH- Select alternate pump and/or bus <i>verify CB's</i>	18		
	19	PRESS-GLYCOL DISC a. Normal: >34 psia	→	19a. Pump or bus redundancy lost. Continue operation on active bus or functional glycol pump	19a. Electrical or pump failure.
		b. Remains LOW:	20		
	20	MSFN CF0550P a. NORMAL:	→	20. Check glycol P across cold place net # 2. 20a. Loss at glycol pump outlet pressure indication. Use CF0550P as glycol flow indication	20a. Glycol Pumps Outlet Press. Sensor /Circuitry Failure.

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
37. (Cont)		b. LOW:	→	20b. Complete loss or degraded glycol pump capability. Probable loss of spacecraft thermal control.	20b. BOTH GLYCOL PUMPS or circuitry failure.

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
39. GLY ACCUM QUANTITY - HIGH: increasing >70%	1	Verify a. GLYCOL ACCUM S/O valve-OPEN b. GLYCOL RESERVE valve-CLOSED c. GLYCOL RESERVOIR INLET/OUT-LET valves - CLOSED d. GLYCOL RESERVOIR BYPASS valve - OPEN	2	1. Establish system configuration	
NOTE: Glycol accumulator pressure is referenced to Cabin Pressure - hence any glycol accumulator quantity <100% cannot result in coolant loop overpressurization. Normal accumulator quantity 30-60%.					
	2	GLYCOL RESERVOIR INLET valve - OPEN	3	2. Permits transfer of glycol from accumulator to reservoir.	
	3	GLY ACCUM QUANTITY indicator a. 70% <i>decreases</i> b. No decrease <i>stay same</i>	4	(decreases at 70%)	
			5	3b. Quantity indication lost, use reservoir for positive accumulator action.	3b. Indicator failure
	4	GLYCOL RESERVOIR INLET valve - CLOSED <i>(at 70%)</i>			
	5	GLY ACCUM QUANTITY a. Remains normal or slow increase b. Rapid increase	→	5a. Repeat steps 3-4 as required to maintain normal pressure.	5a. Slow leakage of GLYCOL RESERVE valve
			6		5b. Large leakage of GLYCOL RESERVE valve.
	6	GLYCOL RESERVOIR INLET valve - OPEN	→	6. Glycol reservoir used for accumulator action	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
41. POTABLE HOT H ₂ O TEMPERATURE LOW					
	1	POT H ₂ O HEATER			
		a. OFF	2		
		b. MN A or B	3		
	2	POT H ₂ O HEATER - MN A or B	→	2. Inadvertant switch position	
	3	POT H ₂ O HEATER - alternate Bus (MN A ² or B)	4		
	4	HOT H ₂ O TEMP.			
		a. Increases	→	4a. Power supply redundancy lost. Approx. one hour recovery time required.	4a. Circuitry failure from MN A or B bus.
		b. No Increase	→	4b. Hot H ₂ O supply lost or re- covery time extended.	4b. Heater failed or degraded. Loss of one or both heater elements.

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
42. POTABLE H ₂ O QUANTITY fails ² to increase on transfer.				Assume proper valve configuration and H ₂ O IND switch - POT.	
	1.	WASTE H ₂ O TK REFILL - 2 (alternate tank)	2.	1. Attempts transfer from redundant SM tank.	
	2.	WATER QUANTITY (Potable)			
	a.	INCREASES	→	2a. One SM WASTE H ₂ O TANK (56#) unusable or empty.	2a. No. 1 or 2 SM WASTE H ₂ O SOLENOID S/O Valve or circuitry failure.
	b.	NO INCREASE	3.		
	3.	Continue normal transfer procedure	4.	3. No evidence of transfer on quantity indicator; however, transfer may be in progress if indicator failed.	
	4.	WATER QUANTITY (Potable)			
	a.	NO CHANGE	→	4a. Monitor MSFN CF 0126 P for pressure increase to overcome WASTE TANK INLET & RELIEF VALVE ΔP - indicating full POTABLE TANK. Then monitor MSFN CF0127P for increase indicating potable tank full <u>waste!</u>	4a. Gage failure
	b.	DECREASES	→	4b. Water did not transfer. Potable water only sure water supply remaining.	4b. N ₂ transfer system failure or line blockage.
	WARNING: Monitor fuel cells for possible flooding				

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE	
43. WATER QUANTITY DECREASE RATE HIGH	1	WASTE TANK WATER & RELIEF VALVE - CLOSE	2	<p>2a. Potable water being used with waste water. Waste tank Inlet Relief valve must be operated manually, and closed for water transfer.</p> <p>Rate of decrease on Potable Water quantity indicator greater than expected for operation mode or as indicated by MSFN.</p> <p>5b. Monitor cabin humidity. Check for water in CM.</p>	2a. Waste Tank Inlet Relief valve failure.	
	2	WATER usage rate				
		a. Normal				
		b. High	3			
	3	WASTE TANK WATER & RELIEF VALVE - AUTO	4			
	4	WATER CONTROL PRESSURE RELIEF - OFF	5			
	5	WATER QUANTITY				
		a. Decrease rate normal.	6			
		b. Decrease rate remains high				
	6	WATER CONTROL PRESSURE RELIEF-1	7			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
43. (Cont)	7	WATER QUANTITY			
		a. No change	→	7a. Relief valve redundancy lost.	7a. No. 2 WATER CONTROL PRESSURE RELIEF Valve failed OPEN.
		b. Excessive decrease rate	8		
	8	WATER CONTROL PRESSURE RELIEF - 2	9		
	9	WATER PRESSURE			
		a. Rate decreases	→	9a. Relief valve redundancy lost.	9a. No. 1 WATER CONTROL PRESSURE RELIEF valve failed OPEN.
		b. Rate remains high.	10		9b. Both WATER CONTROL PRESSURE RELIEF Valves failed open.
	10.	WATER CONTROL PRESSURE RELIEF - OFF	→	10. Automatic pressure relief lost. Refer to ECS Malfunction Procedure No. 45 to control Water pressure. Manual relief valve operation possible when MSFN water pressure information available.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
44. GAS LEAKAGE INTO H ₂ O SUBSYSTEM				It is possible to introduce O ₂ , N ₂ or H ₂ into the Potable or Waste Water subsystem.	
<p><u>WARNING:</u> Gas in Waste H₂O subsystem is not readily identifiable however probable with gas in potable H₂O subsystem. Reduced evaporator performance may be expected as well as a false indication of quantity of on-board H₂O. Pressure measurements not indicative of H₂O quantity.</p>					
	1	GAS IN POTABLE H ₂ O SUBSYSTEM			
		a. Gas entrainment evidenced - but not excessive.	→	1a. Monitor H ₂ O/gas ratio for continued H ₂ O subsystem degradation.	
		b. Gas entrainment excessive	2		
	2	POTABLE WATER - Quantity			
		a. Constant 100% full	→	2a. Refer to ECS Malfunction Procedure NO. 1.	2a. O ₂ leakage into H ₂ O supply subsystem. Probable Potable tank bladder leak or rupture.
		b. < full	3		
	3	Fill fecal bag with gas and Gas chromatograph orifier installed in bag.	4	3. 80 min cycle to determine type gas (H ₂ , N ₂ or O ₂)	
		<i>put on tank mask "from cabin." Turn selector mode to cabin</i>			
	4	Gas chromatograph indication			
		a. H ₂	→		4a. Excessive H ₂ inflow from F/C. ²
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
44. (Cont)		b. N ₂	→	4b. Use alternate S/M water tank for futher water transfer (if water had been transferred).	4b. N ₂ transfer system bladder rupture.
		c. O ₂	→		4c. Small O ₂ leak.

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SYMPTOM	STEP	PROCEDURE	NO STEP	REMARKS	FAILURE
45. POTABLE & WASTE WATER SYSTEM PRESSURE HIGH (≥48 psid) MSFN CPO326P and CPO327P				Water not relieving overboard. Failure to dump water will probably be noted by failure to dump urine. Another indication will be MSFN overpressure of POTABLE & WATER TANKS. Loss of fuel cells may be a consequence of water system overpressurization	
NOTE: Withdraw potable water as required to maintain safe water pressure.					
	1	Monitor MSFN for pressure indications until failure corrected			
		a. Pressure remains stable	→	1a. Overboard dump not obstructed or Waste Water tank never filled.	1a. Relief setting shift.
		b. Pressure increases	2	1b. Waste Water tank full and overboard dump obstructed.	1b. Overboard dump obstructed
	2	Withdraw Potable Water to maintain safe pressure	3	2. Continue to withdraw water as required until malfunction corrected or re-entry to preclude fuel cell flooding.	
	3	Waste Management selector Valve- URINE FECS OVBD VALVE - DUMP then both OFF.	4	3. Check for suction to determine status of urine dump port.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
45. (Cont)	4	SUCTION			
		a. NORMAL	6	4a. Dump port unobstructed	
		b. DEGRADED or NONE	5	4b. Refer to ECS Malfunction Procedure No. 51.	4b. Overboard dump port obstructed.
	5	Withdraw Potable Water to maintain safe pressure.	→	5. Continue to withdraw water as required until malfunction corrected or re-entry to preclude fuel cell flooding.	
	6	Cycle PRESSURE RELIEF SELECTOR Valve	7	6. Attempt to clear possibly clogged valve posts.	
	7	WATER PRESSURE		7. MSFN indication	
		a. DECREASES	→	7a. Failure corrected and normal relief available.	7a. Clogged PRESSURE RELIEF SELECTOR Valve
		b. NO DECREASE	8		7b. Relief line blockage or both relief valves failed closed.
	8	Withdraw Potable Water to maintain safe pressure.		8. Continue to withdraw water as required until re-entry to preclude fuel cell flooding. Relief capability lost. Dump excess water through waste management system or store in urine bags.	

NOTE: If one or both SM WASTE H₂O TANKS have been transferred to CM tanks place the WASTE H₂O TK REFILL switch in position 1 or 2 (used tank): Excess fuel cell water will be stored in SM WASTE H₂O TANKS (56 lb each) until filled. Water pressure will increase again when SM tanks fill. Normal water transfer available when required; however MSFN pressure monitoring required to preclude overpressurization of water system.

PREPARED BY: <u>J. Berger</u>	FLIGHT CREW SUPPORT DIVISION	ENVIRONMENTAL CONTROL SYSTEM	APOLLO OPERATIONS HANDBOOK	
<u>T.O. McGowan</u>	DATE: <u>JAN 27, 1967</u>	MALFUNCTION PROCEDURES	S/C <u>012</u>	REV <u>FINAL</u>
<u>R. B. B. B.</u>			SECTION <u>9.1.6</u>	PAGE <u>75</u>

SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
51. UNABLE TO DUMP URINE.					
	1	Verify WASTE MANAGEMENT SELECTOR-URINE FECES.	2		
	2	Verify WASTE MANAGEMENT OVBD DRAIN - DUMP	3		
	3	Verify Q/D and urine hose/receptacle	4		
	4	URINE OVERBOARD DUMP			
	a.	DUMPS	→	4a. Resume normal ops. Corrected by steps 1 - 3.	
	b.	DOES NOT DUMP	5		
	5	Cycle ECS STEAM DUCT HTR MN A C/B			
	6	URINE OVERBOARD DUMP.		6. Allow time for urine tip htr. operation.	
	a.	DUMPS	→	6a. Continue normal ops.	6a. Open C/B circuit
	b.	DOES NOT DUMP	⇒	6b. Orient S/C for max. heat on urine overboard dump port to clear probable ice blockage. Use onblard urine containers if line remains blocked.	6b. URINE TIP HTR failure or line blockage.
<p>NOTE: BATTERY VENT, fecal canister vacuum and OVERBOARD WATER DUMP capability loss probable. Monitor RAD INLET and OUTLET temp limits (due to S/C orientation restrictions).</p>					
PREPARED BY: <u>J. Baker</u> <u>T.O. Montgomery</u> <u>R. Bodurtha</u>		FLIGHT CREW SUPPORT DIVISION DATE: JAN 27, 1967		ENVIRONMENTAL CONTROL SYSTEM MALFUNCTION PROCEDURES	
				APOLLO OPERATIONS HANDBOOK S/C 012 REV FINAL SECTION 9.1.6 PAGE 76	

SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
52. LOW VACUUM SUCTION	1	Verify WASTE MANAGEMENT SELECTOR-VACUUM CLEANER	2		
	2	Verify hose integrity	3		
	3	SUCTION			
	a.	NORMAL	→	3a. Resume normal use. Corrected by steps 1 & 2.	
	b.	No change in status	4		
	4	Change FILTER	5		
	5	SUCTION			
	a.	NORMAL	→	5a. Resume normal use.	5a. Filter clogged or expended.
	b.	No change in status	6		
	6	Cycle ECS CABIN AIR FAN AC 1 (3) C/B's	7		
	7	SUCTION			
	a.	NORMAL	→	7a. Resume normal use.	7a. C/B circuit failure.
	b.	No change in status	→	7b. Vacuum cleaner use lost or degraded.	7b. Vacuum cleaner FAN failure or line blockage.
	<p>NOTE: Suit circuit return air ck valve assy screen must be cleaned manually as required.</p>				
PREPARED BY: <i>J. B. BAKER</i> <i>T. O. McFarlane</i> <i>R. B. BAKER</i>		FLIGHT CREW SUPPORT DIVISION DATE: JAN 27, 1967		APOLLO OPERATIONS HANDBOOK S/C 012 SECTION 0.1-6	
ENVIRONMENTAL CONTROL SYSTEM MALFUNCTION PROCEDURES				REV FINAL PAGE 77	

SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
53. FECAL CANISTER VACUUM - LOW	1	Verify FLUSH VALVE - OPEN	2		
	2	Verify FECAL CANISTER, hose assembly, and Q/D integrity.	3		
	3	Verify WASTE MANAGEMENT SELECTOR- URINE FECES	4		
	4	Verify WASTE MANAGEMENT OVERBOARD DRAIN - DUMP	5		
	5	FECAL CANISTER VACUUM			
	a.	NORMAL	→	5a. Resume normal ops. Corrected by steps 1 - 4.	
	b.	Remains LOW	6		
	6	Cycle ECS STEAM DUCT HTR MN A C/B	7		
	7	FECAL CANISTER VACUUM		7. Allow time for urine tip htr operation.	
	a.	NORMAL	→	7a. Continue normal ops.	7a. Open C/B circuit
b.	Remains LOW	→	7b. Orient S/C for max. heat on urine overboard dump port to clear probable ice blockage. Use Fecal bags without canister if vacuum remains low.		
<p>NOTE: BATTERY VENT, URINE DUMP and OVERBOARD WATER DUMP capability loss probable. Refer to ECS Malfunction Procedure NO. 45. Monitor RAD INLET and OUTLET temp limits (due to S/C orientation restrictions)</p>					
PREPARED BY: <u>J. Baker</u> <u>V.O. Montague</u> <u>R. G. G. G.</u>		FLIGHT CREW SUPPORT DIVISION DATE: JAN 27, 1967		ENVIRONMENTAL CONTROL SYSTEM MALFUNCTION PROCEDURES	
				APOLLO OPERATIONS HANDBOOK S/C 012 SECTION 9.1.6 REV FINAL PAGE 78	

SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
61. Inadequate Ventilation after landing.				ATTITUDE CONTROL SWITCH will automatically close EXTERIOR AIR INTAKE and CABIN AIR EXHAUST valves and shut off fan if C/M tilts > 60° from vertical. Assume stable 1 position.	
	1	Visually verify valve positions (2).			
		a. Open	3		
		b. Closed	2		
	2	Verify EXTERIOR AIR INTAKE and CABIN AIR EXHAUST valve LOCK PINS - REMOVED.	3		
	3	POST LANDING VENT FAN - OFF/HIGH and LOW	4	3. Try both HIGH and LOW positions for operation. Assume PLVC switch - NORMAL.	
	4	Visually verify valve positions.			
		a. Open	7		
		b. Closed	5		
	5	PLVC switch - OPEN	6		
	6	Valve positions (2)			
		a. OPEN	7		
		b. CLOSED	→	6b. Alternate ventilation required. Egress may be required.	6b. POST LANDING VENT valves failed closed.
PREPARED BY: <u>J. Bayard</u> <u>T.O. Montgomery</u> <u>R. B. Sullivan</u>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
DATE: <u>JAN 27, 1967</u>		ENVIRONMENTAL CONTROL SYSTEM MALFUNCTION PROCEDURES		S/C <u>012</u>	REV <u>FINAL</u>
				SECTION <u>9.1.6</u>	PAGE <u>79</u>

SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
62. Water inflow after landing. (after cabin press relief valves closed)				ATTITUDE CONTROL SWITCH will automatically close EXTERIOR AIR INTAKE and CABIN AIR EXHAUST valves and shut off fan if C/M titlts >60° from vertical.	
NOTE: Some water inflow expected until pressure relief valve closed.					
	1	Verify PLVC Switch - Normal	2		
	2	Verify CABIN PRESSURE RELIEF VALVES - CLOSED	3		
	3	Water C/M inflow			
		a. Terminates	→	3a. PLVC switch misposition.	
		b. Continues	4		
	4	POST LANDING VENT FAN - OFF	5		
	5	WATER C/M INFLOW			
		a. Terminates	→	5a. Resume ops. Manual control of Vent valves required.	5a. Pendulum Ring switch did not close Vent valves.
		b. Continues	→	5b. Reopen POST LANDING VENT Valves for ventilation (may increase leakage rate). Egress may be required.	5b. Probable C/M pressure vessel failure.
PREPARED BY: <i>J. B. Ford</i>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
<i>T.O. Montgomery</i>		DATE: JAN 27, 1967		S/C 012 REV FINAL	
<i>R. B. ...</i>		ENVIRONMENTAL CONTROL SYSTEM MALFUNCTION PROCEDURES		SECTION 9.1.6 PAGE 81	

MAL FUNCTION PROCEDURES (A-204)
(4 COLUMN)

UNITED STATES GOVERNMENT

Memorandum

TO : See attached list

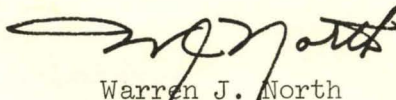
FROM : CF/Chief, Flight Crew Support Division

SUBJECT: Final Apollo I malfunction procedures

DATE: JAN 25 1967

In reply refer to:
CF323-7M-29

Enclosed are the final malfunction procedures for the Apollo I Mission. They should be incorporated into section 9 of the Apollo Operations Handbook. All comments or questions concerning these procedures should be directed to Mr. Richard Benson, CF32, extension 4271.



Warren J. North

Enclosure

CF323:CFDavis:jat 1-23-67

MEMORANDUM

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APOLLO 1 MALFUNCTION PROCEDURES

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PROCEDURES ENTRY SHEET

SECTION 9.1.1.1

GUIDANCE AND NAVIGATION MALFUNCTION PROCEDURES

SYMPTOM	SYMPTOM NUMBER	STEP	PAGE
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OCDU DRIVE PROBLEM	1	1	8
OPTICS DRIVE PROBLEM	2	1	8
OPTICS ZERO ENCODE PROBLEM	3	1	8
ACCELEROMETER FAIL (ISS LOOP)	1	1	9
IMU FAIL	2	1	9
TUMBLER IMU	3	1	9
LARGE IMU ALIGNMENT ERRORS	4	1	9
CDU FAIL LIGHT ON	1	1	10
ABNORMAL FDAI ATT ERROR NEEDLES IN G&N ATT	2	1	10
SUSPECTED AGC PROBLEM	1	1	11
COMP FAIL LIGHT ILLUMINATES (MDC)	1	1	12

SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
S/C 012 Check List Error Code					
00101		Depress error reset. Wait for zero encoder light off. Place Optics Mode switch in Zero Optics position & wait until zero encoder light off again.		Optics Mode switch removed from Zero Optics position before end of 60 second wait.	
00102		Depress Error reset			Computer unable to achieve desired optics mode.
00104		Depress Error Reset on DSKY. Switch Optics Mode to Manual and complete optics drive manually.			The computer has failed to properly control the optics drive. The OCDU's may drive with no desired optics angles.
00105		Depress Error Reset and continue or return to P00 and start over.		Internal marks request with mark system busy.	
00106		Depress Error Reset and continue.		Too many marks	
00107		Depress Error Reset and continue.		Mark reject (V52E) with mark system not in use.	
00110		Depress Error Reset. If rejection of an accepted mark is desired, go back to P00 and start over.		Mark reject with no effect, i.e., no mark between mark rejects or all requested marks have been accepted when V52E entered.	
00112		Depress Error Reset and continue.		Optics mark with none requested.	
PREPARED BY: <i>AM</i>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
DATE: <i>8/13/67</i>		Jan 27, 1967		GUIDANCE AND NAVIGATION MALFUNCTION PROCEDURES	
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E. C. Mosley
J. N. Lockey

HO/Astronaut Office 7
Attn: Lola Morrow
DD4/J. F. Ziegleschmidt 22
Code 552/A. G. Tucker 5

PD11/K. L. Nelson

PD6/F. H. Bearsdley

PF2/W. H. Taylor

PM5/C. R. Haines

2

PD4/S. C. Jones

A. W. Joslyn

W. M. Speier

PK/A. D. Mardel

EC/C. Lute

EE/G. Johnson

R. Edmiston

SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
00122		Depress Error Reset. Re-enter program and make 2 marks or select a known landmark.		Only one mark made for unknown landmark.	
00123		Depress Error Reset. Re-enter program and try again.		Mark data unavailable after restart.	
00201		Depress Error Reset. Wait until zero encoder light off. Reselect Zero Encode Mode and wait until zero encode light off again.		IMU Mode changed from Zero Encode before end of 35 sec. delay.	
00202		Depress Error Reset. Check switches.			Computer unable to achieve desired mode.
00203		Depress Error Reset. Check IMU status.		No IMU mode indicated to computer.	
00204		Depress Error Reset. Select switch configuration to avoid this situation.		IMU mode changed with transfer switch at COMPUTER, but computer did not command the change.	
00205		Depress Error Reset. See PIPA failure malfunction procedures. (Entrance to P00 is enabled by the alarm.)			Excessive accelerometer output (≥ 18.5 g's)
00310		Depress Error Reset and continue (cautiously)			Error return from routine.
00401		Depress Error Reset and continue or realign if desired.		Desired gimbal angles yield gimbal lock. (MGA $\geq 60^\circ$)	
PREPARED BY: <i>gma</i>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
DATE: Jan 27, 1967		GUIDANCE AND NAVIGATION MALFUNCTION PROCEDURES		S/C 012	REV FINAL
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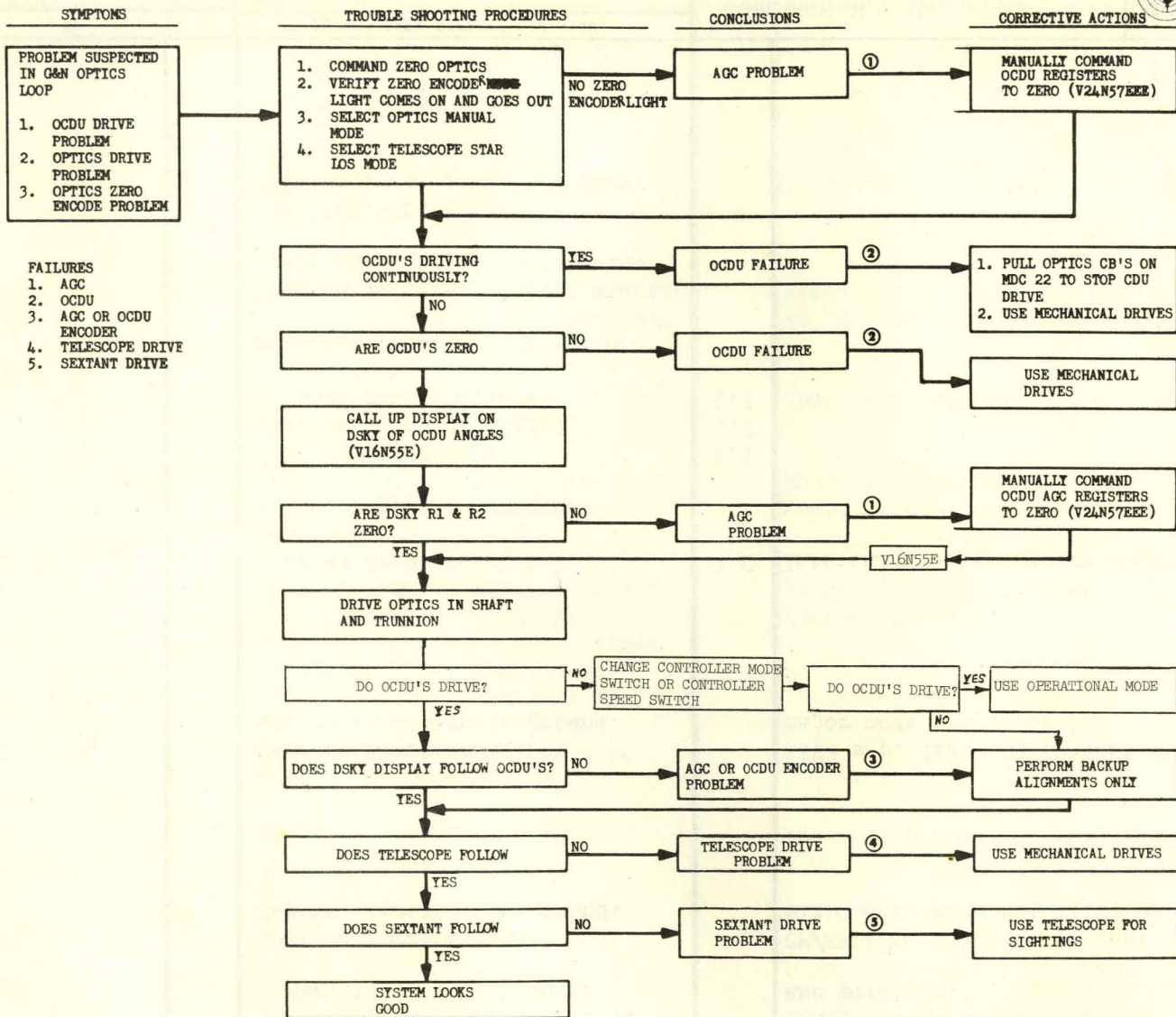
SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
00402		Depress Error Reset. Maneuver vehicle to obtain stars. Reselect program.		Star out of FOV.	
00405		Depress Error Reset. Select proper mode. If no SCS monitor desired (wasn't disabled by V33E at the proper time), key V21NO1E 730E 77776E.		SCS Mode not in desired state.	
00412		Depress Error Reset. Reselect program and change associated time by 15 min. or more.		Time and longitude too far apart.	
01101		Depress Error Reset. Check with ground.			Rupt 2 (not expected, not wired) Hardware suspect
01102		Record R2 and R3 contents. Relay to ground. Depress Error Reset.			AGC self-test error. Use computer with caution.
01103		Depress Error Reset.	1.0		Forbidden step executed (by computer). Use computer with caution.
01104		Record DSKY display. Depress Error Reset. Relay information to ground.			C-relay failed during test.
01201		Depress Error Reset.	1.0		No VAC areas available. Use computer with caution.
PREPARED BY: <i>gmc</i>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
DATE: <i>MBB</i>		Jan 27, 1967		S/C 012 REV FINAL	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
01202		Depress Error Reset.	1.0		No correct areas available. Use computer with caution.
01203		Depress Error Reset.	1.0		Waitlist overflow
01204		Depress Error Reset.	1.0		Task couldn't be fit into the waitlist.
01206		Depress Error Reset.	1.0	Display system routine already in use.	
01207		Depress Error Reset.	1.0		No VAC area available for marks. Use computer with caution.
01210		Depress Error Reset	1.0	Job already waiting in --- STALL	
01301		Depress Error Reset.		Possible erasable memory disturbance.	Arccos or Arcsin argument too large. Use computer with caution.
01302		Depress Error Reset.	1.0	Possible erasable memory disturbance.	Square root argument excessively negative. Use computer with caution.

PREPARED BY: <i>gms</i>	FLIGHT CREW SUPPORT DIVISION	APOLLO OPERATIONS HANDBOOK	
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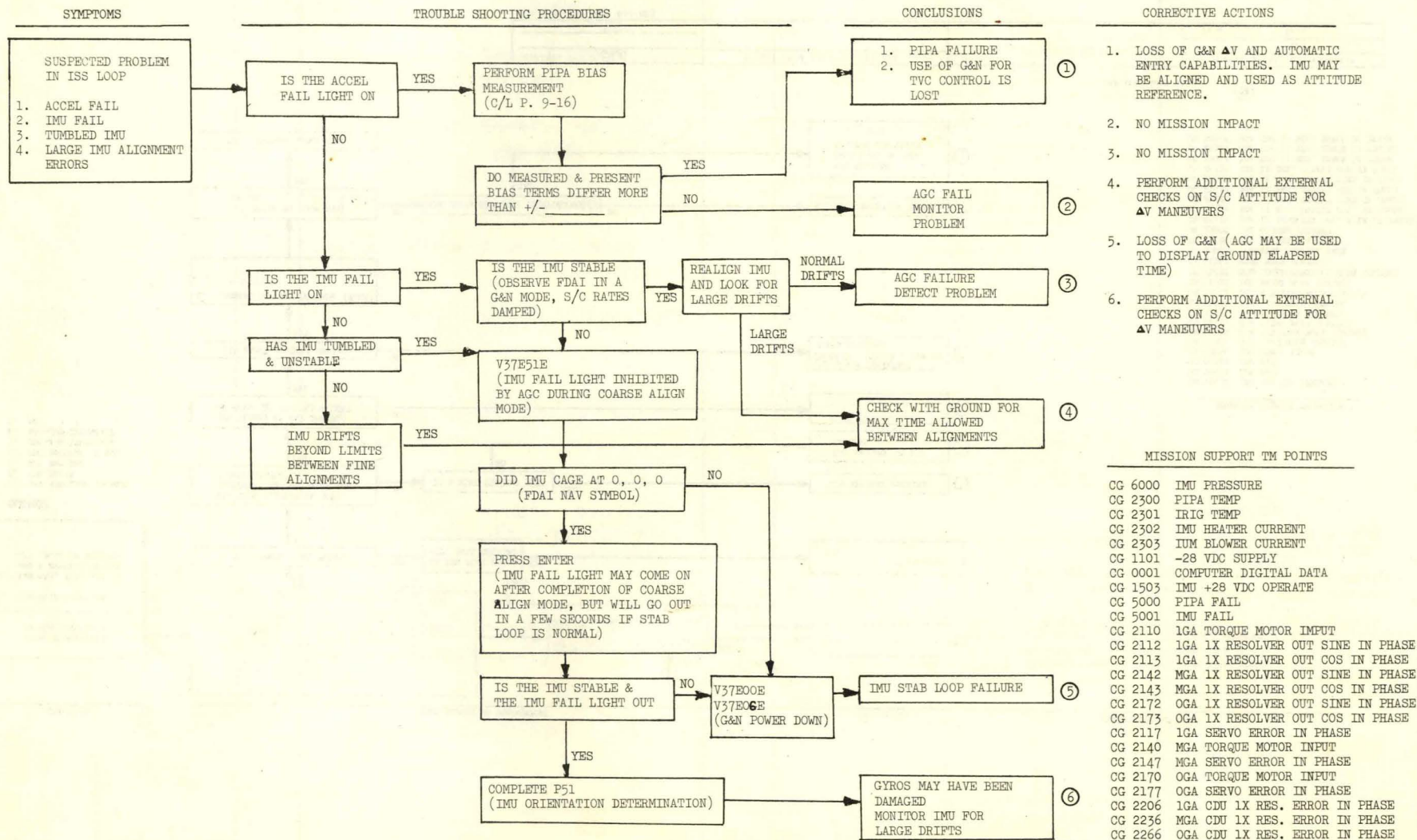
SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
01401		Depress Error Reset. Select P00 and troubleshoot for poor alignment, control system problem etc.		Thrust misalignment exceeds 90°.	
01405		Depress Error Reset. Return to prethrust program via P00 and try again.		Less than 5 min. to ignition.	
01406		Depress Error Reset. Select P00 and reselect prethrust program.		Error return from maneuver to ignition attitude.	This alarm may indicate transient computer error.
01407		Depress Error Reset. Similar to pattern 00401.		Commanded CDUZ exceeds 60°.	
01410		Depress Error Reset. Reselect P32 through P00. Change input parameters.		Entry conditions not computable.	
01411		Depress Error Reset. Reselect P32 through P00. Change latitude of target. If target beyond max. declination is desired, select latitude in P32 to avoid 01411 alarm. Reselect desired latitude in P62.		Target latitude exceeds declination of orbit.	
01421		Go to SCS entry procedures.		Avg. g not running for entry. (Not likely)	
01426		Depress Error Reset. Avoid roll into gimbal lock.		IMU orientation not satisfactory for entry (Computer waits 5 sec and proceeds)	
PREPARED BY: <i>gm</i>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
DATE: <i>NBB</i>		Jan 27, 1967		GUIDANCE AND NAVIGATION MALFUNCTION PROCEDURES	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
01427		Depress Error Reset. Add 180° to backup bank angle charts. 0 deg. roll is lift down.		IMU orientation reversed for entry (Computer waits 5 sec and proceeds.)	
01430		Depress Error Reset. Report condition to ground.		CM/SM sep. discrete present with major mode not 11 or 62.	Since spacecraft not wired for this discrete, appearance of this alarm implies computer transient error.
01431		Depress Error Reset. Report condition to ground.		SIVB sep. discrete present with major mode not 11 or 12.	Since spacecraft not wired for this discrete, appearance of this alarm implies computer transient error.
01501		Depress Error Reset	1.0	Internal display system alarm.	
	1.0	Allow program to continue			
		a. POO displayed	1.1		
		b. POO not displayed	1.2		
		c. Repeated aborts	1.3		
	1.1	Reselect program, try again			
	1.2	Program is attempting to start again at an appropriate point			
	1.3	Key V36E (Fresh Start). Reinitialize erasable memory.			
PREPARED BY: <i>MM</i>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
DATE: <i>HBB</i>		Jan 27, 1967		GUIDANCE AND NAVIGATION MALFUNCTION PROCEDURES	
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MISSION SUPPORT TM POINTS

- CG 3102 V SXT TRUN MOTOR DRIVE IN PHASE
- CG 3112 V SXT SHAFT MOTOR DRIVE IN PHASE
- CG 3133 V SCT. TRUN MOTOR DRIVE
- CG 3141 V TRUN CDU 16X RES. ERROR IN PHASE
- CG 3200 V TRUN CDU MOTOR DRIVE IN PHASE
- CG 3220 V SHAFT CDU MOTOR DRIVE IN PHASE



MISSION SUPPORT TM POINTS

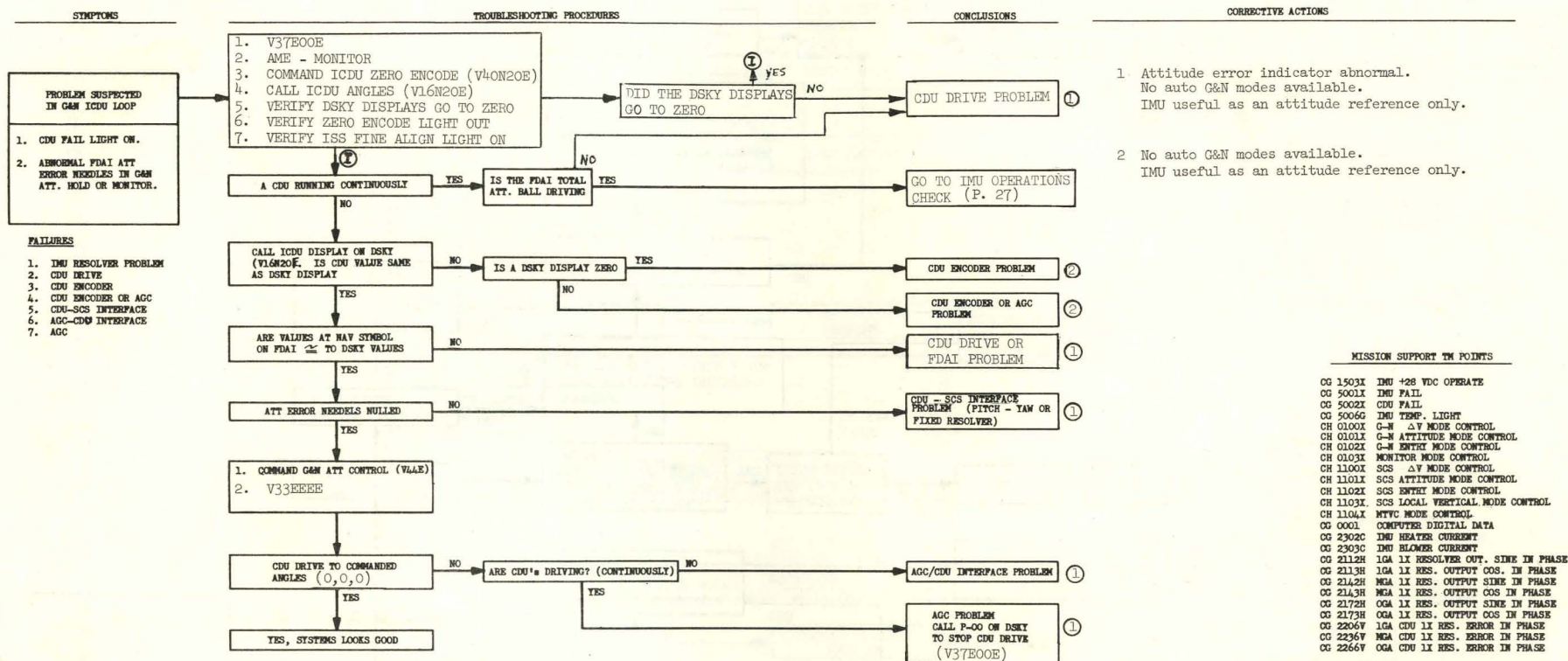
- CG 6000 IMU PRESSURE
- CG 2300 PIPA TEMP
- CG 2301 IRIG TEMP
- CG 2302 IMU HEATER CURRENT
- CG 2303 IUM BLOWER CURRENT
- CG 1101 -28 VDC SUPPLY
- CG 0001 COMPUTER DIGITAL DATA
- CG 1503 IMU +28 VDC OPERATE
- CG 5000 PIPA FAIL
- CG 5001 IMU FAIL
- CG 2110 1GA TORQUE MOTOR IMPUT
- CG 2112 1GA 1X RESOLVER OUT SINE IN PHASE
- CG 2113 1GA 1X RESOLVER OUT COS IN PHASE
- CG 2142 MGA 1X RESOLVER OUT SINE IN PHASE
- CG 2143 MGA 1X RESOLVER OUT COS IN PHASE
- CG 2172 OGA 1X RESOLVER OUT SINE IN PHASE
- CG 2173 OGA 1X RESOLVER OUT COS IN PHASE
- CG 2117 1GA SERVO ERROR IN PHASE
- CG 2140 MGA TORQUE MOTOR INPUT
- CG 2147 MGA SERVO ERROR IN PHASE
- CG 2170 OGA TORQUE MOTOR INPUT
- CG 2177 OGA SERVO ERROR IN PHASE
- CG 2206 1GA CDU 1X RES. ERROR IN PHASE
- CG 2236 MGA CDU 1X RES. ERROR IN PHASE
- CG 2266 OGA CDU 1X RES. ERROR IN PHASE

PREPARED BY: <u>DLB</u>	FLIGHT CREW SUPPORT DIVISION	APOLLO OPERATIONS HANDBOOK	
DATE: <u>Jan 27, 1967</u>	GUIDANCE AND NAVIGATION MALFUNCTION PROCEDURES	S/C <u>012</u>	REV <u>FINAL</u>
		SECTION <u>9.1.1.1</u>	PAGE <u>9</u>

NSC Form 460 (Rev Dec 66)

IMU Operations Check

27

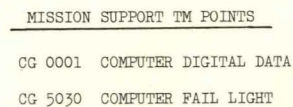


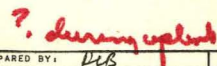
G&N ICDU Loop Check

28

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DATE: <u>Jan 27, 1967</u>			5/C 012 REV FINAL
			SECTION 9.1.1.1 PAGE 10

MSC Form 460 (Rev Dec 66)



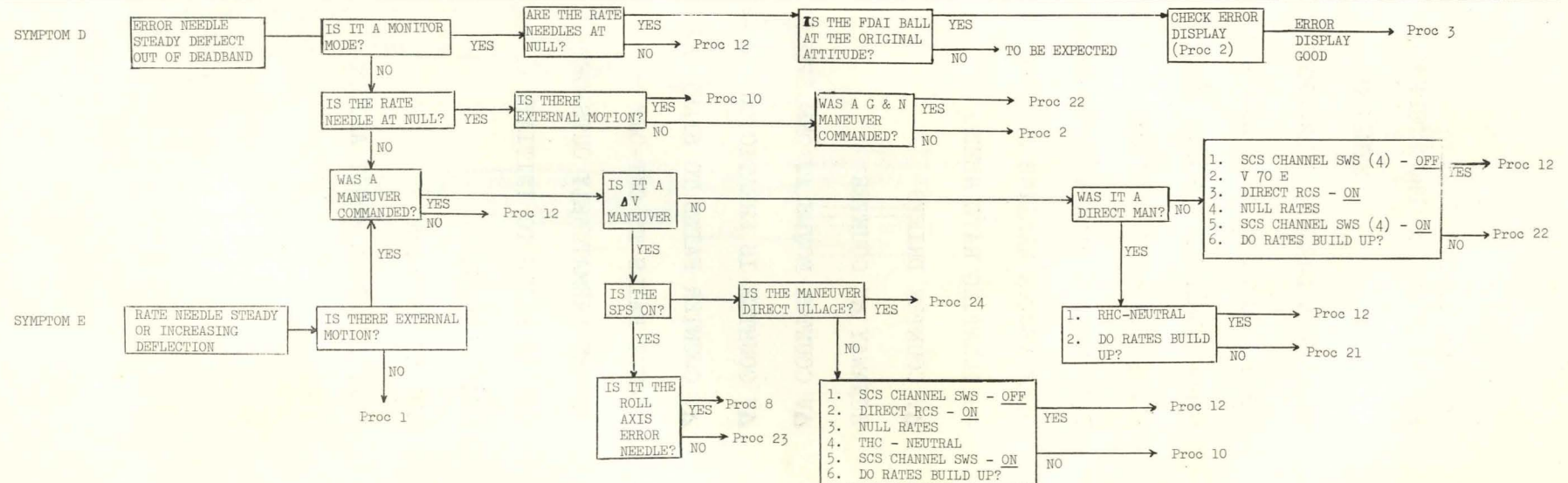
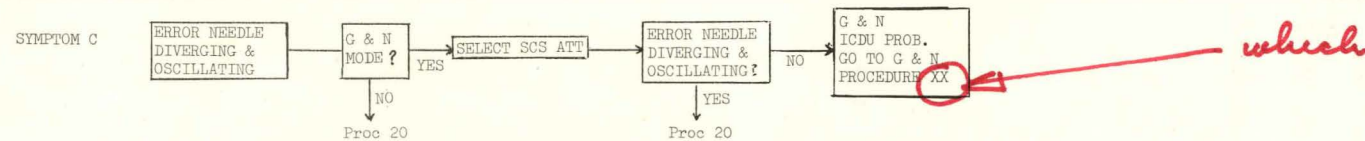
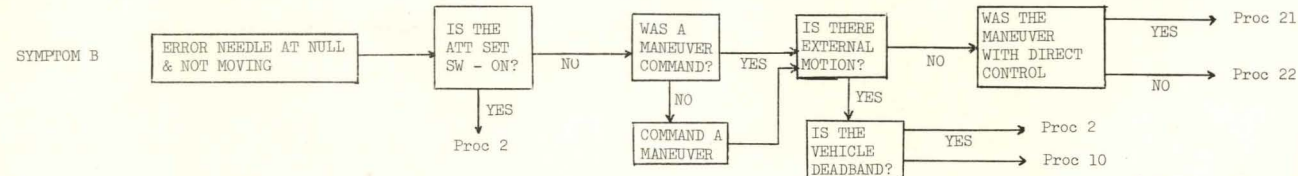
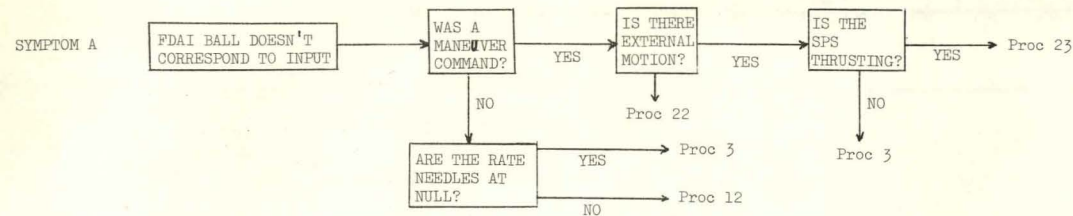


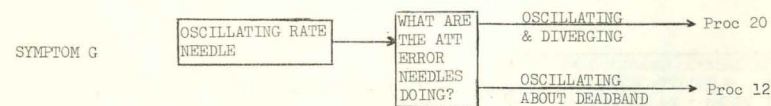
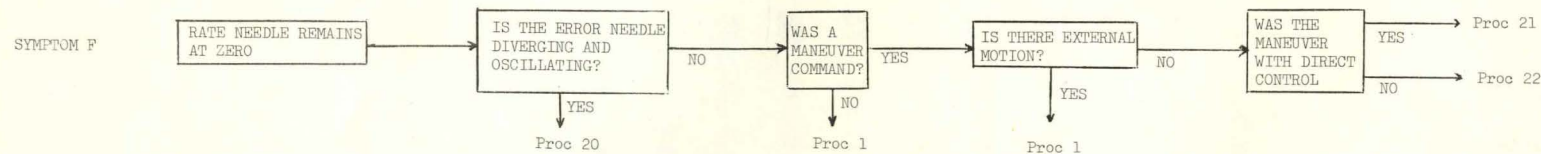
PREPARED BY: <i>WLB</i>	FLIGHT CREW SUPPORT DIVISION	GUIDANCE AND NAVIGATION MALFUNCTION PROCEDURES	APOLLO OPERATIONS HANDBOOK	
<i>WLB</i>	DATE: Jan 27, 1967		S/C 012	REV FINAL
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PROCEDURES ENTRY SHEET

SECTION 9.1.1.2 SCS MALFUNCTION PROCEDURES

SYMPTOM	SYMPTOM LETTER	PAGE
FDAI BALL DOESN'T CORRESPOND TO INPUT	A	2
ERROR NEEDLE AT NULL AND NOT MOVING	B	2
ERROR NEEDLE DIVERGING AND OSCILLATING	C	2
ERROR NEEDLE STEADY DEFLECTION OUT OF DEADBAND	D	2
RATE NEEDLE STEADY OR INCREASING DEFLECTION	E	2
RATE NEEDLE REMAINS AT ZERO	F	3
OSCILLATING RATE NEEDLE	G	3
ΔV COUNTER DRIFTS	H	3
RUNAWAY ΔV COUNTER	I	3
ΔV COUNTER MOVES AT ONE SPEED ONLY	J	3
ΔV COUNTER IS ERRATIC OR ONE-WAY ONLY	K	3
ΔV COUNTER FAILS TO START COUNTING	L	3
THRUST FAILS TO CUT-OFF	M	3
THRUST PREMATURELY CUTS-OFF	N	3
THRUST FAILS TO INITIATE	O	3
GPI HARDOVER	P	3
GPI NO RESPONSE	Q	3
FDAI LIGHTING WON'T ADJUST	R	3





SYMPTOM H ΔV COUNTER DRIFTS → Proc 5 - A

SYMPTOM I RUNAWAY ΔV COUNTER → Proc 5 - B

SYMPTOM J ΔV COUNTER MOVES AT ONE SPEED ONLY → Proc 5 - C

SYMPTOM K ΔV COUNTER IS ERRATIC OR ONE-WAY ONLY → Proc 5 - D

SYMPTOM L ΔV COUNTER FAILS TO START COUNTING → Proc 5 - E

SYMPTOM M THRUST FAILS TO CUT-OFF → Proc 6 - A

SYMPTOM N THRUST PRE-MATURELY CUTS-OFF ^{1.} → Proc 6 - B

SYMPTOM O THRUST FAILS TO INITIATE → Proc 6 - C

SYMPTOM P GPI HARDOVER → Proc 23

SYMPTOM Q GPI NO RESPONSE → Proc 23

SYMPTOM R FDAI LIGHTING WON'T ADJUST → Proc 4

REMARKS

1. ALSO CONSIDERS ECO AT IGNITION

PREPARED BY: *CSH*

FLIGHT CREW SUPPORT DIVISION

DATE: Jan 27, 1967

STABILIZATION AND CONTROL
MALFUNCTION PROCEDURES

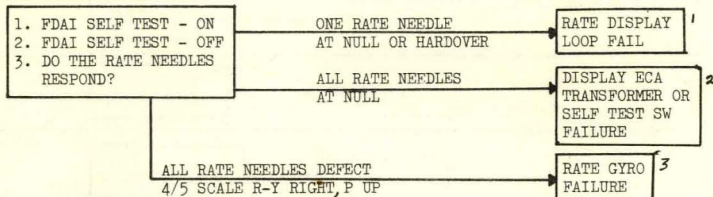
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SCS 1

PROCEDURE

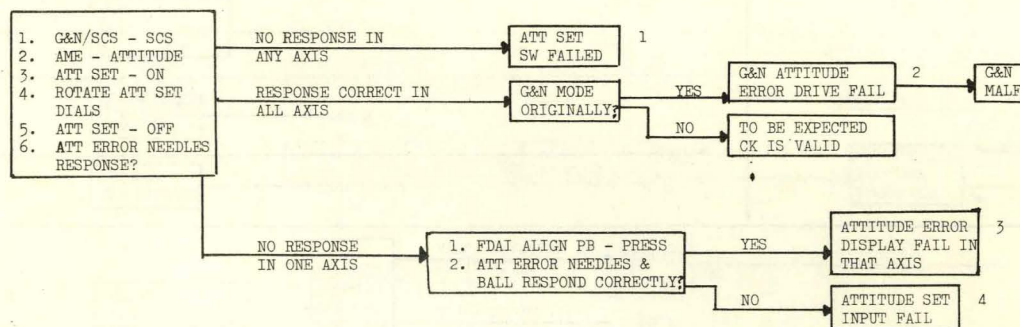
REMARKS



1. LAUNCH: NO ACTION
BALL, ATTITUDE ERROR INDICATORS, AND PHYSICAL SENSES ARE AVAILABLE AS BACKUP RATE CUES. USE DISPLAY SELF CHECK AFTER INJECTION.

MIDCOURSE, ΔV 'S & ENTRY: BALL OR EXTERNAL REFERENCES, ATTITUDE ERROR INDICATORS, AND/OR PHYSICAL SENSES ARE AVAILABLE AS BACKUP RATE CUES. DISREGARD RATE DISPLAY IN AFFECTED AXIS.
2. ALL PHASES: DISPLAY SELF TEST FUNCTION IS LOST. USE CROSS CHECK OF BALL OR EXTERNAL REFERENCES, ATTITUDE ERROR INDICATORS, AND/OR PHYSICAL SENSES FOR CORRECT RATE CONTROL RESPONSE FOR REMAINDER OF MISSION. IF TRANSFORMER FAILED GPI DISPLAY WILL NOT FUNCTION PROPERLY.
3. TBD

SCS 2



1. ALL PHASES: ATTITUDE SET FUNCTION LOST. FDAI ALIGN STILL FUNCTIONAL.
2. LAUNCH: NO ACTION
BALL, RATE DISPLAYS, AND PHYSICAL SENSES ARE AVAILABLE AS BACKUP CUES. USE ATTITUDE ERROR INDICATOR CHECK AFTER INJECTION.

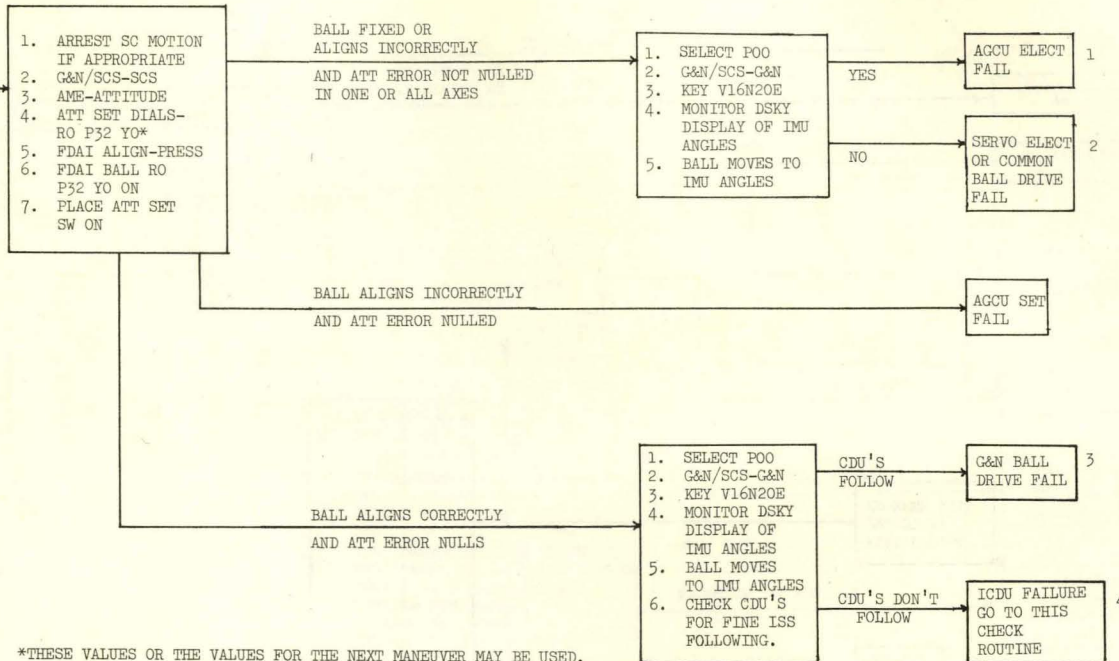
MIDCOURSE, ΔV 'S, AND PRE 0.05G ENTRY: BALL OR EXTERNAL REFERENCES, RATE DISPLAYS, AND/OR PHYSICAL SENSES ARE ALL AVAILABLE AS BACKUP ATTITUDE ERROR CUES. DISREGARD ATTITUDE ERROR INDICATION IN AFFECTED AXIS.

POST 0.05G: ROLL COMMAND ANGLE (β) WILL BE DISPLAYED IN R1 AS LONG AS THE V16N71 DISPLAY IS PRESENT. PITCH AND YAW ATTITUDE ERRORS NO LONGER ARE REQUIRED.
3. ALL PHASES: SAME AS 2 EXCEPT BOTH G&N AND SCS ATTITUDE ERROR DISPLAY ARE LOST.
4. ALL PHASES: ATTITUDE SET FUNCTION LOST. FDAI ALIGN LOST. G&N ATTITUDE ERROR DISPLAY STILL FUNCTIONAL.

PROCEDURE

REMARKS

SCS 3



*THESE VALUES OR THE VALUES FOR THE NEXT MANEUVER MAY BE USED.

GENERAL FOR LAUNCH PHASE: NO ACTION IF BALL DRIVE IS INCONSISTENT. USE OTHER CUES AND PERFORM TROUBLESHOOTING FOLLOWING INJECTION INTO ORBIT.

1 MIDCOURSE & V'S: USE G&N MODES FOR BALL DISPLAY OR DSKY CALLUP (V16N2OE) WHEN SCS MODES ARE NEEDED. SCS ATTITUDE DISPLAY IS LOST FOR THE REST OF THE MISSION.

ENTRY: USE G&N ENTRY MODE AND DISPLAY AS PRIMARY PATH. VISUAL "OUT-THE-WINDOW" ORIENTATION IS AVAILABLE UNTIL POST.05G ROLLING ENTRY IS FINAL BACKUP.

2 MIDCOURSE & V'S: USE DSKY DISPLAY (V16N2OE) FOR TOTAL ATTITUDE INDICATION OR READ CDU'S AT LEB.

ENTRY: NORMAL ENTRY EXCEPT NO TOTAL ATTITUDE BALL.

3 SAME AS 1 EXCEPT THAT THE AGCU DRIVEN BALL DISPLAY IS AVAILABLE AS A RELATIVE INDICATOR IF THE LOSS OF RESET CAPABILITY DOES NOT MAKE THE MENTAL COORDINATE TRANSFORMATION PROBLEM TOO DIFFICULT.

4 MIDCOURSE: USE SCS MODES FOR BALL DISPLAY OR DSKY CALLUP (V16N2OE). G&N TOTAL ATTITUDE DISPLAY IS LOST BUT ALL G&N MODES MAY STILL BE USED WITHOUT TOTAL ATTITUDE FUNCTIONAL.

V'S: EITHER G&N OR SCS V'S MAY BE PERFORMED BUT THE TAKE OVER ATTITUDE REFERENCE MUST BE THE EXTERNAL REFERENCE SUPPLIED BY MSFN.

ENTRY: G&N MANUAL ENTRY IS POSSIBLE BY USING PROCEED (V33E) AT THE G&N ENTRY MODE SELECT POINT. AN SCS BALL WITH DSKY DISPLAY OF PROGRAMS 61-67 WOULD BE USED OR ANY OF THE OTHER BACKUP MODES.

PREPARED BY: *CFB*

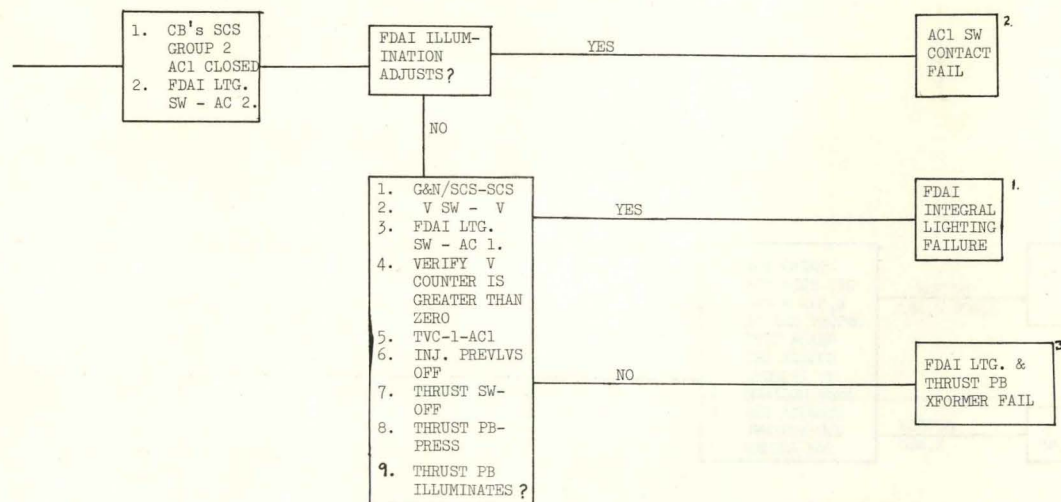
FLIGHT CREW SUPPORT DIVISION

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STABILIZATION AND CONTROL
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1 ALL PHASES: ADJUST FLOODLIGHTING FOR BEST ILLUMINATION AND CONTINUE WITH MISSION.

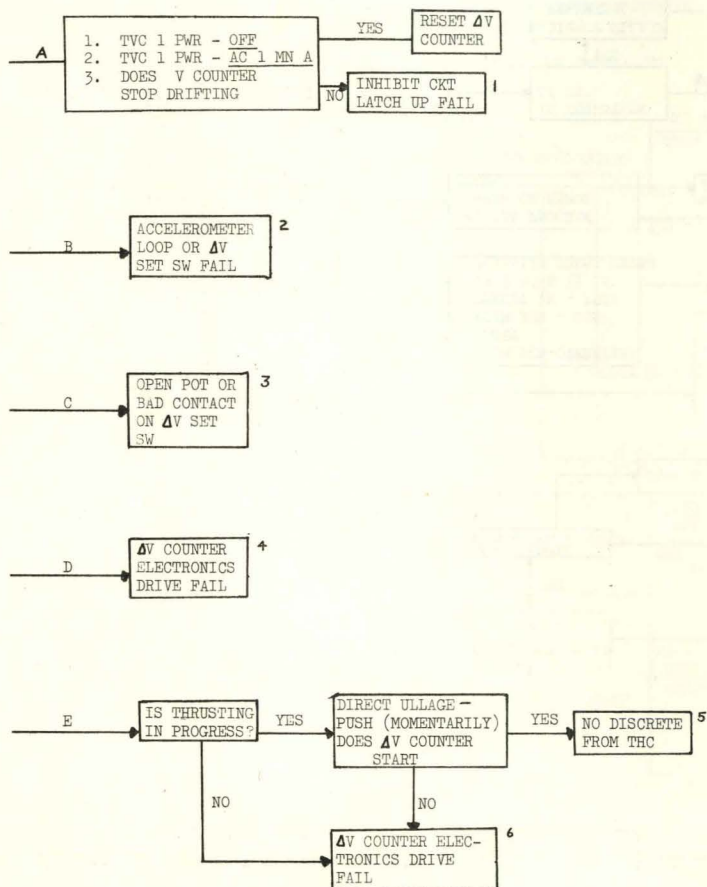
2 ALL PHASES: USE AC-2 SWITCH POSITION FOR FDAI LIGHTING SWITCH. REVERSE THE TVC SWITCHING CONVENTION FOR V'S, i.e.,

SCS POWER - AC2
RATE GYROS - AC2
TVC-1 - AC2
BMAG's - AC1
ROTATION CONTROL - AC1
TVC-2 - AC1
G&N LIGHTING - AC2
SPS GUAGING - AC2

3 ALL PHASES: ADJUST FLOODLIGHTING FOR BEST ILLUMINATION. THRUST ON LIGHT CHECKS NO LONGER POSSIBLE. CONTINUE WITH MISSION.

PREPARED BY: <i>ST</i>	FLIGHT CREW SUPPORT DIVISION	STABILIZATION AND CONTROL MALFUNCTION PROCEDURES	APOLLO OPERATIONS HANDBOOK
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SCS 5



1. USE G&N FOR THRUST MAGNITUDE CONTROL
2. USE G&N CONTROLLED BURNS
3. USE OTHER THREE DRIVE SPEEDS TO GET PROPER COUNTER SETTING
4. USE G&N CONTROLLED BURNS
5. NEXT BURN ULLAGE WITH OTHER THC
6. USE G&N CONTROLLED BURNS

PREPARED BY: *CTH*

FLIGHT CREW SUPPORT DIVISION

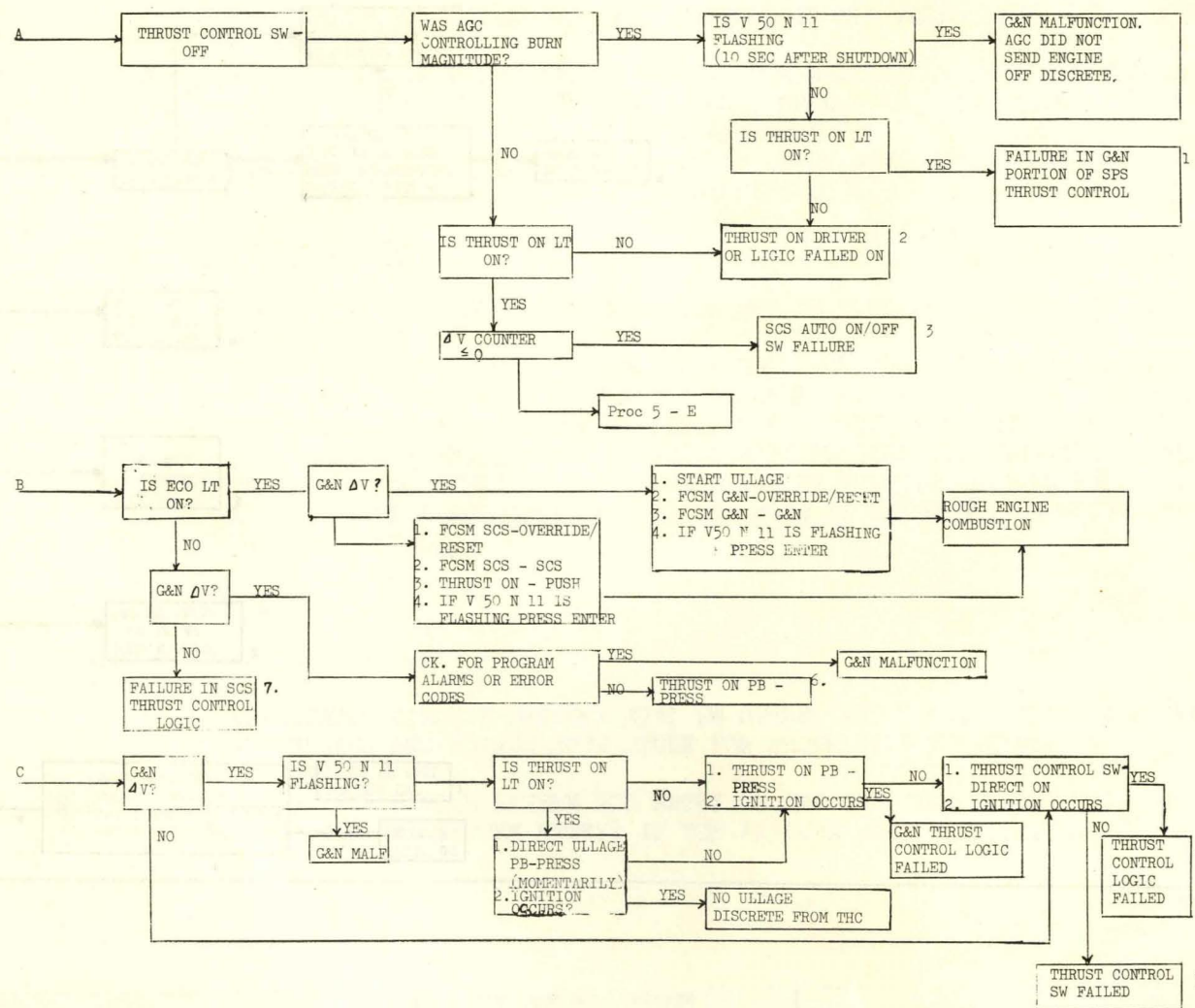
DATE: Jan 27, 1967

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SCS 6



1. USE SCS THRUST CONTROL
2. USE DIRECT ON/OFF OF THRUST CONTROL SW FOR SUBSEQUENT BURNS.
3. USE G&N TO CONTROL BURN OR DIRECT ON/OFF OF THRUST CONTROL SW FOR SUBSEQUENT BURNS.
4. USE DIRECT ON/OFF OF THRUST CONTROL SW FOR SUBSEQUENT BURNS
5. SPS NON-OPERATIONAL
6. G&N THRUST CONTROL LOGIC FAILURE, USE SCS FOR SUBSEQUENT BURNS.
7. USE G&N FOR ALL SUBSEQUENT BURNS.

SCS 7

TVC #2 CHECK

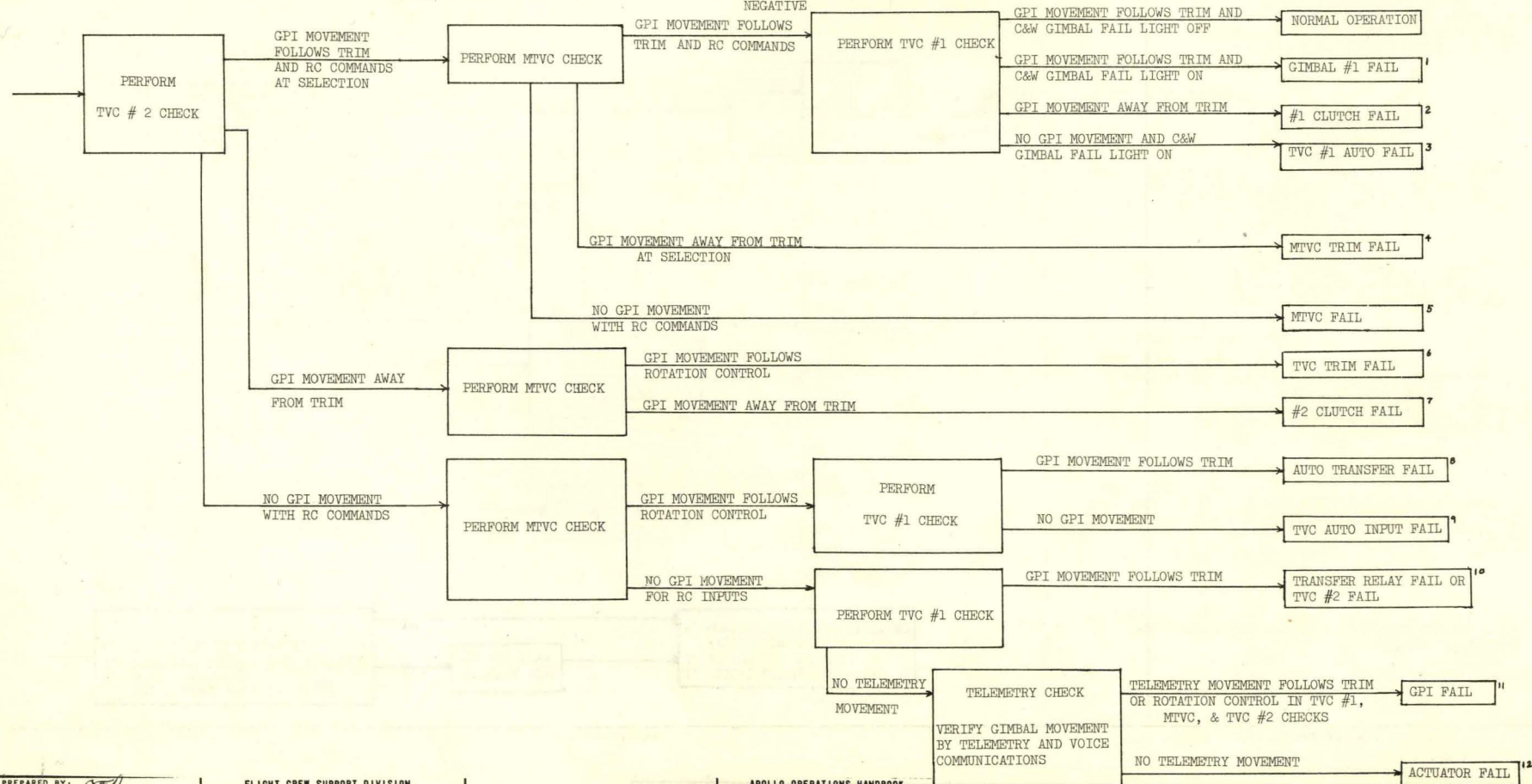
1. TVC #1 SWITCH - AC #1
2. TVC #2 SWITCH - AC #2
3. START PITCH #2 GIMBAL MOTOR
4. START YAW #2 GIMBAL MOTOR
5. CHANGE PITCH TRIM POSITIVE THEN NEGATIVE
6. CHANGE YAW TRIM POSITIVE THEN NEGATIVE

MTVC CHECK

1. V SWITCH - ON
2. ROTATE TRANSLATION CONTROL CE
3. ROTATE ROTATION CONTROL POSITIVE THEN NEG. IN PITCH
4. ROTATE ROTATION CONTROL POSITIVE THEN NEG. IN YAW
5. ΔV SWITCH - OFF
6. RETURN TRANSLATION CONTROL TO CENTER

TVC #1 CHECK

1. GIMBAL MOTORS PITCH #2 & YAW #2 - OFF
2. GIMBAL MOTORS PITCH #1 - START/ON
3. GIMBAL MOTORS YAW #1 - START/ON
4. ΔV sw - ON
5. Verify C&W GIMBAL FAIL LT OFF
6. CHANGE PITCH TRIM POSITIVE THEN NEGATIVE
7. CHANGE YAW TRIM POSITIVE THEN NEGATIVE

PREPARED BY: *[Signature]*

FLIGHT CREW SUPPORT DIVISION

DATE: Jan 27, 1967

STABILIZATION AND CONTROL
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PREPARED BY: *[Signature]*

FLIGHT CREW SUPPORT DIVISION
DATE: Jan 27, 1967

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SCS 8

PROCEDURE

REMARKS

1. SCS CHANNEL ROLL (2) - OFF
2. DIRECT RCS - ON
3. MANUALLY CONTROL ROLL ATTITUDE
4. IS THE VEHICLE STABLE?

YES

CONTINUE WITH
THE SPS BURN

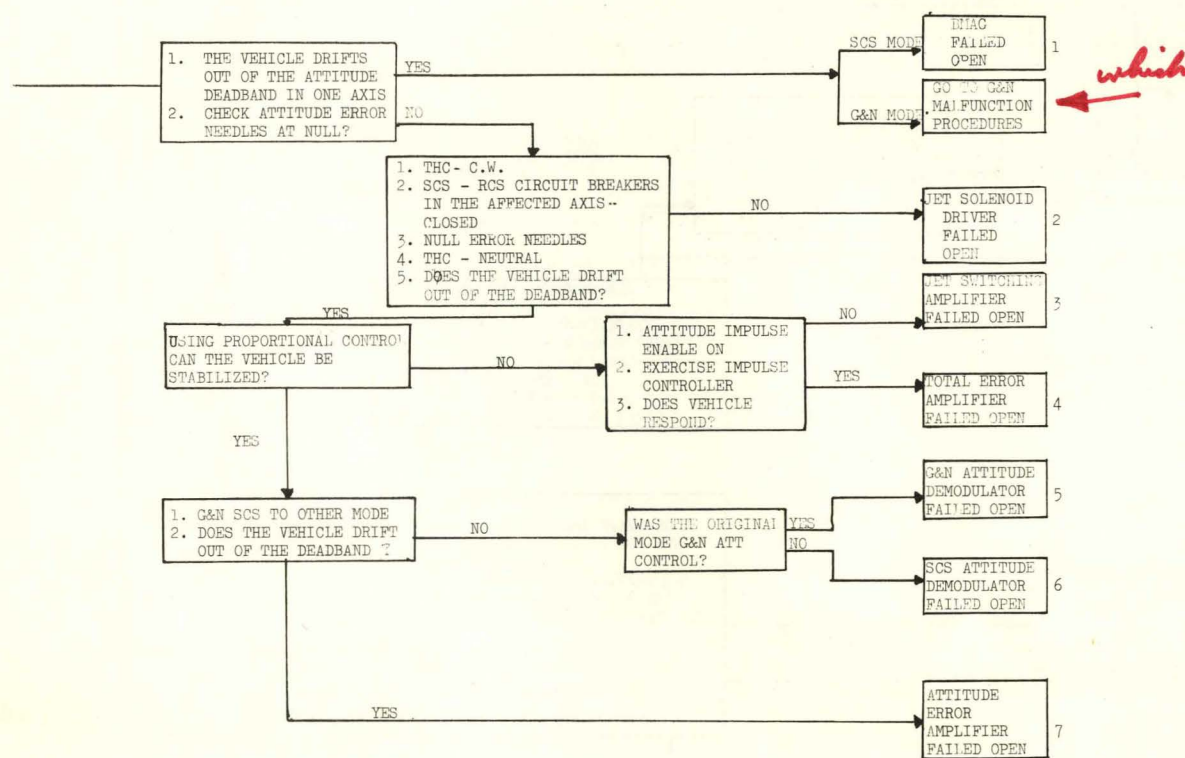
NO

1. THRUST CONTROL SW - OFF
2. SELECT SCS ATT HOLD
EXCEPT: LIMIT CYCLE - OFF
3. MONITOR FOR OTHER SYMPTOMS

PROCEDURE

REMARKS

523 10



1. EMAG OPEN.

LAUNCH - NOT DETECTABLE
ALL OTHER PHASES - SCS AUTO. CONTROL LOST IN ONE AXIS.
G&N, DIRECT & PROPORTIONAL CONTROL ALL
REMAIN. SCS V, MTVC (IF FAILURE IN
PITCH OR YAW) & SCS ATTITUDE ARE LOST.
2. DRIVER OPEN:

LAUNCH - NOT DETECTABLE
MIDCOURSE & V'S - USE OPPOSITE JET PAIR FOR SINGLE JET
ATTITUDE CONTROL AND/OR TRANSLATIONS
(ROLL FAILURES FAIL 1/2 OR Y OR Z
± OR - CONTROL)

ENTRY - SET UP FOR EITHER AN "A" OR "B" AUTO ENTRY DE-
PENDENT ON WHETHER OR NOT THE FAILED DRIVER IS IN
"B" OR "A" (IGNORE IF IT WAS AN A&C ROLL DRIVER)
3. SWITCHING AMPLIFIER OPEN

LAUNCH - NOT DETECTABLE
ALL OTHER PHASES - AUTO ATTITUDE, RATE, AND PROPORTIONAL
RATE CONTROL IS LOST IN THIS AXIS.
DIRECT CONTROL IS THE ONLY REMAINING
RCS CONTROL PATH.
4. TOTAL ERROR AMPLIFIER OPEN

LAUNCH - NOT DETECTABLE
ALL OTHER PHASES - AUTO ATTITUDE, RATE, AND PROPORTIONAL
RATE CONTROL IS LOST IN THIS AXIS.
DIRECT CONTROL IS THE ONLY REMAINING
RCS CONTROL PATH OTHER THAN MINIMUM
IMPULSE CONTROL.
5. G&N ATTITUDE DEMODULATOR OPEN

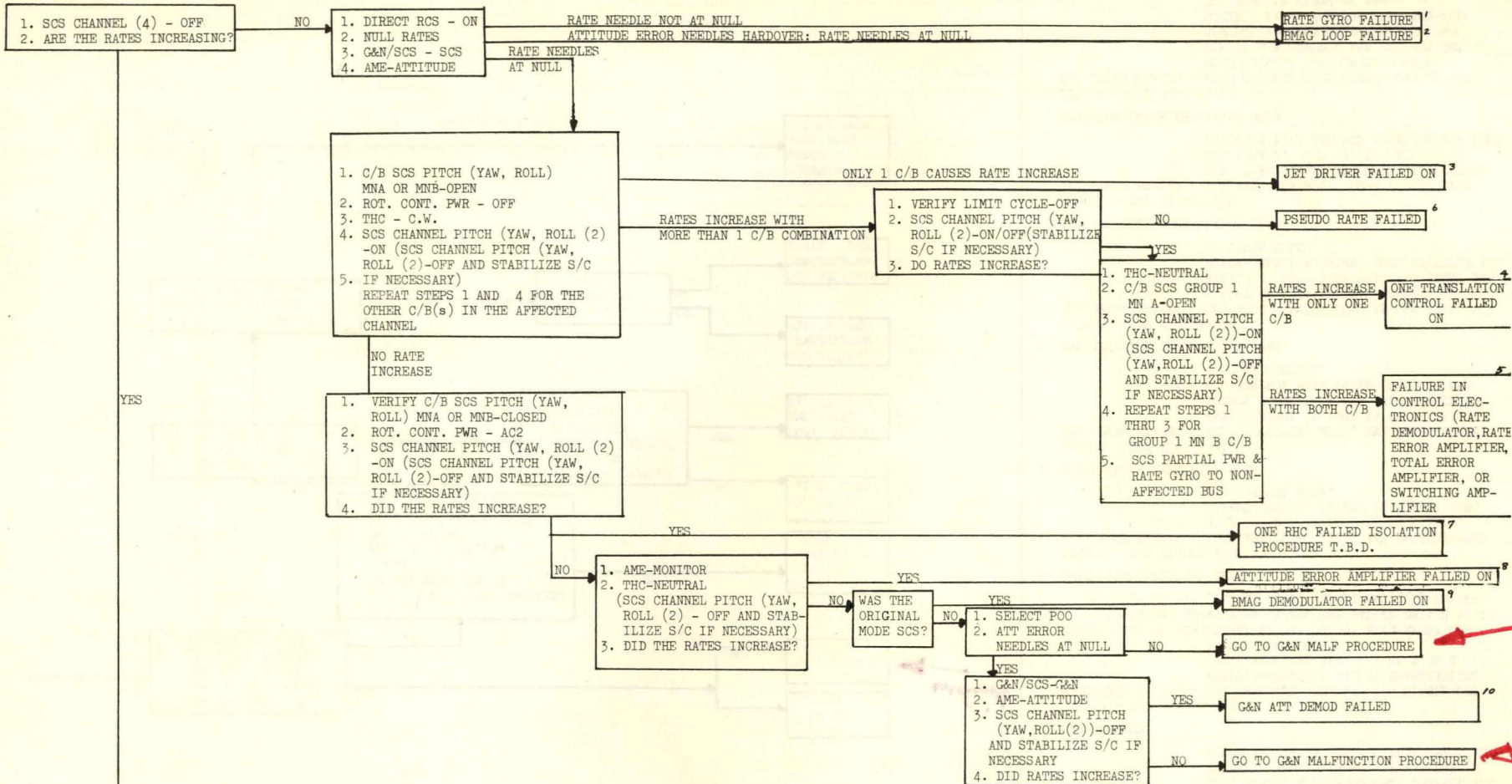
LAUNCH - NOT DETECTABLE
ALL OTHER PHASES - G&N AUTO CONTROL LOST IN ONE AXIS.
DIRECT OR PROPORTIONAL CONTROL OF RCS
REMAINS. SCS V OR MTVC FOR BURNS AND
MANUAL G&N FOR ENTRY. SCS ATTITUDE FOR
ATTITUDE HOLD.
6. SCS ATTITUDE DEMODULATOR OPEN

LAUNCH - NOT DETECTABLE
ALL OTHER PHASES - SCS AUTO CONTROL. LOST IN ONE AXIS
G&N, DIRECT, AND PROPORTIONAL CONTROL
ALL REMAIN. SCS V (IF FAILURE IS
PITCH OR YAW) AND SCS ATTITUDE ARE LOST.
7. ATTITUDE ERROR AMPLIFIER OPEN

LAUNCH - NOT DETECTABLE
ALL OTHER PHASES - AUTO CONTROL FROM EITHER G&N OR SCS
HOLD SIGNALS LOST IN THIS AXIS.
DIRECT RCS CONTROL AND MINIMUM IMPULSE
CONTROL ARE THE ONLY REMAINING RCS
CONTROL PATHS FOR THE AFFECTED AXIS.
USE MTVC IF PITCH OR YAW.

SCS 12 (A)

PROCEDURE

(CONTINUED ON
SCS - 12 B)PREPARED BY: *[Signature]*

FLIGHT CREW SUPPORT DIVISION

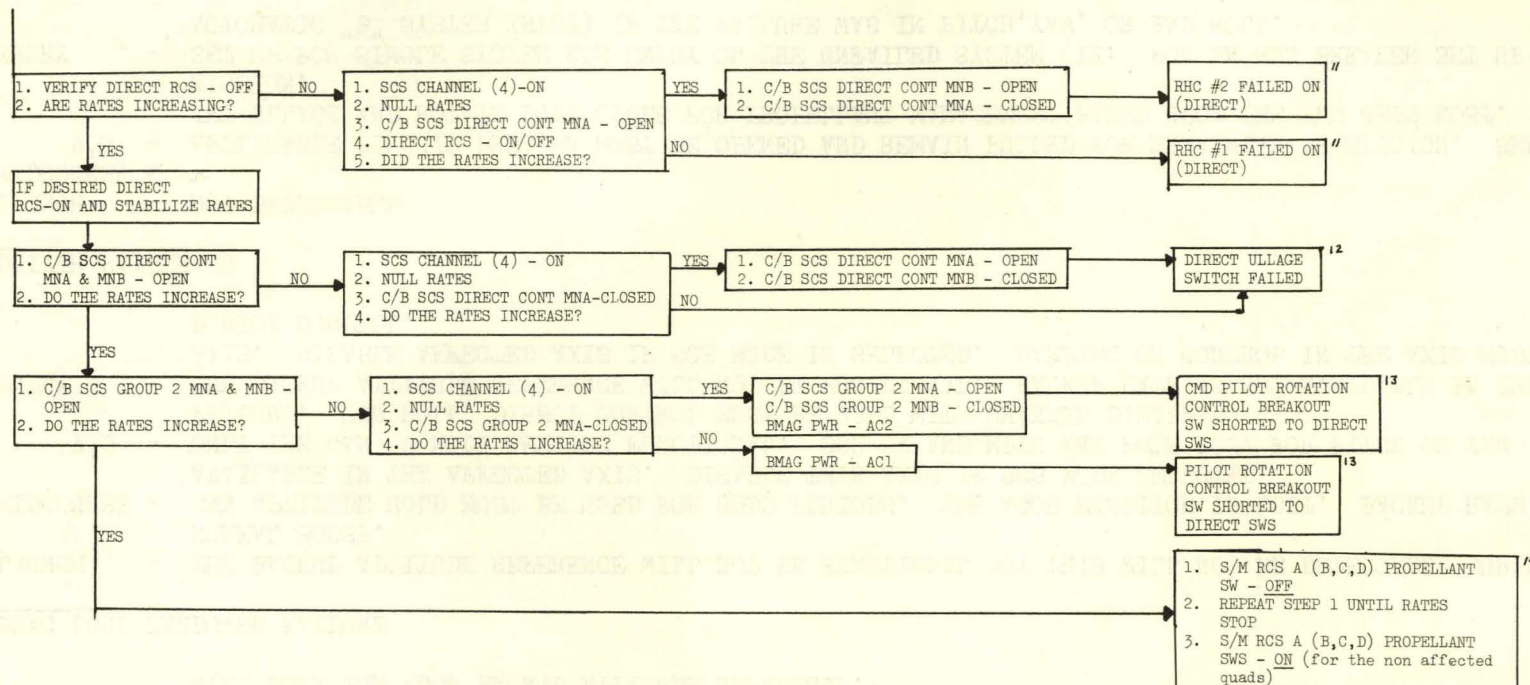
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STABILIZATION AND CONTROL
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APOLLO OPERATIONS HANDBOOK

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SECTION 9.1.1.2 PAGE 12

SCS 12 (B)



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DATE: Jan '27, 1967

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SECTION 9.1.1.2 PAGE 13

1 RATE GYRO HARDOVER FAILURE

- LAUNCH - RATE DISPLAY WILL NOT AGREE WITH ATTITUDE, ATTITUDE ERROR (IF STILL ACTIVE), AND PHYSICAL SENSES. THIS CAN BE CORRECTED BY SELECTING BACKUP RATE IN THE AFFECTED AXIS.
- MIDCOURSE - LEAVE THE RATE GYRO SWITCH OFF MOST OF THE TIME. ATTITUDE HOLD CAN BE HANDLED BY THE G&N AND LIMIT CYCLE SWITCH OR THE BMAG'S AND LIMIT CYCLE SWITCH. FOR MANEUVERS, PLACE THE BMAG'S TO BACKUP RATE OR USE DIRECT AUTO CONTROL IN ALL THREE AXES. IN THE FORMER CASE THE AGCU CAN NO LONGER UPDATE.
- V'S - SCS V MODE IS NO LONGER FUNCTIONAL FOR A PITCH OR YAW AXIS PROBLEM. G&N V WITH A BMAG IN BACKUP RATE AND MTVC ARE STILL OPERATIONAL. IN THESE MODES THE RATE GYROS WOULD BE ON WITH BACKUP RATE SELECTED IN THE AXIS AFFECTED.
- ENTRY - IN THESE MODES, THE RATE GYROS WOULD BE ON WITH BACKUP RATE SELECTED IN THE AXIS AFFECTED. THIS WILL LOSE THE AGCU BACKUP ATTITUDE REFERENCE.

2 BMAG LOOP HARDOVER FAILURE

- LAUNCH - THE BACKUP ATTITUDE REFERENCE WILL NOT BE FUNCTIONAL BUT THIS WILL NOT BE DETECTABLE DURING A NORMAL BOOST.
- MIDCOURSE - G&N ATTITUDE HOLD MUST BE USED FOR HOLD PERIODS. THE AGCU FUNCTION IS LOST. BACKUP RATE IS NOT AVAILABLE IN THE AFFECTED AXIS. DISABLE THIS AXIS IF SCS MODE SELECTED.
- V'S - ONLY THE G&N V MODE REMAINS FUNCTIONAL. SCS V AND MTVC ARE BOTH LOST FOR PITCH OR YAW FAILURE. FOR ROLL, DIRECT CONTROL MUST BE USED WITH CHANNEL DISABLED.
- ENTRY - THR BACKUP ATTITUDE REFERENCE WILL NOT BE FUNCTIONAL. BACKUP RATE IS NOT AVAILABLE IN THE AFFECTED AXIS. DISABLE AFFECTED AXIS IF SCS MODE IS SELECTED. DAMPING OR CONTROL IN THE AXIS MUST BE WITH DIRECT CONTROL.

3 DRIVER FAILED ON

- LAUNCH - NOT DETECTABLE
- MIDCOURSE & V'S - APPLICABLE CIRCUIT BREAKER MUST BE OPENED AND REMAIN PULLED FOR REMAINDER OF MISSION. SELECT TWO JET ULLAGE AND ROTATE DUTY CYCLE FOR PROPELLANT MANAGEMENT BASED UPON THE TWO JETS LOST. CONTINUE MISSION.
- ENTRY - SET UP FOR SINGLE SYSTEM RCS ENTRY ON THE UNFAILED SYSTEM (1E: FOR AN MNA BREAKER SET UP FOR AN AUTOMATIC "B" SYSTEM ENTRY) IF THE FAILURE WAS IN PITCH,YAW, OR B&D ROLL.

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4 ONE TRANSLATION CONTROL BAD

LAUNCH - NOT APPLICABLE

MIDCOURSE &

V'S - PULL EITHER THE MNA OR MNB BREAKER FOR SCS GROUP 1 POWER. SET SCS POWER AND TVC #1 POWER TO OPPOSITE POSITIONS. USE OTHER TRANSLATION CONTROL. HALF OF THE POWER FOR THE SCS CONTROL PANEL IS NOW OFF.

ENTRY - THE CIRCUIT BREAKER CAN BE RE-CLOSED AS BOTH THE POWER PATHS ARE OPENED BY CM-SM SEPARATION.

5 FAILURE IN CONTROL ELECTRONICS

LAUNCH - NOT DETECTABLE

MIDCOURSE - AFFECTED AXIS MUST BE DISABLED. DIRECT RCS CONTROL AND DIRECT ULLAGE ARE THE ONLY REMAINING MEANS OF FIRING THE JETS IN THIS AXIS.

V'S - THIS FAILURE GROUP MUST BE FURTHER ISOLATED TO DETERMINE IF THE TVC CONTROL CAPABILITY HAS BEEN AFFECTED, WHEN THERE IS A PITCH OR YAW FAILURE. FOR A ROLL FAILURE, DIRECT ROLL CONTROL MUST BE USED.

THE ISOLATION SHOULD BE ACCOMPLISHED AS FOLLOWS:

1. SELECT SCS V MODE
2. RECONFIRM THRUST CONTROL SWITCH - OFF
3. RECONFIRM PREVALVE SWITCHES (2) - OFF
4. GIMBAL MOTORS IN AFFECTED AXIS (2) - START - ON
5. CONFIRM RESPONSE TO GIMBAL TRIM THEN STABILIZATION AT TRIM POINT
6. THRUST ON PUSHBUTTON - PRESS
7. CONFIRM THRUST ON LIGHT - ON
8. OBSERVE GPI IN AFFECTED AXIS. DOES IT REMAIN STABLE?
(CONFIRM WITH TM IF COVERAGE IS AVAILABLE)

STABILITY ISOLATES THE FAILURE TO THE TOTAL ERROR AMPLIFIER OR THE SWITCHING AMPLIFIER SO THAT ANY OF THE THREE TVC CONTROL METHODS MAY BE USED. DIRECT ULLAGE AND DIRECT ROTATION MUST BE USED THOUGH FOR RCS CONTROL.

LACK OF STABILITY MEANS NO TVC. RCS DEORBIT MUST BE USED.

ENTRY - SAME AS MIDCOURSE EXCEPT THAT THE DIRECT ULLAGE DOES NOT APPLY

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6 PSEUDO RATE FAILED

LAUNCH &

ENTRY - NOT DETECTABLE (IN ENTRY THE LIMIT CYCLE SWITCH MUST BE OFF)

MIDCOURSE &

V'S - LIMIT CYCLE SWITCH MUST BE OFF. HIGHER RCS PROPELLANT CONSUMPTION AND LIMIT CYCLE RATES WILL BE OCCURRING.

7 ROTATION CONTROL BAD (PROPORTIONAL)

ALL PHASES - T.B.D.

8 ATTITUDE ERROR AMPLIFIER FAILED

LAUNCH - NOT DETECTABLE

ALL OTHER

PHASES - THE AFFECTED AXIS MUST REMAIN DISABLED. ALL CONTROL METHODS USING THE AUTOMATIC RCS COILS IN THIS AXIS ARE LOST. PITCH OR YAW FAILURES ALSO LOSE BOTH AUTOMATIC TVC CONTROL PATHS BUT MTVC IS STILL FUNCTIONAL.

9 BMAG DEMODULATOR FAILURE

LAUNCH - NOT DETECTABLE

ALL OTHER

PHASES - SCS AUTOMATIC RCS CONTROL AND SCS V MODES (FOR PITCH AND YAW FAILURES) ARE LOST. IF AN SCS MODE IS SELECTED THE AXIS MUST BE DISABLED FOR AUTO CONTROL AND DIRECT RCS OR DIRECT ULLAGE SUBSTITUTED.

10 G&N ATTITUDE DEMODULATOR FAILURE

LAUNCH - NOT DETECTABLE

ALL OTHER

PHASES - G&N AUTOMATIC CONTROL IS LOST BUT, USING THE TRANSLATION CONTROL LOCKOUT (HANDLE CW), THE COMMANDS CAN BE FLOWN OUT FROM G&N DISPLAY WITH THE PROPORTIONAL CONTROL OR MTVC AS APPROPRIATE.

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11 ROTATION CONTROL BAD (DIRECT)

ALL PHASES - THE DIRECT CONTROL CIRCUIT BREAKER FOR THE SHORTED SWITCH CONTACT MUST BE OPENED. ONLY ONE ROTATION CONTROL WILL BE EFFECTIVE FOR DIRECT CONTROL. ONLY ONE SIDE OF THE THRUST CONTROL SWITCH WILL BE ACTIVE. FULL DIRECT ULLAGE CAN BE OBTAINED USING THE ABORT POSITION OF THE TRANSLATION CONTROL THROUGH THE MESC.

12 DIRECT ULLAGE SWITCH FAILED

ALL PHASES - THE DIRECT CONTROL CIRCUIT BREAKER FOR THE SHORTED SWITCH CONTACT MUST BE OPENED. ONLY ONE ROTATION CONTROL WILL BE EFFECTIVE FOR DIRECT CONTROL. ONLY ONE SIDE OF THE THRUST CONTROL SWITCH WILL BE ACTIVE. FULL DIRECT ULLAGE CAN BE OBTAINED USING THE ABORT POSITION OF THE TRANSLATION CONTROL THROUGH THE MESC.

13 BREAKOUT SWITCH POWER SHORTED TO DIRECT CONTROL

ALL PHASES - THE GROUP 2 MNA OR MNB CIRCUIT BREAKER INVOLVED MUST BE OPEN FOR THE REST OF THE MISSION. THE BMAG POWER SWITCH SHOULD BE PLACED TO THE OPPOSITE POWER SETTING. ONE ROTATION CONTROL WILL NO LONGER HAVE BREAKOUT SWITCH POWER AND SHOULD NO LONGER BE USED. THE CONTROL CAN BE DETERMINED BY:

1. DISABLING THE RCS CHANNELS
2. SELECTING THE SCS ΔV MODE
3. WAITING FOR AN ATTITUDE ERROR INDICATION FROM THE BMAGS
4. DISPLACING ONE ROTATION CONTROL PAST BREAKOUT
5. IF THE BMAG'S CAGE ATTITUDE ERROR WILL GO TO ZERO AND THE BALL DRIVE WILL START. THIS IS THE GOOD ROTATION CONTROL.

14 RCS QUAD PROBLEM

ALL PHASES - QUAD USE IS LOST FOR REST OF MISSION.

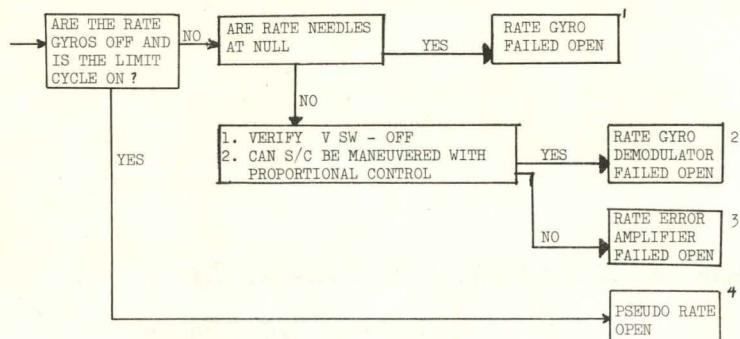
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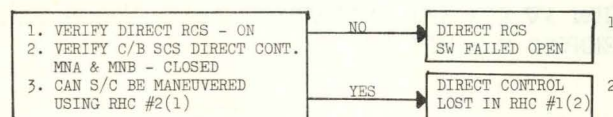
PROCEDURE

REMARKS



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1. DIRECT RCS SWITCH FAILED OPEN

LAUNCH - NOT DETECTABLE
ALL OTHER - DIRECT ROTATION CONTROL IS
PHASES LOST. AUTOMATIC PROPORTIONAL
CONTROL, MANUAL PROPORTIONAL
CONTROL, AND DIRECT AUTO
CONTROL ALL REMAIN FOR RCS
CONTROL.

2. DIRECT CONTROL LOST IN ONE ROTATION CONTROL

LAUNCH - NOT DETECTABLE

ALL OTHER - KEEP OPERABLE ROTATION CONTROL
PHASES AT CMD PILOTS' STATION

1. RATE GYRO FAILED OPEN

- LAUNCH - DETECTABLE FROM LACK OF DISPLAY MOTION DURING LAUNCH. CAN BE CORRECTED BY SELECTION OF BACKUP RATE RESTORING RATE DISPLAY.
- MIDCOURSE & - SELECTION OF BACKUP RATE PROVIDES AN ALTERNATE RATE SOURCE BY CHANNEL FOR MANEUVERS OR TVC. ATTITUDE CONTROL DURING LOW RATE CONDITIONS CAN BE HANDLED BY PSEUDO RATE SO THAT THE BMAG CAN STILL BE USED FOR ATTITUDE HOLD. THE SCS DELTA V MODE IS LOST THOUGH AND THE BMAG IS COMMON TO BOTH G&N DELTA V AND MTVC FOR PITCH OR YAW FAILURES.
- ENTRY - BMAG IS AFFECTED AXIS CAN BE PLACED TO BACKUP RATE FOR G&N OR SCS MODES. UPDATING OF THE AGCU WILL BE LOST. ATTITUDE HOLD IN SCS ENTRY MODE MUST BE MANUAL. VISUAL BACKUP ATTITUDE REFERENCE IS AVAILABLE.

2. RATE GYRO DEMOD OPEN

- ALL PHASES - RATE DISPLAYS REMAIN FUNCTIONAL
- LAUNCH - NOT DETECTABLE
- MIDCOURSE & - ONLY DIRECT CONTROL - DIRECT AUTO CONTROL AND MTVC (FOR PITCH OR YAW CHANNEL PROBLEMS) DELTA V'S REMAIN IN THE AXIS.
- PRE 0.05G - ONLY DIRECT CONTROL OR DIRECT AUTO CONTROL REMAIN IN THE AXIS AFFECTED.
- POST 0.05G - AUTOMATIC RATE DAMPING LOST IN AXIS. DIRECT AUTO OR DIRECT CONTROL CAN BE USED WITH THE ACTIVE RATE DISPLAY OR IN ROLL TO CONTROL ATTITUDE.

3. RATE ERROR AMP OPEN

- ALL PHASES - RATE DISPLAYS REMAIN FUNCTIONAL
- LAUNCH - NOT DETECTABLE
- MIDCOURSE & - ONLY DIRECT CONTROL AND MTVC (FOR PITCH OR YAW CHANNEL PROBLEMS) REMAIN IN THE AXIS.
- PRE 0.05G - ONLY DIRECT CONTROL REMAIN IN THE AXIS AFFECTED.
- POST 0.05G - AUTOMATIC RATE DAMPING LOST IN AXIS. DIRECT CONTROL CAN BE USED WITH THE ACTIVE RATE DISPLAY OR IN ROLL TO CONTROL ATTITUDE.

4. PSEUDO RATE OPEN

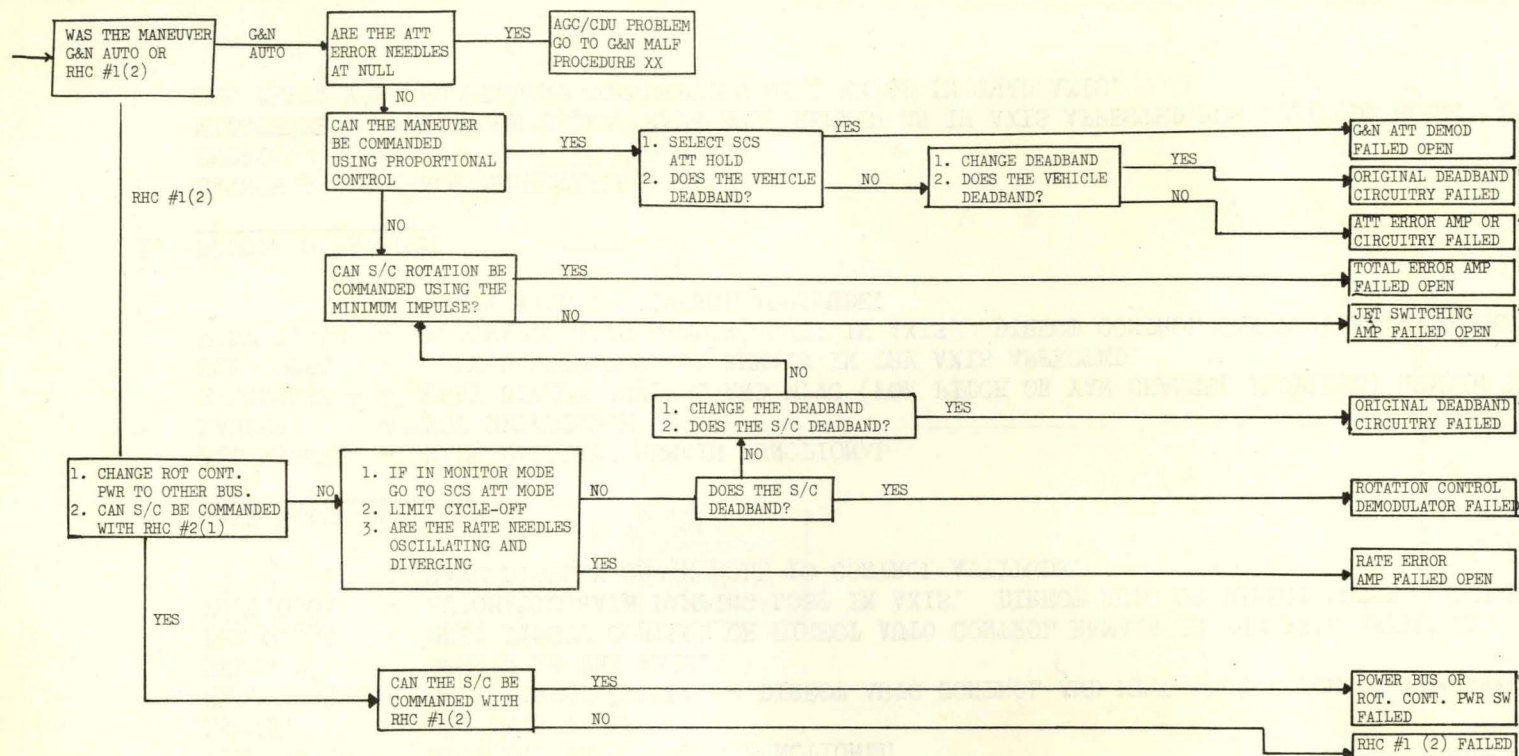
- LAUNCH & - NOT DETECTABLE
- ENTRY
- MIDCOURSE & - RATE OR BACKUP RATE MUST REMAIN ON IN AXIS AFFECTED FOR ATTITUDE HOLD. HIGHER RCS PRE DELTA V'S PROPELLANT CONSUMPTION WILL EXIST IN THAT AXIS.

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PROCEDURE

REMARKS



See Page 15a

See Page 15(b)See Page 15(b)

1. G&N ATTITUDE DEMOD OPEN

LAUNCH - NOT DETECTABLE
ALL OTHER - G&N AUTO CONTROL LOST IN ONE AXIS. DIRECT OR PROPORTIONAL CONTROL OF RCS REMAINS. SCS V OR
PHASES MTVC FOR BURNS AND MANUAL G&N FOR ENTRY. SCS ATTITUDE FOR ATTITUDE HOLD.

2. ATTITUDE ERROR AMPLIFIER OPEN

LAUNCH - NOT DETECTABLE
ALL OTHER - AUTO CONTROL FROM EITHER G&N OR SCS HOLD SIGNALS LOST IN THIS AXIS. DIRECT RCS CONTROL AND
PHASES MINIMUM IMPULSE CONTROL ARE THE ONLY REMAINING RCS CONTROL PATHS FOR THE AFFECTED AXIS

3. TOTAL ERROR AMPLIFIER OPEN

LAUNCH - NOT DETECTABLE
ALL OTHER - AUTO ATTITUDE AND RATE PROPORTIONAL RATE CONTROL IS LOST IN THIS AXIS. DIRECT CONTROL IS THE
PHASES ONLY REMAINING CONTROL PATH OTHER THAN MINIMUM IMPULSE CONTROL.

4. SWITCHING AMPLIFIER OPEN

LAUNCH - NOT DETECTABLE
ALL OTHER - AUTO ATTITUDE AND RATE AND PROPORTIONAL RATE CONTROL IS LOST IN THIS AXIS. DIRECT CONTROL IS THE
PHASES ONLY REMAINING CONTROL.

5. DEADBAND CIRCUITRY FAILED

LAUNCH - NOT DETECTABLE
ALL OTHER - MANUAL ATTITUDE HOLD REQUIRED WHEN AFFECTED DEADBAND IS SELECTED.
PHASES

6. ROTATION CONTROL DEMODULATOR OPEN

ALL PHASES- THE USE OF PROPORTIONAL RCS CONTROL AND MANUAL TVC ARE LOST FOR THE REMAINDER OF THE MISSION.
AUTO TVC MODES WITH RATE DAMPING AND NO MANUAL INPUT MTVC BACKUP ARE STILL AVAILABLE. DIRECT AND
AUTO RCS CONTROL STILL REMAIN FOR ALL MODES.

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7. RATE ERROR AMPLIFIER OPEN

ALL PHASES - RATE DISPLAYS REMAIN FUNCTIONAL
 LAUNCH - NOT DETECTABLE
 MIDCOURSE
 & V'S - DIRECT RCS IS ONLY AVAILABLE CONTROL MODE IN THAT AXIS.
 PRE-0.05G - ONLY DIRECT CONTROL AVAILABLE IN AFFECTED AXIS
 POST-0.05G - AUTOMATIC RATE DAMPING LOST IN AXIS. DIRECT RCS CAN BE USED WITH THE ACTIVE RATE DISPLAY OR IN ROLL TO CONTROL ATTITUDE.

8. ONE ROTATION CONTROL LOST

ALL PHASES - USE THE OPERATIONAL ROTATION CONTROL AT BOTH THE G&N LEB STATION AND PILOTS STATION FOR PROPORTIONAL CONTROL. DIRECT CONTROL SHOULD STILL BE FUNCTIONAL IN THE OTHER CONTROL.

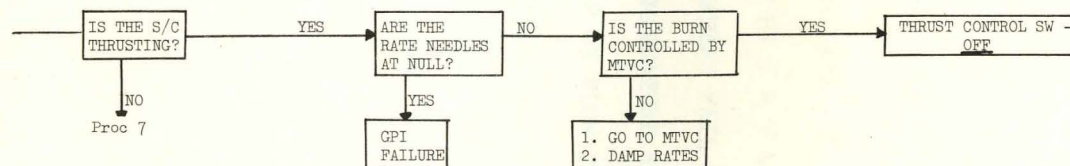
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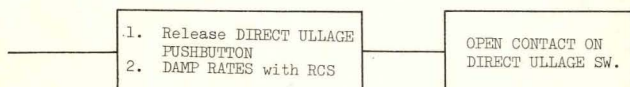
SCS 23

PROCEDURE

REMARKS



SCS 24



1. If direct ullage is needed use the abort position of the THC to command direct ullage through the sequence.

PROCEDURES ENTRY SHEET

SECTION 9.1.2

SPS MALFUNCTION PROCEDURES

SYMPTOM	SYMPTOM NUMBER	STEP	PAGE
SPS ROUGH ECO DURING MISSION CRITICAL BURN	1	1	2
SPS ROUGH ECO DURING NON-MISSION CRITICAL BURN	2	1	3
PITCH OR YAW GMBL DR FAIL C & W LIGHT ILLUMINATES DURING MISSION CRITICAL BURN	3	1	4
PITCH OR YAW GMBL DR FAIL C & W LIGHT ILLUMINATES DURING NON-MISSION CRITICAL BURN	4	1	5
SPS PRESS C & W LIGHT ILLUMINATES DURING THRUSTING	5	1	6
FUEL AND/OR OX TANK PRESS LOW DURING THRUSTING	5	2	6
FUEL AND/OR OX TANK PRESS HIGH DURING THRUSTING	5	7	7
SPS PRESS C & W LIGHT ILLUMINATES DURING NON- THRUSTING	6	1	8
FUEL AND/OR OX TANK PRESS LOW DURING NON-THRUSTING	6	2	8
FUEL AND/OR OX TANK PRESS HIGH DURING NON-THRUSTING	6	6	9
SPS WALL TEMP HI C & W LIGHT ILLUMINATES	7	1	10
PROPELLANT HEATERS FAIL TO RAISE TEMPERATURE	8	1	10
PROPELLANT TEMPERATURE READING ABNORMAL	9	1	11
NO RESPONSE OF OX FLOW FLAGS TO OX FLOW ADJUSTMENT	10	1	11
ABNORMAL PROPELLANT QUANTITY READOUT	11	1	11
UN BALANCE METER IS ERRATIC OR PEGGED	12	1	13
LOSS OF SPS HELIUM TANK PRESSURE	13	1	13
ABNORMAL SPS HELIUM VALVE TB INDICATION	14	1	14

SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1 SPS ROUGH ECO DURING MISSION CRITICAL BURN				Light illuminates if 70 ± 20 msec at a vibration level of 180g's peak-to-peak or 30-70 msec at a vibration level of 360g's peak-to-peak. Light is extinguished when FCSM circuitry is reset. THRUST SW-ON overrides the FCSM monitors. Monitor PRESS ENG INLET FUEL and OX for decreased pressure or unbalanced pressure and flow.	Excessive engine vibration due to combustion instability.
	1	FCSM G&N or SCS SW- <u>VERRIDE</u> / <u>RESET</u>	2	1. If in G&N ΔV , automatic restart of the engine will occur if <10 sec has elapsed since shutdown. If >10 sec V5ON11 will flash, and the ENTER must be depressed for automatic restart.	
	2	FCSM G&N SCS SW- <u>G&N</u> or <u>SCS</u> a. G&N b. SCS	4 3	2a. <u>VERRIDE</u> / <u>RESET</u> has restarted engine. Interruption of engine "ON" command occurs during switching transient.	
	3	THRUST ON - <u>DEPRESS</u>	4		
	4	Monitor SPS ROUGH ECO light a. Re-illuminates b. Remains extinguished	5 →		4b. Transient vibration level sensed in SPS engine.
PREPARED BY: <u>WFE</u>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
DATE: Jan. 27, 1967		Service Propulsion System Malfunction Procedure		S/C 012	REV FINAL
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
	5	FCSM G&N or SCS SW- <u>VERRIDE/RE-SET</u> a. G&N b. SCS	→ 6	5a. Automatic restart of the engine will occur if <10 sec has elapsed since shutdown. If >10 sec V50N11 will flash, and the ENTER must be depressed for automatic restart.	
	6.	THRUST ON- <u>DEPRESS</u>	→	6. Continue normal procedures	
2. SPS ROUGH ECO DURING NON-MISSION CRITICAL BURN	1	THRUST SW- <u>OFF</u>	2	Light illuminates if 70 ± 20 msec at a vibration level of 180g's peak-to-peak or 30-70 msec at vibration level of 360g's peak-to-peak. THRUST SW- <u>ON</u> overrides the FCSM monitors. SPS is operable but FCSM may terminate subsequent burns.	Excessive engine vibration due to combustion instability.
	2	Terminate ullage.	3		
	3	Reset FCSM logic with any of the following switches: a. FCSM G&N or SCS SW- <u>VERRIDE/RESET</u> b. Δ V SW- <u>OFF</u> c. ATTITUDE/MONITOR/ENTRY SW- <u>MONITOR</u> or <u>ENTRY</u> .	→ → →	3. The SPS ROUGH ECO light is also reset.	
PREPARED BY: <u>WE</u>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
		DATE: Jan. 27, 1967		Service Propulsion System Malfunction Procedure	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
3. PITCH OR YAW GMBL DR FAIL LIGHT ILLUMINATES DURING MISSION CRITICAL BURN	1	Monitor FDAI and GIMBAL POSITION INDICATOR for divergence from burn heading.		1. SPS is now operating on secondary gimbal motor. If this motor fails, the SPS must be shutdown.	Over or under current to primary drive motor.
	2	If divergence occurs; <u>THC-CW</u> .	3	2. This action initiates MTVC operation	
	3	Damp rates using MTVC.	4		
	4	THRUST SW-OFF:	5		
	5	THC-CENTER	6		
	6	With the RCS reorient the S/C to burn attitude.	7		
	7	THRUST SW- <u>NORMAL</u>	8		
		a. G&N	→	7a. Auto restart of the engine will occur if <10 sec has elapsed since shutdown. If >10 sec, V5ON11 will flash, and the ENTER must be depressed for automatic restart.	
		b. SCS	8		
	8	THRUST ON - <u>DEPRESS</u>	9		
9	If divergence OCCURS, THRUST SW- <u>OFF</u>	→	9. SPS inoperative as gimbal control is lost in an axis	9. GIMBAL FAILURE IN ONE AXIS	
PREPARED BY: <u>WA</u>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
DATE: Jan. 27, 1967		Service Propulsion System Malfunction Procedure		S/C 012 REV FINAL	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
4. PITCH or YAW GMBL OR FAIL LIGHT ILLUMINATES DURING NON-MISSION CRITICAL BURN.	1.	THRUST sw - <u>OFF</u>	2	Both GIMBAL MOTORS for PITCH or YAW have been turned on.	Over or undercurrent to primary drive motor.
	2.	Damp any rates with the RCS.	3.		
	3.	Gimbal motors PITCH or YAW 1 sw-START; release to <u>ON</u> .			
	4.	Monitor PITCH or YAW GMBL or FAIL light.			
	a.	Re-illuminated	5.		
	b.	Extinguished	7.		
	5.	GIMBAL MOTORS PITCH or YAW 2 sw- <u>OFF</u>	6.		
	6.	Rotate PITCH or YAW GIMBAL POSITION thumbwheels			
	a.	Needle deflects	→ 6a.	For any subsequent burns, the GIMBAL POSITION indicator must be monitored with the FDAI for divergence from planned heading as these are the only means of monitoring the status of the gimbal motors.	6a. PITCH or YAW GMBL OR FAIL light has failed on.
	b.	Needle doesn't deflect	→ 6b.	SPS now functional on secondary gimbal drive motor. Any subsequent burns must be monitored for gimbal motor failure on the GIMBAL POSITION indicator and the FDAI.	6b. Over or undercurrent to primary drive motor.
7.	SPS GIMBAL MOTORS PITCH or YAW 2 sw - OFF				
8.	Rotate PITCH or YAW GIMBAL POSITION thumbwheels.	8.			
PREPARED BY: <u>WE</u>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
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				SECTION 9.1.2	PAGE 5

SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE		
		a. Needle deflects		8a. SPS functional, but gimbal switchover may occur at any time during thrusting.	8a. Transient over or under current.		
		b. Needle doesn't deflect		8b. GMBL DR FAIL light should also have re-illuminated. Motor is unable to assume the load and drops off the line.	8b. Over or under current to primary motor.		
5 SPS PRESS LIGHT ILLUMINATES DURING THRUSTING				Light illuminates if FUEL or OX TANK PRESS is >200 psia or <160 psia. Normal operating pressure is 171-179 psia.			
		WARNING - IF Pc INDICATOR \leq 70 PSIA: THRUST sw - OFF					
FUEL AND/OR OX TANK PRESS LOW DURING THRUSTING	1.	Monitor FUEL and/or OX TANK PRESS					
	a.	High	7				
	b.	Low	2				
	c.	Normal	2				
	2.	Monitor PRESS ENG INLET FUEL and/or OX					
	a.	Low	3	2a. If FUEL and/or OX TANK PRESS NORMAL; FUEL and/or OX TANK PRESS INDICATORS ARE INACCURATE	2a. FUEL AND/OR OX indicator failed.		
	b.	Normal		2b. Monitoring of SPS pressure gages is required for all subsequent burns	2b. C&W Circuitry Failure.		
	c.	High		2c. If FUEL and/or OX TANK PRESS NORMAL FUEL and/or OX TANK PRESS INDICATORS ARE INACCURATE.	2c. FUEL AND/OR OX INDICATOR FAILED.		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
FUEL AND/OR OX TANK PRESS HIGH DURING THRUSTING.	3	If non-critical burn: THRUST sw- <u>OFF</u> .	4.		
	4	Monitor FUEL and OX TANK PRES- SURES a. If continues to decrease b. If pressure low, but steady	4.	Use inlet pressures if TANK PRESSURE indicator failed 4a. SPS not operable. Subsequent repressurization may result in tank rupture.	4a. Leak in propellant system.
	5.	He VLV sws (2) - <u>ON</u>	5		
	6.		6.	Tanks are manually repressurized for subsequent burns. Burns are not to exceed 20 sec if propellant tank pressure cannot be raised during manual repressurization; SPS not operable due to propellant tank pressure < 160 psia.	
	6	Monitor PRESS ENG INLET FUEL and/or OX a. High b. Normal	7.	7b. If indicator failure, inlet pressure should remain normal however inlet pressures should be monitored to see if a time delay may have given inaccurate normal reading.	7a. One regulator assembly failure open 7b. Indicator failure
	7.	SPS HELIUM sws (2) - <u>OFF</u> <i>sensor fail determination</i>	8.	8a With helium supply shut off, propellant tank ullage pressures are sufficient to provide 20 seconds of operation. After 20 seconds, O/F ratio becomes too high and engine operation may become rough. SPS will not be operable after this 20 seconds.	
8.	If non-mission critical, THRUST sw - <u>OFF</u>	→			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
6 SPS PRESS LIGHT ILLUMINATES DURING NON-THRUSTING PERIOD FUEL AND/OR OX TANK PRESS LOW DURING NON-THRUSTING	1.	Monitor FUEL and OX (TANK) PRESS		Light illuminates if fuel and/or oxidizer pressure is >200 psia or <160 psia. Normal operating pressures are 171-179 psia.	
		a. High	2		
		b. Low	2		
		c. Normal	2		
	2	Confirm FUEL and OX PRESS with ENG INLET PRESS.			
		a. High	6	2a. If FUEL and/or OX TANK PRESS were normal: FUEL and/or OX TANK pressure indicators are inaccurate.	2a. FUEL and/or OX TANK PRESS INDICATOR FAILED.
		b. Low	3	2b. If FUEL and/or OX TANK PRESS were normal: FUEL and/or OX TANK pressure indicators are inaccurate.	2b. FUEL and/or OX TANK PRESS INDICATOR FAILED.
		c. Normal	→	2c. Monitor of SPS press gauges will be required.	2c. C/W circuitry failed.
	3	Monitor FUEL and OX PRESS			
		a. Stable	4		
		b. Decreasing	→	WARNING:- Subsequent repressurization considered dangerous due to possibility of tank rupture.	3b. Propellant system leak.
	4.	SPS HELIUM sws (2)-ON/AUTO when press \geq 175 psia.		4a. Tanks are manually repressurized for next burn if 175 psia is not obtainable: SPS HELIUM sws (2) - OFF. Major leak in pressurization systems SPS not operable for tank pressures <160 psia.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
FUEL AND/OR OX TANK PRESS HIGH DURING NON-THRUSTING	5.	Monitor FUEL AND/OR OX TANK PRESS		5a. SPS is functional <u>WARNING</u> :- Subsequent repressurization considered dangerous due to possibility of tank rupture.	5a. Apparent heat leak from SPS system. 5b. PROPELLANT SYSTEM LEAK
	6.	NONE	→		6. Heat leak into SPS system.

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
7. SPS WALL TEMP HI LIGHT ILLUMINATES				Light illuminates when throat surface temperature is 380°F or greater. Ablation rates will be so severe that loss of chamber may be expected at any time, resulting in catastrophic failure. Maximum temperature should occur \approx 30 min after shut-down.	
MISSION CRITICAL: CONTINUE BURN - COMPLETE LOSS OF THE SPS SHOULD BE EXPECTED					
	1	If thrusting, THRUST sw - <u>OFF</u>	→	1. MSFN can confirm wall temperature over 380°F. Loss of entire chamber very possible upon refiring of SPS	1. Excess throat chamber ablation rates or instrumentation failure.
8. PROPELLANT HEATERS FAIL TO RAISE PROPELLANT TEMPERATURE	1	A/OFF/AB sw - <u>AB</u>	2	In the A position, the 26 electrical strip heaters receive 28V; in AB position an additional 26 heaters receive 28V.	
	2	Monitor PROP TEMP gage a. Propellant temperature increases b. Propellant temperature decreases		2a. Double heater operation is required for temperature control. 2b. If A/B not maintaining temperature above 45°F, attitude constraints must be observed or SPS may become non-operational. SPS not operable if Fuel temp < 25°F.	2a. System A heaters failed OFF. 2b. Both heater systems have failed, or SW failure, or instrumentation failure.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
9. PROP TEMP READING ABNORMAL	1	Revert to 5 hr-ON, 6 hr-OFF SPS LINE HEATER duty cycle.		<p>1. MSFN will provide back-up by monitoring propellant temperatures. If telemented FUEL TEMP abnormal, MSFN must monitor OX TEMP and provide back-up to crew for SPS LINE HEATER on-off control:</p> <p>HEATERS ON $T < 45^{\circ}\text{F}$ HEATERS OFF $T > 55^{\circ}\text{F}$</p> <p>Also, HEATERS ON if any OX line temp less than 20°F: HEATERS ON if any FUEL line temp, or if VALVE BODY temp, less than 25°F.</p>	
10. NO RESPONSE OF OX FLOW FLAGS TO OX FLOW ADJUSTMENT (PRI VALVE)	1	Valve sw - <u>SEC</u>	2	<p>Secondary valve has sufficient range to compensate for PRIMARY VALVE failure in any position and still provide valve openings for INCREASE, NORMAL or DECREASE OX FLOW.</p> <p>NOTE: Operation of OX FLOW valve is not critical to mission AS-204</p>	PRI OX FLOW VALVE failed
	2	Use OX FLOW switch as desired to adjust flow rate.			
11. ABNORMAL PROPELLANT QUANTITY READOUT	1	SENSOR sw - <u>PRI</u>	2	Complete any thrusting activity prior to check of quantity readout.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
	2	TEST/AUTO/TEST sw - <u>TEST</u> (upper) for 10 sec and monitor quantities:	3	In TEST mode the display will not move for the first 4.5 sec. Next it will race for ≈ 1 sec, and then will roll steadily at 2 to 4 digits per sec. If display reacts as above after primary system failure, then failure is in a tank probe. If tank probe is not failed, then random or bogey readings will be displayed.	
	3	a. Random reading b. Correct reading	4		
	4	SENSOR sw - <u>AUX</u>	5		
	5	TEST/AUTO/TEST sw - <u>TEST</u> (upper) for 10 sec, then sw - <u>TEST</u> (lower) for 10 sec. Read quantities:		In TEST mode the display will not move for the first 4.5 sec. Next it will race for ≈ 1 sec, and then will roll steadily at 2 to 4 digits per sec. If display reacts as above after primary system failure, then failure is in a tank probe. If tank probe is not failed, then random or bogey readings will be displayed.	
		a. Random reading	→	MSFN must now supply any propellant quantity data.	Display failed
		b. Correct reading	→	Continue in AUX mode. Telemetry will provide total quantities from auxiliary system, and sump tank quantities from PRI system.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
12. UNBALANCE METER IS ERRATIC OR PEGGED.	1	SENSOR switch - <u>AUX</u>	2	Complete any thrusting activity prior to checking unbalance meter.	
	2	TEST/AUTO/TEST sw - <u>TEST</u> (upper) for 10 sec. Monitor unbalance meter. SW - <u>TEST</u> (lower) for 10 sec. Monitor unbalance indicator			
	a.	Bogey Reading	3		UNBALANCE meter failed.
	b.	Normal reading	→	Use AUX mode for operation of quality guaging system	PRIMARY UNBALANCE failed
	3	SENSOR sw - <u>PRI</u>	4		
	4	TEST/AUTO/TEST sw - <u>TEST</u> (upper) for 10 sec; then sw - <u>TEST</u> (lower) for 10 sec.	5	Actuation of TEST switch here will realign digital display to PRIMARY system setting.	
	5	SENSOR sw - <u>NORM</u>			
13. LOSS OF SPS HELIUM TANK PRESSURE	1	Monitor He PRESS indicator		MSFN will correlate He temperature data with He press.	
	a.	He temperature drops concurrently with pressure	→	1a. Helium depletion imminent. Leak in helium supply.	1a LEAK IN HELIUM SUPPLY
	b.	He temperature does not reflect drop concurrent with pressure.	2	Leak cannot be verified until a SPS burn is performed.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
	2	Monitor FUEL TANK PRESS indicator during burn a. Fuel tank press decays from nominal (green band) valve b. Fuel tank press remains steady in green band.	→ →	Verifies last ^{Loss} of He supply pressure. Only 20 sec of safe SPS burn time remains after loss of Helium supply. Instrumentation is erroneous, and SPS is fully operational.	Helium supply leak. Instrumentation failed.
14. ABNORMAL SPS HELIUM VALVE TB INDICATION	1	Monitor He Flags a. One or both barberpole during non-burn period. b. One gray during burn c. Two gray during burn	2 2 3	1a. SPS operable, but propellant tank pressures may be slightly higher than normal. 1b. SPS operable with one helium isolation valve and regulator bank only unless manual override is successful 3	1a. Circuitry or valve failure closed ^{open} 1b. Circuitry or valve failure closed.
	2.	Attempt manual operation of valve.			
	3.	SPS He sw (2) - <u>ON</u>	3	<u>MISSION CRITICAL</u> - If still gray, monitor SPS FUEL (TANK) PRESSURE. If pressure decays from nominal (green) band TERMINATE FIRING PRIOR to 20 seconds. If manual override works, SPS operable. Helium valves must	3. Circuitry or valve failure closed.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
14. Cont.				be manually opened at thrust on and closed at thrust off. <u>NON-MISSION CRITICAL</u> - If still grey, TERMINATE FIRING.	
<p><i>Abnormal SPS INJECT VALVE INDICATION (FOR BLOCK II.)</i></p>					
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PROCEDURES ENTRY SHEET

SECTION 9.1.3

RCS MALFUNCTION PROCEDURES

SYMPTOM	SYMPTOM NUMBER	STEP	PAGE
<u>S/M RCS</u>			
S/M RCS C&W LIGHT ILLUMINATES	1	1	2
S/M RCS TEMP PKG LOW	1	4	2
S/M RCS TEMP PKG HIGH	1	10	3
S/M RCS PRESS MANF LOW	1	19	5
S/M RCS PRESS MANF HIGH	1	22	5
S/M RCS PRESS He LOW OR DECREASING	2	1	7
<u>C/M RCS</u>			
C/M RCS ENGINE TEMP FAILS TO INCREASE WITH HEATERS ON	3	1	9
C/M RCS C&W LIGHT ILLUMINATES	4	1	10
C/M RCS PRESS F OR OX HIGH	4	3	11
C/M RCS PRESS F OR OX LOW	4	4	11
C/M RCS PRESS He LOW	5	1	12

SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE	
1. S/M RCS A (B,C,D) Light illuminates	1.	S/M RCS A(B,C,D) Helium 1 & 2 sws <u>OFF</u>	2.	Light illuminates if TEMP PKG is >175° or <63°; or if PRESS MANF is <155 psia or >215 psia.		
	2.	RCS INDICATOR sw - <u>S/M A(B,C,D)</u>	3.			
	3.	Monitor S/M RCS TEMP PKG		3. Normal operating range: 115 - 175°F		
		a. LOW	4.			
		b. HIGH	10.	3b. Boost heating may cause the temperature to rise above 200°F, but it should drop during the first rev. Prolonged RCS firing and solar heat soak orientation may result in a high TEMP PKG.		
		c. NORMAL	18.			
S/M RCS TEMP PKG LOW	4.	If TEMP PKG <45°F: SCS CHANNEL sws A&C ROLL (B&D ROLL) and PITCH (YAW)-OFF	5.	4. Two SCS CHANNEL sws and DIRECT RCS must be disabled to electrically isolate the affected quad, however the opposite quad on the S/M is also disabled.		
	5.	DIRECT RCS - <u>OFF</u>	6.	Actuation at temperatures lower than 63°F can result in incomplete combustion and dangerous pressure spikes.		
<p>WARNING: If there was probable engine valve actuation while the quad's PKG TEMP was below 45°F: S/M RCS A(B,C,D) PROPELLANT SW - <u>OFF</u>; SCS CHANNEL sws (2) - <u>ON</u>. Reactivate the quad only in an emergency; S/M RCS A(B,C,D) HELIUM 1 & 2 sws - <u>ON</u>. If the quad is reactivated, the first pulse on each jet of the quad should be a minimum of one second in duration in order to attempt disipation of possible residue.</p>						
	6.	S/M RCS A(B,C,D) HELIUM 1&2 sws- <u>ON</u> (if applicable)	7.			
	7.	If possible, reorient S/C with quad A(B,C,D) in sunlight and monitor S/M RCS TEMP PKG				
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. (continued)		a. TEMP INCREASES	8.	7a. Temperature of quad must be maintained using solar heating.	7a. S/M PKG HEATER FAILED OFF
		b. TEMP DOES NOT INCREASE	9.	7b. If the indicator failed, S/M RCS A(B,C,D) light will not be illuminated; however if the sensor failed the light will be on. Use the temperature of the other quads to determine temp of the affected quad, and continuous monitoring of the affected quad is advised, if the sensor failed. If the indicator failed temperatures should be obtained from ground TM	7b. C/W CIRCUITRY TO S/M RCS LIGHT OR INSTRUMENTATION FAILURE.
S/M RCS TEMP PKG HIGH	8.	When RCS A(B,C,D) TEMP PKG > 63°F.	9.	→ 9. Use system normally	
	9.	SCS CHANNEL sws (2) - <u>ON</u> (if applicable)			
	10.	C/B RCS HEATERS A MNB (B MNA, C MNB, D MNA) - <u>OPEN</u>	11.	10. Boost heating may cause the temperature to rise above 200°F, but it should drop during the first rev. Prolonged RCS firing and solar heat soak orientation may result in a high TEMP PKG.	
	11.	Monitor S/M RCS TEMP PKG a. > 210°F b. < 210°F	12.		
	12.	SCS CHANNEL sws A&C ROLL (B&D ROLL) and PITCH (YAW) - <u>OFF</u>	13.	12. Two SCS CHANNEL sws and the DIRECT RCS must be disabled to electrically isolate the affected quad, however the opposite quad on the S/M is also disabled	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. (continued)	13.	DIRECT RCS - <u>OFF</u>	14.	If the engine valves are actuated above 220°F, deformation of the valve seats can occur with possible leakage of propellants.	
	14.	S/M RCS A(B,C,D) HELIUM 1& 2 sws- <u>ON</u> (if applicable)	15.		
	15.	If possible, orient the S/C to position the affected quad away from the sun to effect cooling monitor S/M RCS TEMP PKG			
	a.	TEMP DECREASES	16.	15a. Use the C/B to manually maintain the TEMP PKG within limits of 70°F-210°F CAUTION: If temp falls below 63°F go to RCS 1 step 4	15a. S/M HEATER FAILED ON
	b.	TEMP DOES NOT DECREASE	17.	15b. If indicator failed, S/M RCS A(B,C,D) light will not be illuminated. If the sensor failed, the light will be on. Use the temperatures of the other quads to estimate the temp. of the affected quad. Continuous monitoring of the quad is advised	15b. PKG TEMP INDICATOR OR SENSOR FAILED.
	16.	When RCS A(B,C,D) TEMP PKG falls below 200°F.	17.		
	17.	SCS CHANNEL sws - <u>ON</u>	→	17. Use system normally	
	18.	MONITOR S/M RCS PRESS MANF		18. Normal Helium operating pressure: 177 psia - 185 psia. In addition to helium manifold pressures MSFN can read out FUEL MANIFOLD PRESSURES on all quads and OXIDIZER MANIFOLD PRESSURES on quads A&D.	
	a.	LOW			
	b.	HIGH			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. (continued)		c. NORMAL	→	18c. RCS SELECTOR sw should be left in the affected quad position after every system status checks.	18c. C/W circuitry to S/M RCS light or instrumentation failure.
S/M RCS PRESS MANF LOW	19.	S/M RCS A(B,C,D) HELIUM 1&2 sws- <u>ON</u>	20.		
	20.	Operate the quad until RCS PRESS MANF drops below 100 psia.	21.		
	21.	S/M RCS A(B,C,D) PROPELLANT sw - <u>OFF</u> (Verify striped display)	→	21. Firing jets at pressures lower than 100 psia may cause engine wall burn-through due to inadequate film cooling. Refer to S/M RCS 2 (S/M RCS PRESS He LOW or DECREASING) Reactivation of the quad should only be accomplished in an emergency.	21. LEAK IN HELIUM PRESSURIZATION SYSTEM OR INSTRUMENTATION FAILURE.
S/M RCS PRESS MANF HIGH	22.	When practical, operate the thrusters on the affected quad, monitor S/M RCS A(B,C,D) PRESS MANF		22. Burst disks receptive at 220 - 236 psia. Relief valves open at 225-248 psia and reseal at about 220 psia. Some loss of helium is to be expected throughout these ranges.	
	a.	DECREASES	24.		
	b.	REMAINS CONSTANT	23.	22b. If indicator failed, S/M RCS A(B,C,D) light will not be illuminated. If sensor failed light will be illuminated.	22b. S/M RCS PRESS MANF INDICATOR OR SENSOR FAILED.
	23.	S/M RCS A(B,C,D) HELIUM 1&2 sws- <u>ON</u>	→	23. Continue normal operation.	
	24.	When S/M RCS PRESS MANF < 170 psia: S/M RCS A(B,C,D) HELIUM 1 sw - <u>ON</u> (Verify gray display) MONITOR S/M RCS PRESS MANF			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
		a. RETURNS HIGH b. NORMAL	25. →	24b. Quad is fully functional on redundant regulator assembly. If pressure was between 185-194 psia the primary regulator has failed and the secondary regulator was controlling Redundancy in the affected leg lost and should be used only as a last resort in case of failure closed in the other leg. If second set of regulators fail cycle S/M RCS HELIUM 1 or 2 sw to maintain adequate manifold pressure.	24b. S/M RCS A(B,C,D) HELIUM 2 REGULATOR ASSEMBLY FAILED.
	25.	S/M RCS A(B,C,D) HELIUM 1 sw - <u>OFF</u> (Verify striped display)	26.	→ 26. Pressure will decrease with use of the quad and the light (if on) will extinguish when pressure drops below 215 psia. Quad is fully functional on redundant regulator assembly. If pressure was between 185-194 psia the primary regulator has failed and the secondary regulator was controlling Redundancy in the affected leg lost and should be used only as a last resort in case of failure closed in the other leg. If second set of regulators fail cycle S/M RCS HELIUM 1 or 2 sw to maintain adequate manifold pressure.	Failure ?
	26.	S/M RCS A(B,C,D) HELIUM 2 sw - <u>ON</u> (Verify gray display)			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
2. S/M RCS PRESS He LOW OR DECREASING.	1	SCS CHANNEL sws A & C ROLL (B & D ROLL) AND PITCH (YAW) - <u>OFF</u>	2	1. TWO SCS CHANNELS AND DIRECT RCS MUST BE DISABLED TO ISOLATE THE AFFECTED QUAD.	
	2	DIRECT RCS - <u>OFF</u>	3	<u>CAUTION:</u> Propellant quantity gauging using PV is inaccurate.	
	3	S/M RCS A(B,C,D) HELIUM 1 & 2 sws - <u>OFF</u> (VERIFY STRIPED DISPLAY)	4		
	4	S/M RCS A(B,C,D) PROPELLANT sw- <u>OFF</u> (VERIFY STRIPED DISPLAY)	5		
	5	MONITOR S/M RCS PRESS He	6 →	5b. Configure to original conditions and NORMAL USE OF THE QUAD UNTIL S/M RCS PRESS MANF DROPS BELOW 100 PSIA THEN PLACE S/M RCS A(B,C,D) PROPELLANT SW - <u>OFF DO NOT</u> OPERATE QUAD IF PRESS MANF IS LESS THAN 100 PSIA EXCEPT IN AN EMERGENCY.	5b. HELIUM LEAK UP-STREAM OF HELIUM ISOLATION VALVES
	6	MONITOR S/M RCS PRESS MANF		→	6a. Use quad for emergency or separation only by: S/M RCS A(B,C,D) PROPELLANT Sw - <u>ON</u>
	7	WHEN IN RANGE OF MSFN, S/M RCS A(B,C,D) PROPELLANT sw - <u>ON</u>	7 8		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
	8	MONITOR OX AND/OR FUEL MANIFOLD PRESSURE THROUGH MSFN		8. OX measurements on quads B & C are not available.	
		a. REMAINS CONSTANT	→	8a. Use only for emergency or separation by SCS CHANNEL sws - ON. PLACE S/M RCS A (B,C,D) HELIUM 1 & 2 sws - <u>ON</u>	8a. HELIUM LEAK BETWEEN THE HELIUM ISOLATION VALVES AND THE CHECK VALVES.
		b. DECREASES	→	8b. THE LEAK COULD BE EITHER GAS OR LIQUID. USE ONLY FOR EMERGENCY OR SEPARATION BY PLACING THE SCS CHANNEL SWS AND THE S/M RCS A(B,C,D) HELIUM SWS TO <u>ON</u> .	8b. LEAK BETWEEN THE CHECK VALVES AND PROPELLANT ISOLATION VALVES.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
3. C/M RCS ENGINE TEMP FAILS TO INCREASE WITH HEATERS ON	1	PLACE TEST SELECTOR SW TO THE OTHER THRUSTER TEMP POSITIONS (1,2,3,4,11,12)	2		
	2	CYCLE FUNCTION SELECT SW FROM C/M RCS HTRS TO OFF AND BACK AND MONITOR DC AMMETER.			
		a. DC AMPS CHANGE MORE THAN 5 AMPS	3		
		b. DC AMPS CHANGE LESS THAN 5 AMPS	3		2b. C/M HEATERS NOT FUNCTIONING
	3	MONITOR DC VOLT METER (ENGINE TEMP)		3. INDICATES THRUSTER TEMP.	
		a. ANY TEMP INCREASING	→	3a. USE ONE OF OTHER ENGINE TEMPS FOR THAT OF AFFECTED ENGINE.	3a. TEMP SENSOR FAILURE.
		b. ALL TEMPS CONSTANT. BUT ANY BELOW 64°F (1.8 VDC)	4		
	4	MESC PYRO sws(2)-SAFE	5		
	5	C/M PROP JETT DUMP sw - <u>ON</u>	6	5. All engines will be heated with the exception of the two + pitch engines.	
	6	When coldest engine reaches 100°F (2.5 VDC) or for 13 minutes whichever comes first:	7		
7	C/M PROP JETT DUMP sw - <u>OFF</u>				

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
4. C/M RCS A OR B LIGHT ILLUMINATES	1	RCS INDICATOR SW - <u>CM RCS A OR B</u>	2	1. ILLUMINATES IF FUEL OR OXIDIZER PRESSURE IS <265 PSIA OR >325 PSIA.	
	2	MONITOR C/M RCS PRESS F AND OX a. HIGH b. LOW c. NORMAL	3 4 →	2. NORMAL 287-308 PSIA 2c. CONTINUE NORMAL OPERATION.	2c. C/W CIRCUITRY TO C/M RCS A OR B LIGHT FAILED ON.
C/M RCS PRESS F OR OX - HIGH	3	NONE	→	3. CONTINUE USING THE AFFECTED SYSTEM TO DEPLETION. BURST DISC RUPTURES AT 332-348 PSID. THE RELIEF VALVE CRACKS AT 332-360 PSIA AND RESEATS AT 327 PSIA. THERE WILL BE A LOSS OF HELIUM DUE TO VENTING.	3. REGULATOR ASSEMBLY FAILED OPEN
C/M RCS PRESS F OR OX - LOW	4	NONE	→	4. CONTINUE USING THE AFFECTED SYSTEM UNTIL HELIUM DEPLETION OCCURS. IF THE REMAINING SYSTEM IS SERIOUSLY DEGRADED THE HELIUM SYSTEMS MAY BE INTERCONNECTED BY PLACING THE C/M PROP DUMP SW - <u>DUMP</u> (MOMENTARILY) AND THEN RETURNING IT TO THE <u>OFF</u> POSITION. THIS SHOULD BE DONE AS A LAST RESORT ONLY AS HELIUM FROM THE GOOD SYSTEM IS BEING SUPPLIED TO A MALFUNCTIONING SYSTEM AND COULD BE LOST. ONCE THE SYSTEMS ARE INTERCONNECTED, THEY CANNOT BE ISOLATED.	4. REGULATOR ASSEMBLIES FAILED CLOSED OR LEAK IN SYSTEM.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
5. C/M RCS PRESS He LOW OR DECREASING	1.	HAS THE C/M RCS BEEN PRESSURIZED			
		a. YES	→	1a. NORMALLY LOADED AT 4100-4200 PSIA. CONTINUE USING THE AFFECTED SYSTEM UNTIL HELIUM DEPLETION OCCURS. IF THE REMAINING SYSTEM IS SERIOUSLY DEGRADED, THE HELIUM SYSTEMS MAY BE INTERCONNECTED BY PLACING THE C/M PROP DUMP SW - <u>DUMP</u> MOMENTARILY AND THEN RETURNING IT TO THE <u>OFF</u> POSITION. THIS SHOULD BE DONE AS A LAST RESORT ONLY AS HELIUM FROM THE GOOD SYSTEM IS BEING SUPPLIED TO A MALFUNCTIONING SYSTEM AND COULD BE LOST. ONCE THE SYSTEMS ARE INTERCONNECTED, THEY CANNOT BE ISOLATED.	
		b. NO	2.		
	2.	WHEN PRESS He = 600 psia	3.		
	3.	C/B MESC ARM A BATT A - <u>CLOSED</u>	4.		
	4.	C/B MESC ARM B BATT B - <u>CLOSED</u>	5.		
	5.	MESC PYRO ARM SWS(2) - <u>ARM</u>	6.		
	6.	RCS C/M PRESS - <u>ON/OFF</u>	7.	6. THIS PRESSURIZES THE C/M RCS IN ORDER TO TRAP ENOUGH	6. LEAK IN HELIUM SUPPLY
	7.	MESC PYRO ARM SWS(2) - <u>SAFE</u>	8.	HELIUM DOWNSTREAM FOR USE OF SYSTEM. IF THE OTHER SYSTEM IS	
	8.	C/B MESC ARM A BATT A - <u>OPEN</u>	9.	SERIOUSLY DEGRADED, THE HELIUM SYSTEMS MAY BE INTERCONNECTED	
9.	C/B MESC ARM B BATT B - <u>OPEN</u>	→	BY PLACING THE C/M PROP DUMP SW - <u>DUMP</u> MOMENTARILY AND THEN		
PREPARED BY: <i>CFM</i>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
				RETURNING IT TO THE OFF POSITION. THIS SHOULD BE DONE AS A LAST RESORT ONLY AS HELIUM FROM THE GOOD SYSTEM IS BEING SUPPLIED TO A MALFUNCTIONING SYSTEM AND COULD BE LOST. ONCE THE SYSTEMS ARE INTERCONNECTED, THEY CANNOT BE ISOLATED.	

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SECTION 9.1.4

EPS MALFUNCTION PROCEDURES

<u>SYMPTOMS</u>	<u>NO.</u>	<u>STEP</u>	<u>PAGE</u>
<u>CRYOGENICS</u>			
O ₂ (H ₂) PRESS LIGHT ILLUMINATES	1	1	2
O ₂ (H ₂) TANK 1 (AND/OR 2) PRESSURE LOW	1	2	2
O ₂ (H ₂) TANK 1 (AND/OR 2) PRESSURE HIGH	1	20	6
O ₂ (H ₂) TANK 1 (AND/OR 2) PRESSURE HIGH	1	20	6
<u>FUEL CELLS</u>			
F/C 1 (2 OR 3) LIGHT ILLUMINATES	1	1	10
FUEL CELL MODULE TEMP CON EXH HIGH	1a	1.00	11
FUEL CELL MODULE TEMP CONT EXH LOW	1b	2.00	14
FUEL CELL 1 (2 or 3) CIR & SEP MOTORS (AC) C/B OPEN	1c	3.00	16
FUEL CELL FLOW - O ₂ (H ₂) - HIGH	1d	4.00	17
FUEL CELL FLOW - O ₂ (H ₂) - LOW	1e	5.00	18
F/C 1 (2 OR 3) PH - HIGH - FLAG STRIPED	1f	6.00	20
O ₂ REG OUT PRESS HIGH - FLAG STRIPED	1g	7.00	22
H ₂ REG OUT PRESS HIGH - FLAG STRIPED	1h	8.00	24
O ₂ & H ₂ REG OUT PRESS - HIGH OR	1i	9.00	25
O ₂ & H ₂ & N ₂ REG OUT PRESS HIGH			
F/C 1 (2 or 3) RAD OUT TEMP - LOW	1j.	10.00	26
FUEL CELL 1 (2 OR 3) MODULE SKIN TEMP LOW ($\leq 375^{\circ}\text{F}$)	1k	11.00	27
FUEL CELL 1 (2 or 3) MODULE SKIN TEMP HIGH ($> 450^{\circ}\text{F}$)	1l	12.00	29

PROCEDURES ENTRY SHEET

(CONTINUED)

<u>SYMPTOMS</u>	<u>NO.</u>	<u>STEP</u>	<u>PAGE</u>
<u>POWER DISTRIBUTION</u>			
MN BUS A (B) UNDERVOLT LIGHT-ON DC VOLTS >26V	1	1	30
DC VOLTS METER INDICATES PYRO BATTERY A(B) BELOW 35 VOLTS	2	1	31
BATTERY CHGR OUTPUT CURRENT DROPS TO ZERO & CIRCUIT BREAKERS BATTERY CHARGER MN A&B OPEN	3	1	32
BATT CHGR OUTPUT CURRENT ZERO (IN ALL SWITCH POSITION)	4	1	33
DC INDICATORS - BAT BUS A(B), DC VOLTS 27-30 & DC AMPS >ZERO WITH BUS SWS OFF	5	1	34
BATT CHGR VOLTAGE 40 VDC AND CURRENT ZERO WHEN CHARGING BATTERY A(B,C)	6	1	36
INV 1 (2 or 3) TEMP ≥190°F (MSFN MONITORING CAPABILITY)	7	1	37
AC BUS FAIL LIGHT ILLUMINATED	8	1	40
AC BUS FAIL LIGHT & AC BUS 1 (2) OVERLOAD LIGHT ILLUMINATED	9	1	42
AC BUS 1 & 2 FREQUENCY INDICATES <393 CPS OR >407 CPS (SINGLE INVERTER OPERATION)	10	1	45
AC BUS FAIL LIGHT ILLUMINATED & AC BUS 1 (2) VOLTAGE <90v (DUAL INVERTER)	11	1	46
AC BUS FAIL LIGHT ON AFTER AC INVERTER 2 (1) IS APPLIED TO AC BUS 2(1)	12	1	47
MN BUS A & B UNDERVOLT LIGHT, AC BUS 1 & 2, & F/C BUS DISCONNECT LIGHTS ILLUMINATE (DUAL INVERTER CONFIGURATION)	13	1	49
MN BUS A&B UNDERVOLT LIGHT, AC BUS 1&2 & F/C BUS DISCONNECT LIGHTS ILLUMINATE (SINGLE INVERTER CONFIGURATION)	14	1	50

SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. O ₂ (H ₂) PRESS light illuminates.				C/W low pressure limits: O ₂ : TANK 1 & 2 = 800 psia H ₂ : Tank 1 & 2 = 220 psia C/W upper pressure limits O ₂ : Tank 1 & 2 = 950 psia H ₂ : Tank 1 & 2 = 270 psia	
	1	Monitor TANK PRESSURE - O ₂ (H ₂) - 1 & 2			
		a. Pressure low	2		
		b. Pressure high	20		
O ₂ (H ₂) Tank 1 (and/or 2) pressure low	2	O ₂ (H ₂) HEATERS Sw - 1 (and/or 2) - <u>OFF</u> (off limit tank(s))	3	(2) Low O ₂ (H ₂) pressure in one tank is not time critical and should be verified with MSFN to determine possible indicator failure. The surge tank should be isolated when marked decreasing trend in both O ₂ tank pressures is noticeable.	
	3	O ₂ (H ₂) FANS - 1 (and/or 2) - <u>OFF</u> (off limit tank(s))	4		
	4	Monitor Flow - O ₂ (ECS)			
		a. Flow >.45 lbs/hr	→	(4a.) Reference ECS symptom No. 1 (O ₂ Flow High)	(4a.) Leak in ECS
		b. Flow <.45 lbs/hr	5		
	5	Monitor CABIN PRESS			
PREPARED BY: <i>J. R. Dalry</i>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
<i>R. E. Dalry</i>		DATE: Jan 27, 1967		EPS-CRYOGENICS	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
		a. Pressure \rightarrow 5.6 psia	\rightarrow	(5a.) Reference ECS symptom No. 21 (Cabin Pressure high)	(5a.) Leak in ECS
		b. Pressure \leftarrow 5.6 psia	6		
	6	Monitor TANK PRESSURE O ₂ (H ₂) - 1 (and/or 2) & F/C FLOW - F/C 1, 2, & 3			
		a. Press steady or gradual decrease & F/C flow rates equivalent.	8.	(6a.) Pressure changes will be more evident with H ₂ gauge scale than with O ₂ gauge scale. F/C flow rate comparisons will reveal purge valve open.	(6a.) Motor or pressure switch failure or leak prior to flow sensor.
		b. Flow high in one fuel cell, pressure continues to drop	11		(6b.) Purge valve seat leak or plumbing leak.
		c. Fuel cell flow rates equivalent & pressure indicates marked drop in one tank	7	(6c.) Tank vent valve being open necessitates a previously high pressure or failure of relief valve. O ₂ tank relief vents at 983 psig and reseats at 970 psig. H ₂ relief valves vent at 273 psig & reseats at 268 psig.	(6c.) Tank vent valve open or plumbing leak.
	7	Leave both tank heaters & fans - OFF.	\rightarrow	(7) Surge tank should be isolated when marked decreasing trend in both O ₂ tank pressures is noticeable. Sufficient flow may be obtained in a pressure decay mode of operation.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
				Minimum cryo systems pressures are: O ₂ : 500 psi (required for worst case cabin repress) H ₂ : 150 psi Management constraints are: a. Quantity remaining in both tanks. b. Rate of depletion of faulty tanks.	
	8	O ₂ (H ₂) HEATERS Sw - 1 (and/or 2) <u>ON</u>	9		
	9	O ₂ (H ₂) FANS Sw - 1 (and/or 2) <u>ON</u>	10		
	10	Monitor TANK PRESSURE - O ₂ (H ₂) - 1 (and/or 2) a. Pressure increases steadily b. Pressure continues to gradually decrease		(10a) Single switch failure results in loss of automatic pressure control in both tanks. Manual control is required. (10b) Tank pressure will decay and is effectively lost for rest of mission.	(10a) Motor or pressure switch failure. (10b) Leak prior to flow sensor.
	11	Cycle FUEL CELL 1 (2 or 3) - O ₂ (H ₂) - PURGE 3 to 5 times consecutively & return to <u>OFF</u>	12		
	12	Monitor - FLOW - O ₂ (H ₂) meter			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
	12	a. Flow returns to normal	13	(12a.) Normal purge maximum flow increases are: O ₂ : 0.6 lb/hr H ₂ : 0.75 lb/hr	(12a.) Purge valve seat open temporarily.
		b. Flow remains high	15	(12b) A plumbing leak in the area involved here is very remote.	(12b.) Plumbing leak down stream of fuel cell or purge valve.
	13	O ₂ (H ₂) HEATERS sw - 1 (and/or 2) - <u>AUTO</u>	14		
	14	O ₂ (H ₂) FANS sw - 1 (and/or 2) - <u>AUTO</u>	→		
	15	Repeat Step 9			
		a. Flow remains high	16	(15a) See statement of step 12a.	
	16	O ₂ (H ₂) HEATERS sw - 1 (and/or 2) - <u>AUTO</u>	17		
	17	O ₂ (H ₂) FANS sw - 1 (and/or 2) - <u>AUTO</u>	→ 18	(17) Fuel cell purge valve being open may give a critical operational mode if purge cycle is initiated during low pressure condition of tank. Consumption data & mission length should be adjusted accordingly. If flow rate exceeds flow rate of remark 12a, crew - MSFN option to shutdown fuel cell.	
	18	Monitor TANK PRESSURE - O ₂ (H ₂) - 1 & 2			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
O ₂ (H ₂) TANK 1 (and/or 2) PRESS HIGH	18	a. Pressure returns to normal	→		
		b. Pressure decreases	19		
	19	Use manual pressure control			
	20	O ₂ (H ₂) HEATERS - 1 (and/or 2) - <u>OFF</u>	21	20. Note: Purge would normally be initiated when the tank pressures trigger the C/W. C/W upper pressure limits are: O ₂ : TANK #1 - 950 psia TANK #2 - 950 psia H ₂ : TANK #1 - 270 psia TANK #2 - 270 psia Tank relief valve crack pressures: O ₂ : Tank #1 - 983 psig Tank #2 - 983 psig H ₂ : Tank #1 - 270 psig Tank #2 - 270 psig	
	21	O ₂ (H ₂) FANS - 1 (and/or 2) - <u>OFF</u>	22		
	22	Monitor O ₂ (H ₂) Tank pressure			
		a. O ₂ high	23		
		b. H ₂ high	27		
	23	Monitor cryogenic & surge tank pressures			
		a. Surge tank = 900 \pm 35 and << highest cryo tank	24	(23a) Loss of sensor capability necessitates coordination with MSFN.	(23a) O ₂ Sensor circuit failure in tank with highest indicated pressure.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
		b. Surge tank \approx highest cryo tank	28'		
	24	PRESS IND SW-SURGE TANK	25		
	25	O ₂ HEATERS SW-1(&/or 2) - AUTO	26		
	26	O ₂ FANS SW-1(&/or 2) - AUTO	→	(26) Normal configuration is mission time dependent	
	27	Verify with MSFN H ₂ tank pressure			
		(a) Normal	→		(27a) H ₂ sensor circuit failure
		(b) One or two tanks high	28		
	28	FUEL CELL 1,2, & 3-O ₂ (H ₂) PURGE (normal duration)	29	(28) H ₂ purge line heater should be on at least 10 minutes (no more than 20 minutes should be required) prior to purge. Immediate purge may be initiated if vent valve crack pressures are imminent.	
	29	Monitor: TANK PRESSURE-O ₂ (H ₂)-1 & 2 TANK QUANTITY-O ₂ (H ₂)-1 & 2			
		(a) Pressure decreases in 1 tank	→	(29a) Mission constraint is quantity remaining in normal tank.	(29a) Tank outlet line blocked.
		(b) Press decreases in both tanks &			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
		(1) $O_2(H_2) > 950$ psia (270 psia)	30		(29.b.1) Cryogenic control circuitry or insulation degradation, or a combination of high heat leak influence and low demand.
		(2) 800 psia (210 psia) $< O_2(H_2) < 950$ psia (270 psia)			
		(a) In min. dQ/dM region	31	(29.b.2) The minimum dQ/dM region may be defined as the region of tank densities wherein design pressures may be maintained by tank heat leak only. The following tank densities correspond approximately to entry of min. dQ/dM region. H_2 <u>15</u> lbs/tank O_2 <u>135</u> lbs/tank	
		(b) Outside min dQ/dM region	32		
	30	Repeat purge if required	29	(30) If normal purging of fuel cells does not sufficiently decrease pressure, continuous purging is an option or increasing cabin pressure (O_2 only)	
		(a) Pressure decreases			
		(b) Pressure high	30 →		(30b) Insulation degradation
	31	Power up ($\approx 2.5\Delta$ amps per fuel cell) e.g. Two inverters, S-Band high mode, battery charger		(31) These indicated loads will probably provide sufficient increase in demand	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
		(a) Pressure stabilizes	→	(31a) Maintain present minimum load requirements until tank densities are approximately: O ₂ : 15 lbs/ft ³ H ₂ : 1.0 lbs/ft ³	(31a) Predominant heat leak influence
		(b) Pressure increases steadily	→ 35		(31b) Excessive heat leak-possible insulation degradation
	32	Manually maintain normal pressure & quantity balance	33		
	33	Monitor - TANK PRESSURE - O ₂ (H ₂) - 1(&/or 2)			
		(a) Pressure remains normal	34	(33a) Loss of automatic pressure control necessitates use of normal control	(33a) Motor &/or pressure switch failure.
		(b) Pressure increases			
		(1) In one tank	34		(33.b.1) Insulation degradation
		(2) In both tanks	35	(34.b.2) Crew option to manually or automatically control tank pressure	(33.b.2) Combination of high heat leak & low demand
	34	Continue manual pressure control			
	35	Increase power &/or purge as required to control pressure below C/W upper limit			
PREPARED BY: <i>J. W. Radloff</i>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
F/C 1 (2 or 3) Light Illuminates	1	FUEL CELL INDICATORS - 1(2 or 3)			
	2	Survey F/C meters & annunciators			
	a.	FUEL CELL MODULE TEMP COND EXH - High	1.00	$T_{CE} \geq 175^{\circ}\text{F}$ (Spec)	
	b.	FUEL CELL MODULE TEMP COND EXH - Low	2.00	$T_{CE} \leq 152^{\circ}\text{F}$ (Spec)	
	c.	Fuel cell 1 (2 or 3) - CIR & SEP MOTORS (AC) - C/B - OPEN	3.00	May occur independent of F/C 1, 2, or 3 light.	
	d.	FUEL CELL FLOW - $\text{O}_2(\text{H}_2)$ - High	4.00	Flow ≥ 1.276 lb/hr (.1606 lb/hr) (Spec)	
	e.	FUEL CELL FLOW - $\text{O}_2(\text{H}_2)$ - Low	5.00	Flow $\leq .140$ lb/hr (.018 lb/hr) (Spec)	
	f.	PH HI-striped	6.00	C/W trigger values ph ≥ 9.0 (Spec)	
	g.	O_2 REG OUT PRESS HI-Striped	7.00	O_2 press ≥ 75 psia (Spec)	
	h.	H_2 REG OUT PRESS HI-Striped	8.00	H_2 press ≥ 75 psia (Spec)	
	i.	O_2 REG OUT PRESS HI & H_2 REG OUT PRESS HI - STRIPED OR O_2 REG OUT PRESS HI & H_2 REG OUT PRESS HI & N_2 REG OUT PRESS HI - STRIPED	9.00	N_2 Press ≥ 70 psia (Spec)	
	j.	F/C RAD TEMP LOW - Striped	10.00	Temp $\leq -30^{\circ}\text{F}$ (Spec)	
	k.	FUEL CELL MODULE TEMP SKIN Low	11.00	$T_{SKIN} \leq 360^{\circ}\text{F}$ (Spec)	
	l.	FUEL CELL MODULE TEMP SKIN High	12.00	$T_{SKIN} \geq 500^{\circ}\text{F}$ (Spec)	
PREPARED BY: <i>[Signature]</i>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
(a) FUEL CELL MODULE TEMP-COND EXH HIGH	1.00				
	1.01	Monitor - FUEL CELL - 1, 2 & 3 - Module temp - COND EXH		C/W trigger value is 175° F. MSFN verification necessary for C/W failure.	
		a. 1 fuel cell affected	1.02		
		b. 3 fuel cell affected	1.03	(1.01b) $T_{CE} \geq 170^\circ\text{F}$ on fuel cells considered "high".	
CAUTION: DO NOT EXCEED $T_{CE} = 200^\circ\text{F}$ FOR ANY LENGTH OF TIME TO PREVENT H_2 PUMP FAILURE					
	1.02	Monitor - Fuel cell - 1 (2 or 3) Module temp - CONDEXH & skin			
		a. T_{CE} rises to 190° within approximately 10 to 15 min. T_{SKIN} increases after 15 minutes.	1.06	(1.02a) This set of symptom is indicative of limited, but serious flow restriction of coolant - some heat is still being transferred to the second- ary loop. When flow is com- pletely stopped, C/B may, in time, open. When flow is stopped & H_2 pump is operating, T_{CE} will rise sharply ($\approx 8^\circ/\text{min}$) followed by an increase in T_{SKIN} within 15 to 20 minutes.	(1.02a) Coolant flow restriction or leak- age or pump stalled.
		b. T_{CE} rises steadily for normal T_{SKIN} range.	1.03	(1.02b) Steadily rise defined as (.5° to 2°/min). There may be 15 minutes to an hour (at a steady power level) to detect a small but off - nominal increase in T_{SKIN} . The time interval is dependent upon the power level.	(1.02b) Secondary bypass valve or minor flow restriction.
	1.03	FUNCTION SELECT - <u>A</u>	1.04		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
(a) continued	1.04	TEST SELECT - 10 (11 or 12)	1.05		
	1.05	Monitor EPS RAD OUT TEMP			
		(a) Normal	1.07 →	(1.05a) Normal operating boundaries: .6V (-10°F) to 2.0v (+90°v)	(1.05a) Minor flow restriction.
		(b) High and increases with T _{CE}	1.07	(1.05b) The T _{CE} will follow any increase or decrease in RAD OUT TEMP if secondary bypass valve failed in 100% bypass position.	(1.05b) Secondary bypass valve failed in 100% bypass position.
	1.06	Monitor - FUEL CELL -1,2,&3 - Module temp - cond exh & skin			
		(a) T _{CE} rises rapidly & T _{SKIN} rising on 1 or more F/C's after 15 minutes.	→	(1.06a) Rapid rise of T _{CE} defined as 2 → 8°/minute. T _{SKIN} may rise within 20 minutes for a steady power level. This combination of symptoms is indicative of improper coolant flow stalling the three glycol pumps. The cause of the improper coolant flow is common to all three fuel cells. The mission constraint may consider faulty fuel cells useful for reentry burn or until T _{CE} meets the above constraints. After T _{CE} exceeds 299°F the H ₂ pumps will seize (at same unpredictable time or temperature) but further use of fuel cells is available. An SPS deorbit could be supported with continuous purge & immediate entry into deorbit procedures.	(1.06a) Glycol pumps stalled.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
(a) continued		(b) T_{CE} high steady or slowly increasing (all fuel cells)	→	(1.06b) This combination of symptoms necessitates a powered up configuration. Symptom may be corrected by powering down when convenient.	(1.06b) Inadequate glycol to environment heat transfer, e.g. radiator sooting.
	1.07	Open circuit F/C or purge to control T_{CE} below 200°F.	1.08	(1.07) Control of T_{CE} may be accomplished by limited open circuit operation as required to restrain T_{CE} below 200°F.	
	1.08	Continue normal operation with appropriate monitoring.	→		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
(b) FUEL CELL - MODULE TEMP - COND EXH - LOW	2.00			C/W will trigger F/C 1, 2 or 3 light when $T_{CE} \approx 150^{\circ}\text{F}$. If T_{CE} remains low, a performance shift may occur.	
	2.01	Function Select - A TEST SELECT - <u>10, 11 & 12</u> (RAD OUT TEMP)	2.02		
	2.02	Monitor RAD OUT TEMP & FUEL CELL MODULE TEMP - SKIN			
	a.	T_{SKIN} rises rapidly on 1 F/C.	2.03	(2.02a) RAD OUT TEMP will go to a stabilized temperature equivalent to the sector ambient. Circuit breaker CIR & SEP MOTORS (AC) should be OPEN or there exists an open circuit condition. T_{SKIN} rapid rise corresponds to 12° to 15° per hour at 1000 watt load on F/C.	(2.02a) H_2 pump failure.
	b.	RAD OUT TEMP low on 1 F/C.	2.05	(2.02b) This failure is detectable in a powered down configuration and T_{CE} is low. Normal operating RANGE: .38V = -20°F 2.0V = $+90^{\circ}\text{F}$ The cond exhaust temp will follow increase or decrease of RAD OUT TEMP in a 100% Bypass position (failure).	(2.02b) Coolant BYPASS valve failed in 100% bypass position.
c.	RAD OUT TEMP $\approx -30^{\circ}\text{F}$	2.05	(2.02c) Corresponding RAD OUT TEMP C/W limits may follow. Aux DC volts of .3 v corresponds to -30°F . (Note that a low T_{CE} is not necessarily indicative of a cold environment.	(2.02c) Cold environment.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
(b) continued	2.03	Monitor fuel cell performance (affected F/C)			
		a. F/C assuming load	2.04		
		b. F/C current ZERO	2.06		
	2.04	(option) Use continuous purge and/or open circuit to control temperatures until current decays.	2.06	2.04 The affected F/C's life may be extended 6 to 8 hours by controlling T_{CE} below 200°F. The lower the power level the more likely an 8 hour extension may be obtained.	
	2.05	Power up S/C as required to bring temperatures up.	→		
	2.06	Isolate F/C. Ref EPS Symp. No. (f) Step No. <u>6.07</u> .	→		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
(c) FUEL CELL 1 (2 or 3) CIR & SEP MOTORS C/B - OPEN	3.00			Loss of pump will cause condenser exit temperature to trigger C/W at $T_{CE} = 175^{\circ}\text{F}$	
	3.01	Attempt to reset C/B (a) C/B resets (b) C/B cannot be reset	→		(3.01a) Momentary H_2 pump stall (3.01b) Circulation & separation pump failure caused by contamination or internal pump failure.
	3.02	Fuel cell pump 1 (2 or 3) - <u>OFF</u>	3.02	(3.01b) <u>NOTE</u> : Glycol pump and pH sensor will be lost since their AC power to common to the H_2 pump.	
	3.03	Place fuel cell 1 (2 or 3) on open cycle and/or open circuit if capable of supplying power.	3.03	(3.03) Keep fuel cell in reserve. Plan to use with continuous purge any time fuel cell is used. Fuel cell with continuous purge can supply 563 watts indefinitely or 1000 watts for short periods.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
d. FUEL CELL FLOW - O ₂ (H ₂) - Hi	4.00			High flowrate C/W limits are: H ₂ : F/C 1 = .161 lb/hr F/C 2 = .162 lb/hr F/C 3 = .162 lb/hr O ₂ : F/C 1 = 1.32 lb/hr F/C 2 = 1.30 lb/hr F/C 3 = 1.32 lb/hr Procedure applicable to conditions of high flowrate independent of those occurring during purge. H ₂ flow Hi C/W may come on during purge.	
	4.01	Cycle FUEL CELL 1 (2 or 3) - O ₂ (H ₂) - <u>PURGE</u> , several times & return to <u>OFF</u> (a) Flowrate returns to normal (b) Flowrate remains high	→ →	(4.01a) Subsequent purges may, again, result in valve seat remaining open. (4.01b) Crew - MSFN option to shutdown F/C based on: (1) Performance of remaining 2 F/C's, & condition of batteries. (2) Time required to complete mission vs. cryogenic quantity remaining	(4.01a) Purge valve seat open (4.01b) Faulty purge valve, or regulator vent valve, or fuel cell assembly leak. The latter is possible but remote.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
(e) FUEL CELL 1(2or3) FLOW O ₂ (H ₂ - LOW	5.00			C/W trigger limits are (actual): F/C 1: .013 lb/hr H ₂ .14 lb/hr O ₂ F/C 2: .018 lb/hr H ₂ .11 lb/hr H ₂ F/C 3: .018 lb/hr H ₂ .14 lb/hr H ₂	
	5.01	Verify FUEL CELL 1 (2,3) REACTANTS SW - <u>ON</u>	5.02	Verify flag - gray,	
	5.02	FUNCTION SELECT - <u>A</u>	5.03		
	5.03	TEST SELECT - <u>4(5,6)</u> or <u>7(8,9)</u>	5.04		
	5.04	O ₂ (H ₂) REGULATOR OUTLET PRESSURE (a) Normal (b) Low	5.05	Normal regulator pressures: O ₂ : 62 PSIA (4.13V) H ₂ : 60.5 PSIA (4.03V) → (5.04b) Imminent loss of fuel cell 1 (2,3) expected. If H ₂ regulator pressure is low, fuel cell should be shut down immediately to prevent flooding (possible KOH contamination.) Refer to EPS symptom (f) step 6.07 for fuel cell shutdown.	(.5.06b) Blocked supply line (from cryo tank).
CAUTION: DO NOT PURGE TO PREVENT PLUGGING OF COMMON VENT LINE					
	5.05	Monitor FUEL CELL 1 (2,3) performance		Reference V - I curve.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
(e) (continued)		(a) Normal performance	→	(5.05a) System normal (correct flow may be estimated from: O ₂ FLOW = 7.9 H ₂ FLOW)	Failed flow indicator
		(b) Abnormal performance	→	(5.05b) Refer to normal procedure "FUEL CELL POWER PLANT PURGING" to attempt to restore normal operation.	Fuel cell degradation
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
(f) F/C 1(2 or 3) pH-Hi- Striped	6.00				
	6.01	Monitor F/C performance (Refer to V1 curve)			
		a. Performance Normal	6.02		
		b. Decreasing trend in performance (steady state power)	6.03	(6.01b) Further F/C degradation can be anticipated. The rate will depend on extent of flooding.	(6.01b) Limited electrode flooding
		c. DC amps indicating zero	6.07		(6.01c) Complete fuel cell flooding.
	6.02	F/C performance over 1 hr.		(6.02) If KOH (limited) is being transferred to H ₂ line without significant loss of performance then it will do so at unpredictable intervals. This is indicative of small quantities being transferred and it is not a critical situation as long as the ph of the water gun output does not exceed \approx 11 ph. If problem is transient, dilution will allow F/C 1(2 or 3) light to extinguish.	(6.01a) C/W failure.
		a. No decrease	→		
		b. Decrease in performance	6.01b		
<p>CAUTION: DO NOT PURGE F/C IF KOH FLOODING IS SUSPECTED. Plugging of common vent line may result.</p>					
	6.03	FUNCTION SELECT-A	6.04		
	6.04	TEST SELECT - 7(8 or 9)	6.05		
	6.05	Monitor H ₂ Reg out press			
		a. Reg out press normal	6.06	(6.05a) 4.2V corresponds to 63 psia regulated pressure.	(6.05a) Limited KOH flooding due to internal F/C rupture.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
(f) continued		b. Reg out PRESS LOW	6.06	(6.05b) This failure of regulator is extremely remote.	(6.05b) Limited KOH flooding due to LOW supply press (reg.)
	6.06	Continue use of F/C until F/C current zero.	→ (6.07)	(6.06) Note that step 6.01b expresses F/C output exist. In either case, (6.05a or 6.05b) there exists 1 to 2 hours of F/C use, depending on S/C power level. When F/C current zero continue to step 6.07.	
Loss of F/C output	6.07	MAIN BUS TIE - <u>BAT A & C</u> - <u>BAT B & C</u>	6.08	(6.07) Monitor PH - (Ref. ECS procedure No. <u> </u>) The initial F/C - Bus configuration assumed is:	
	6.08	Tie two normal F/C's to parallel main buses A & B.	6.09	F/C 1 - MNA - ON F/C 2 - MNA - ON F/C 3 - MNA - OFF	
	6.09	Remove faulty F/C from main bus(es)	6.10	F/C 1 - MNB - OFF F/C 2 - MNB - ON F/C 3 - MNB - ON	
	6.10	Fuel cell 1 (2 or 3) H ₂ O ₂ Valve C/B - <u>CLOSED</u>	6.11		
	6.11	F/C 1 (2 or 3) - (faulty F/C) H ₂ &O ₂ REACTANTS - <u>OFF</u>	6.12		
	6.12	FUEL CELL PUMP - 1 (2 or 3) - <u>OFF</u>	6.13		
	6.13	Open FUEL CELL 1 (2 or 3) - C/B's	6.14		
	6.14	Configure 1 fuel cell to MNA & 1 fuel cell to MNB.	6.15		
	6.15	(Option) MAIN BUS TIES - <u>OFF</u>	→	(6.15) Batteries should be tied during high power levels.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
(g) O ₂ REG OUT PRESS Hi-Striped	7.00				
	7.01	DC INDICATOR sw - FUEL CELL	7.02	This symptom may be caused by either an actual O ₂ regulator failure or an N ₂ regulator failure. This is due to the fact that O ₂ press is referenced 11 psi above N ₂ press and the 75 psia O ₂ C/W trigger value is reached before the N ₂ C/W trigger value of 70 psia.	
	7.02	Monitor fuel cell performance (Ref. VI curves)			
	(a.)	Performance Normal	7.04		
	(b.)	Performance Abnormal (current decreasing rapidly or zero)	7.03 →		(7.02b) O ₂ regulator failure.
	7.03	Shutdown fuel cell (Ref EPS sym. (a) STEP 1.07)	→	(7.03) Loss of one fuel cell the C/W trip limit of 75 psi also corresponds approximately to the point where fuel cell flooding can be anticipated.	
	7.04	FUNCTION SELECT - <u>A</u>	7.05		
	7.05	TEST SELECT - <u>1</u> (2 or 3)	7.06		
	7.06	MONITOR N ₂ REG OUT PRESS			
	(a.)	Normal	→	(7.06a) Normal N ₂ Reg out press- 53 psi (3.55V). Loss of O ₂ C/W flag (except sensor failure) necessitates use of aux DC voltmeter to monitor O ₂ regulator performance.	(7.06a) O ₂ C/W circuitry failure.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
(g) continued		(b.) High	→	(7.06b) Maximum pressure tolerance of fuel cell assembly permits N ₂ regulator failure with O ₂ & H ₂ pressures following. This fuel cell will subsequently run with higher than normal skin temp and consumption. Its efficiency will probably improve.	(7.06b) N ₂ regulator failure.

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
h. H ₂ REG OUT PRESS ² HI - Striped	8.00				
	8.01	DC INDICATORS SW - <u>FUEL CELL</u> <u>1(2 or 3)</u>			
	8.02	FUNCTION SELECT - <u>A</u>	8.03		
	8.03	TEST SELECT - <u>7, 8 or 9</u>	8.04		
	8.04	Monitor: DC AMPS meter & H ₂ regulator pressure			
		a. Regular pressure indicates high, DC AMPS indicating a rapid decrease in F/C output or zero.	8.05 →	(8.04a) Continued use of fuel cell will eventually cause its failure.	(8.04a) H ₂ regulator failure.
		b. Regular pressure indicates high, low or erratic, and no decrease in amperage.	→	(8.04b) Loss of C/W annunciator necessitates use of AUX DC VOLTS meter to monitor H ₂ regulator performance.	(8.04b) C/W circuit failure.
	8.05	Shutdown fuel cell (Ref. EPS symp. No.(f) Step 6.07	→		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
i. O ₂ REG OUT PRESS Hi & H ₂ REG OUT PRESS Hi flags striped or O ₂ REG OUT PRESS Hi & H ₂ REG OUT PRESS Hi & N ₂ REG OUT PRESS Hi flags-striped	9.00				
	9.01	DC INDICATORS - <u>FUEL CELL 1(2or3)</u>	9.02	N ₂ REG OUT PRESS flag will follow an O ₂ flag actuation in a short time.	
	9.02	Monitor fuel cell performance (Ref. VI curves) a. Performance normal or improving.	→	(9.02a) N ₂ regulator failure will not fail fuel cell unless either the O ₂ or H ₂ regulator fails to follow the increase in reference pressure. The increased reference pressure may increase the efficiency of the F/C and therefore it will assume more load than it has previously. The load sharing and respective consumption data should be adjusted accordingly. The situation is not critical.	(9.02a) N ₂ regulator failure.
		b. Performance abnormal (current rapidly decreasing or zero)	→		(9.02b) Double or triple failure of N ₂ and either H ₂ or O ₂ regulators failed or all regulators failed
	9.03	Shut down fuel cell (Ref EPS symp. (f) step <u>6.07</u> .			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
j. F/C 1 (2 or 3) RAD OUT TEMP - LOW	10.00			Flag will trigger at -37°F, -39°F, and -42°F for F/C 1, 2, or 3 respectively. The condenser exhaust temp may trigger C/W (150°F) before the radiator glycol reaches the above trip valves.	
	10.01	Monitor T_{CE} & T_{SKIN} (a) Normal (b) Abnormal (1) T_{CE} & T_{SKIN} high (2) T_{CE} - low & T_{SKIN} - high	10.02	(10.01b.1) Ref. EPS symptom No. (a) FUEL CELL MODULE TEMP-COND EXH HIGH (10.01b.2) Ref EPS symptom No. (b) FUEL CELL MODULE TEMP-COND EXH LOW	
	10.02	FUNCTION SELECT - <u>A</u> TEST SELECT - <u>10, 11, & 12</u>	10.03		
	10.03	Monitor Rad out temps (a) 1 F/C indicates low Rad out temp (b) 3 F/C's Rad out temp low	10.04	(10.03) 1 F/C low Rad out temp compared to remaining two and T_{CE} & T_{SKIN} normal is indicative of an indicator failure. (10.04) Positioning S/C with bay 4 towards sun is an option.	(10.03a) Indicator failure (10.03b) Cold environment
	10.04	Power up S/C as req'd to maintain temperatures.			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
(k) FUEL CELL 1(2or3) MODULE SKIN TEMP LOW (<375°F)				Inline heater maintains skin temp 375-395°F. Performance degrades significantly below this range.	
	11.01	Monitor fuel cell 1 (2 or 3) performance (ref. VI curves)			
	a.	Performance normal for indicated skin temp.	11.02 →		(11.01a) Inline heater failure.
	b.	Performance higher than normal for indicated skin temp.	→	(11.01b) Fuel cell normal skin temp may be estimated from VI curve.	(11.01b) Fuel cell 1 (2 or 3) skin temp indication failed.
	11.02	If desired: Reconfigure fuel cell bus ties so that fuel cell 1 (2 or 3) is shared between buses.	11.03	(11.02-11.03) Fuel cell recovery possible from skin temp as low as 330°F by increasing load on that fuel cell. MSFN-crew option based on: (1) Performance of remaining fuel cells and condition of batteries. (2) Time required to complete mission vs. cryogenic quantity remaining.	
	11.03	Power up spacecraft	11.04		
	11.04	Fuel cell 1 (2 or 3) module skin temp (a) Increases	→	(11.04a) Increase load allowing fuel cell to recover. Estimated load required to maintain that fuel cell skin temp above 375°F is 20 amps.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
(k) continued		(b) Does not increase & fuel cell 1, (2 or 3) performance does not improve.	→	(9.04b) Fuel cell recovery apparently not possible. Open circuiting by reverse current relay anticipated. Refer to EPS Malfunction Procedure for fuel cell shut down (Sym (f) step 6.07)	

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
(1) FUEL CELL 1(2,3) TEMP SKIN HIGH ($>450^{\circ}\text{F}$)	1200			Normal F/C operating temp. range is 375°F - 450°F , depending upon electrical load. C/W trip values are 360°F and 500°F .FCPP open circuit or continuous purge are options. Prolonged operations above 500°F will result in FCPP failure (time and/or temp. at which failure will occur are not predictable) a failure of this nature will have no adverse effect on other FCPPs or S/C systems.	
	12.01	Monitor F/C 1, (2,3) performance using V-I curve and temp-skin. a. Performance normal for indicated temp-skin, b. Performance lower than normal for indicated temp.-skin.	 → →	(12.01a) Fuel cell will perform satisfactorily up to C/W trip temp. of 500°F . (However, it is unlikely that 500°F will be reached during flight). (12.01b) Estimated temp-skin (from W-I curve) lower than indicated temp.	Temp-skin sensor failure
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE	
1. MN BUS A (B) UNDERVOLT LIGHT-ON DC VOLTS >26V	1	MN BUS A(B) RESET- RESET -(CENTER)				
		a. MN BUS A (B) UNDERVOLT LIGHT-OFF →			1a. Transient under voltage	
		b. MN BUS A (B) UNDERVOLT LIGHT-ON	2			
	2	MN BUS A(B) RESET- RESET -(CENTER) several times.				
		a. MN BUS A(B) UNDERVOLT LIGHT-OFF. →			2a. Intermittant malfunction of DC undervoltage sensor	
		b. MN BUS A(B) UNDERVOLT LIGHT-ON.	3		2b. DC Undervoltage sensor failure	
	3	MN BUS A(B) RESET-OFF.				
		a. MN BUS A(B) UNDERVOLT LIGHT-OFF.	4	Loss of MN BUS A(B) C/W under-volt indication.		
	4	Normally maintain DC indicator in MN BUS A(B) position.				
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
2. DC VOLTS meter indicates pyro battery A(B) below 35 volts		(When pyro batteries are required)		(Normal pyro open circuit voltage = 36.9 - 37.2 vdc)	Loss of pyro Bat A(B)
	1.	PYRO A(B) SEQ A(B) CIRCUIT breaker - <u>OPEN</u> .	2	(1) Malfunction detected at EPS verification prior to SIVB sep. or G&N and/or SCS deorbit entry.	Loss of pyro Bat A(B) Internal: - Open circuit - Short circuit - Partial short
	2.	MAIN A(B) BAT BUS A(B) C/B - <u>OPEN</u> .	3	(2) Prepares circuit for BAT BUS A(B) isolation from MAIN BUS A(B) and reduced loading on BAT A(B) to assure voltage is maintained high enough to operate pyros.	
	3.	MAIN A(B) BAT C C/B - <u>CLOSED</u> .	4	(3) Prepares circuit for application of BAT C to MAIN BUS A(B)	
	4.	MAIN B(A) BAT C C/B - <u>OPEN</u> .	5	(4) Prepares circuit so that BAT C cannot be applied to MAIN BUS B(A). This will assure equal depletion of batteries B(A) & C	
	5.	PYRO A(B), BAT A(B) to PYRO BUS TIE C/B - <u>CLOSE</u> .	6	(5) Entry BAT A(B) powering PYRO BUS A(B)	
	6.	Monitor: DC VOLTS METER PYRO BAT A(B)	→	(6) Voltage reading of >34V should be indicated since pyro BUS A(B) power is now furnished by entry BAT A(B) with PYRO BAT A(B) isolated from PYRO BUS A(B).	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
<p>✓ 1. BATTERY CHGR OUTPUT CURRENT drops to ZERO & circuit breakers BATTERY CHARGER MN A & B - OPEN.</p>	1.	(Attempt) Reset Breakers: (a) Breakers reset, (b) Breakers OPEN .	→ 2	(1b) Loss of Battery Charging capability.	(1a) Transient battery charger overload (1b) Distribution diode short to ground or Batt Chrgr internal short.
	2.	BATTERY CHARGER-OFF	→	(2) ΔV maneuver preparations should be adjusted to ensure F/C SKIN TEMP of approximately 430° F during gimbaling, (to conserve battery energy). Powering down unnecessary loads just prior to burn is an option. Note maximum loading of F/C's during preparations (4 to 6 hours) is necessary to achieve above SKIN TEMP.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
4. BATT CHGR out-put CURRENT ZERO (in all switch positions)	1.	BATTERY CHARGER-OFF,	→	(1) Loss of Battery Charging Capability. Δ V maneuver preparations should be adjusted to ensure F/C SKIN TEMP of 430° F during gimbaling, (to conserve battery energy). Powering down unnecessary loads just prior to burn is an option. Note maximum loading of F/C's during preparations (4 to 5 hours) is necessary to achieve the above SKIN TEMP.	(1) Control relay K4 failure.

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
5. DC INDICATORS- BAT BUS A(B), DC VOLTS <u>27-30</u> & DC AMPS <u>>ZERO</u> WITH BUS SWS OFF				DC VOLTS should read <u>34-38</u> & DC AMPS should read <u>ZERO</u> .	
	1	MAIN A(B) BAT BUS A(B) CB <u>-OPEN</u> , a. DC VOLTS meter - <u>34-38</u> & DC AMPS meter - ZERO.	2	1a. Indicates Bat A(B) was still connected to Main Bus A(B) via MAIN BUS TIE BAT A & C C(BAT B & C) motor switch closed contact; circuit breaker in series with contact has dis- connected Bat (A(B) from Main Bus A(B).	(1a) MAIN BUS TIE BAT A & C (BAT B & C motor switch.
	2	DC INDICATORS - BAT C. a. DC VOLTS meter - <u>34-38</u> & DC AMPS meter - ZERO.	3	2a. Indicates Bat C not con- nected to either Main Bus A or B. This is a normal situa- tion since MAIN A BAT C & MAIN B BAT C CB's are normally open.	
	3	MAIN B(A) BAT C CB - <u>CLOSED</u> , a. DC VOLTS meter - <u>27-30</u> DC AMPS meter - greater than ZERO,	4	3a. Indicates Bat C is con- nected to Main Bus B(A) via MAIN BUS TIE BAT A & C (BAT B & C) motor switch closed contact; circuit breaker in series with contact has connected Bat C to Main Bus B(A). This step verifies Bat C functional.	
	4	MAIN B(A) BAT C CB - <u>OPEN</u> . (see page 35)	→	4. This places circuit breaker back in standard configuration.	

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
<p><u>Warning:</u> Future connect or disconnect of Bat A(B) to Main Bus A(B) & Bat C to Main Bus B(A) will have to be accomplished with MAIN A(B) BAT BUS A(B) & MAIN B(A) BAT C circuit breakers. Batteries A(B) & C cannot be recharged since the failed motor switch now has an open pair auxiliary contacts which prevent the charger from feeding Batteries A(B) & C.</p>					
<div style="display: flex; justify-content: space-between;"> <div style="width: 20%;"> <p>PREPARED BY: <i>Jim Baggett</i></p> <p><i>R. E. Kaly</i></p> </div> <div style="width: 20%;"> <p>FLIGHT CREW SUPPORT DIVISION</p> <p>DATE: Jan 27, 1967</p> </div> <div style="width: 20%;"> <p>EPS POWER DISTRIBUTION</p> </div> <div style="width: 40%;"> <p>APOLLO OPERATIONS HANDBOOK</p> <p>S/C 012 REV FINAL</p> <p>SECTION 9.1.4.3 PAGE 35</p> </div> </div>					

SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
<p>6. Battery Charger Voltage 40 vdc and Current 0 when charging Battery A(B,C)</p> <p><i>included in Alt II proc 3</i></p>				<p>Voltage should be >32 but <40 and current should be $>.4$ but <2.8 amps</p>	
	1	<p>Cycle BATTERY CHARGER SW-A,B, and C, and read DC VOLTS AND DC AMPS.</p> <p>a. DC VOLTS 40 vdc and DC AMPS 0 for A, B, and C,</p> <p>b. DC VOLTS 40 vdc and DC AMPS 0 Battery A,(B,C) only.</p> <p>c. DC VOLTS 40 vdc and DC AMPS 0 for A and C(B and C).</p>	<p>→</p> <p>→</p> <p>2</p>	<p>Assumes DC INDICATOR SW-BAT CHARGER.</p> <p>(1a.) Capability to charge Batteries and to check Battery charge lost.</p> <p>(1b.) Capability to charge battery A(B,C) and the check Battery A(B,C) charge lost.</p> <p>1c. Capability to change Batteries A and C(B and C) and to check Battery A and C (B and C) charge lost.</p>	<p>(1a.) Battery charger circuit open circuited</p> <p>1b. Charging circuit for Battery A(B,C) is open circuited.</p> <p>(1c.) Motor switch failed.</p>
	2	<p>MAIN A-BAT BUS A (MAIN B BAT BUS B) CB - OPEN.</p>	→	<p>2. CB must be used to isolate Battery A(B) from Main DC bus</p>	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
<p>INV 1 (2 or 3) TEMP <u>2</u> 190°F</p> <p>(MSFN Monitoring Capability)</p>	1	Set dual inverter configuration Ref EPS Norm. Proc No. _____.	2	C/W Trip valves: Inv 1, 2, 3 Temp. = 241±30°F	
	2	Balance and hold loads steady for 10 minutes.	3	The thermal response time of Inverter heating from 155°F to 190°F is sufficient to ensure MSFN monitoring with the exception of rapid, total loss of coldplate cooling. Normal Inverter thermal response will be from ambient to 125°F in approximately 30 to 40 minutes. Setting a second inverter to load and its temperature increases to 125°F within 10 to 30 minutes is indicative of coldplate problems (assuming proper inverter voltage and frequency).	
	3	Record Mission Elapsed Time Approximate history of AC Load Switching during the 5 minutes prior to symptom activation. ECS RADIATOR OUTLET TEMP.			
		(a) ECS RADIATOR OUTLET TEMP above 97°F (Ref. ECS SYMPTOM NO. _____)	→	(3a) The Inverters may be ro- tated as required to keep temp. below the C/W trip values. If the above C/W trip valves are reached the inverter(s) will	(3a) ECS Glycol Pump failure or extensive leakage.
		(b) ECS RADIATOR OUTLET TEMP Below 97°F.	4	fail within 30 minutes if temperature cannot be decreased.	(3b) Rapid AC Load Switching or inter- nal inverter failure.
	4	At end of 10 minutes specified in step 2 - Communication loads and Battery charger to normal inverter's bus	5		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
	5	MSFN INV 1, (2 or 3) Temp monitoring indicates (a) Inv 1(2 or 3) Temp $\leq 160^{\circ}\text{F}$ (b) Inv 1(2 or 3) Temp does not show gradual decreasing trend at end of 2 hours.	6 7	(5) Note there is no ΔP measurement across the Inverter Coldplate. If internal inverter failure were the cause then AC Volts & Freq would indicate abnormal before inverter could reach these temperatures. (6) Temperature of both Inverters should stabilize between 125°F & 155°F . There is a high probability of failure of overheated inverter but it may be used with dual inverter configuration and with a minimum of load switching.	(5b) Coolant flow restriction within single Inverters Coldplate.
	6	When MSFN indicates inverter temperature is approximately 160°F or less, <u>balance loads & hold steady for at least 1 hour</u> (a) Faulty inverter temperature stabilizes at a nearly equal temperature of normal inverter. (b) Faulty inverter temperature shows increasing trend.	→ →	(6a) Continue mission schedule using affected inverter as required for dual inverter configuration. (6b) Note the original symptom does NOT presume faulty voltage or frequency. This combination of symptoms is remote. MSFN-Crew option to shut-down and isolate faulty inverter depending on sensitivity of thermal control.	(6a) Rapid AC Load Switching at high power levels. (6b) Internal inverter problem dependent on load demand.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
	7	Shutdown & isolate faulty INVERTER.	→	Establish single or dual inverter configuration as required by mission schedule.	

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
8. AC BUS FAIL LIGHT ILLUMINATED	1	AC BUS 1 (2) RESET - <u>RESET</u> (Center)		(IF AC BUS OVERLOAD LIGHT ILLUMINATES AT ANY TIME DURING THESE PROCEDURES, REVERT TO PROCEDURES UNDER AC SYMPTOM 3.)	
		(a) Symptoms extinguish	2		
		(b) Symptoms re-illuminate	3		
	2	Survey for OPEN C/B			
		(a) C/B Open	→		(2a) Load short.
		(b) C/B NOT OPEN	→		(2b) Transient overload.
	3	AC Indicators Bus 1 (&/or 2) - Φ A, B, C	4		
	4	MONITOR: AC VOLTS AC FREQ			
		(a) AC VOLTS & AC FREQ Normal.	→	(4a) Option to set AC BUS RE- SET - OFF. This will permit light to be extinguished but also removes capability of subsequent C/W indication and automatic disconnect of In- verter by Over & Under-Voltage Sensing Unit.	
		(b) AC VOLTS < 90 Vac AC FREQ < 380 cps	5		
		(c) AC VOLTS < 95 ±3 AC FREQ = 400 cps	6		(4a) Inverter Under- voltage.
	5	AC INDICATORS BUS 1 (or 2) - Φ A. AC BUS 1 (or 2) RESET - RESET. MONITOR AC VOLTS.		5. Monitor AC Volts with "Bus at Reset". CAUTION ONLY HOLD RESET SW IN RESET POSITION MOMENTARILY SINCE HIGH VOLTAGE MAY BE APPLIED TO AC LOADS.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
		(a) AC VOLTS >128 Vac	6		(5a) Inverter Over-voltage.
	6	Determine Inverter Configuration			
		a. Single Inverter Conf.	→	Ref EPS Norm. Proced. No. _____	
		b. Dual Inverter Conf.	→	Ref EPS Norm. Proced. No. _____	
		c. Inverter 3 Required.	→	Ref EPS Norm. Proced. No. _____	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
9. AC BUS 1(2) FAIL LIGHT Illuminated				Overload light could take 4 to 20 seconds to illuminate after illumination of AC Bus Fail Light.	
AC BUS 1 (2) OVERLOAD light illuminated	1.	Monitor: - AC volts Frequency.		(1) Frequency should be 400 ± 2 cps with CTE; 400 ± 7 cps with internal oscillator. AC Volts should be $115 \pm 1, -1.5$ v.	
	a.	AC volts & frequency normal.	21		(1a) Sensing unit failure.
	b.	AC volts & frequency abnormal.	2		
	2.	AC BUS 1 (2) RESET - <u>RESET</u> (center).			
	a.	Symptoms extinguished.	→	(2a) Proceed with mission schedule.	(2a) Transient overload condition.
	b.	Reillumination of symptoms.	3	(2b) AC Bus 1 (2) FAIL light and AC Bus 1 (2) Overload light may or may not illuminate depending on magnitude and duration of overload on inverter.	
	3.	Survey AC Circuit breakers for OPEN breaker.			
	a.	Breaker OPEN.	19 →	(3a) <u>Most probable occurrence.</u>	(3a) AC Load failure.
	b.	C/B does not OPEN	4		
	4.	AC BUS 2 (1) Reset - Reset(center)	5	(4) Continue Bus Reset as required to extinguish lamp. There will be a time delay after each reset before re-illumination.	
	5.	Transfer and verify AC loads to normal bus.			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
		(a) AC BUS 2 (1) FAIL light - OFF.	6		
		(b) AC BUS 2 (1) FAIL light-ON.			(5b) AC load failure.
	6.	Monitor:		(6) Steps 6 through 9 verify normalcy of AC loads which cannot be transferred from one AC Bus to the other.	
		TANK QUANTITY - H ₂ - 1 & 2 O ₂ - 1 & 2	8	(6a) Gauge indication being normal will reveal normal quantity amplifier.	
		a. Quantities normal.			
		b. Quantity erroneous.	7	(6b) Quantity amplifier failure may give high, low or erratic reading on Quantity Gauge. In any case, the quantity balance data just prior to occurrence of symptom are reference points.	(6b) Quantity Amplifier.
	7.	OPEN C/B: CRYOGENIC SYSTEM QTY AMPLIFIER-1, 2 - AC 1 (2).	19		
	8.	ECS RADIATOR - 1 (2) A,B-OFF.	9		
	9.	OPEN circuit breakers CRYOGENIC FAN MOTORS-1 (2) AC 1 (2) - A, B, C. GAS ANAL - AC1	10	(9) Cryogenic fans inoperative does not present a critical situation. Quantity readout may have small error with fans OFF.	
	10.	AC BUS 1 (2) RESET - <u>RESET</u> (center)			
		(a) Symptoms Extinguish	16		
		(b) Symptoms reilluminate	11		
	11.	AC INVERTER 1(2)-MNA(B)-OFF	12	(11) AC BUS 1(2) lost for remainder of mission.	(10b) AC BUS SHORT
	12.	AC INVERTER 1(2)- AC BUS 1(2)-OFF	13		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
	13	AC BUS 1(2) RESET - <u>OFF</u>	14		
	14	TELCOM-NONESS - <u>OFF</u>	15		
	15	OPEN C/B's of faulty AC BUS	→	(15) Maintain faulty bus isolated.	
	16	CLOSE C/B GAS ANAL - AC1			
		(a) Symptoms Reilluminate	18		(16a) Gas Anal & C/B failure.
		(b) Symptoms remain extinguished	17		
	17	CLOSE C/B's CRYOGENIC FAN MOTORS 1(2) - AC1(2) A , B , C			
		(a) Symptoms Reilluminate	18		(17a) Cryogenic Fan motor & C/B failure
		(b) Symptoms remain extinguished	→		(17b) ECS RADIATORS VALVE CONTROL & C/B failure.
	18	Isolate faulty load	19	(18) If faulty load detected during load transfer (step isolate by opening respective C/B(s).	
	19	AC BUS 1(2) RESET - <u>RESET</u> (center)	20		
	20	Reconfigure AC loads to normal positions (if applicable)	→	(20) If faulty load detected in either step 16 or 17 then leave appropriate breaker open.	
	21	AC BUS 1(2) RESET - <u>OFF</u>	22		
	22	AC INDICATORS - BUS 1 (2) (affected bus)	→	(22) Mission schedule may be continued with use of Indicators to monitor AC BUS 1(2). The C/W capability & the automatic disconnect capability are lost with AC BUS RESET - OFF.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
10. AC BUS 1 & 2 FREQUENCY INDICATES <393 CPS OR >407 CPS SINGLE INVERTER OPERATION	1	PHASE LOCK SW - ON.		(1) Removes CTE signal to inverter. Inverter on internal oscillator.	
	2	Verify INV PHASE SYNC PWR CB'S - OPEN.			
	a.	Freq within 393 to 407 cps.	→	Inverter is driven off 400 CPS by out of tolerance CTE signal. Replace INVERTER 1(2) with INVERTER 2(1).	2a. CTE malfunction
	b.	Freq 393 CPS or 407 CPS	3		
	3	PHASE LOCK SW - OFF.	4		
	4	AC BUS 1 & 2 RESET - <u>OFF</u> .	5		
	5	AC INVERTER 2(1) - MAIN B(A) - <u>ON</u> .	6		
	6	AC INVERTER 1(2) - AC BUS 1 & 2 - <u>OFF</u> .	7		
	7	AC INVERTER 1(2) - MAIN BUS A(B) - <u>OFF</u> .	8		
	8	AC INVERTER 2(1) - AC BUS 1 & 2 - <u>ON</u> .	9		
	9	AC BUS 1 & 2 RESET - <u>ON</u> .	10		
10	a. FREQ - 400 CPS.	→		9a. Inverter 1(2) oscillator failure.	
b.	FREQ <393 CPS or >407 CPS.	11	Since second inverter indicates same symptoms, this is indicative of frequency meter failure. If voice communication available, verify telemetry readings with MSFN.	9b. Frequency meter failure.	
	11	MSFN to closely monitor frequency.			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
11. AC BUS 1(2) FAIL LIGHT illuminated AC BUS 1(2) Voltage <90v (Dual Inverter)	1	AC BUS 1(2) RESET - <u>RESET</u> (center), a. Symptoms OUT. b. Symptoms Light,	2		(1a.) Transient, (1b.) Inverter overvoltage.
	2	AC INVERTER 1(2) AC BUS 1(2) - <u>OFF</u> ,	3		
	3	AC INVERTER 1(2) MNA(B) - <u>OFF</u> ,	4		
	4	AC BUS 1(2) RESET - <u>OFF</u> ,	5		
	5	CB INV SYNC PWR (3) - <u>CLOSE</u> ,	6		
	6	PHASE LOCK - <u>ON</u> ,	7		
	7	AC INV 3 - MNA (B),	8		
	8	AC INV 3 AC BUS 1(2) - <u>ON</u> ,	9		
	9	AC BUS 1(2) RESET - RESET (Cntr),	10		
	10	Verify AC 1 & 2 Bus Voltages & Frequencies,	11		
	11	PHASE Lock - <u>OFF</u> ,	12		
	12	CB INV SYNC PWR (3) - <u>OPEN</u> ,			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
12 AC BUS 2(1) FAIL Light ON after AC INVERTER 2(1) is applied to AC BUS 2(1).	1	AC BUS 2(1) RESET - <u>RESET</u> (Cntr) several times consecutively.		Single to dual switchover assumed from Inverter 1(2) on AC BUS 1 & 2 to Inverter 1 on AC BUS 1 and Inverter 2 on AC BUS 2.	
	a.	AC BUS 2(1) FAIL light OUT.		(1a.) This failure is likely be occur again.	(1a.) Transient condition.
	b.	AC BUS 2 (1) FAIL LIGHT ON;			
		1. AC BUS 2(1) volts normal.	13		(1b.1) Sensing Unit
		2. AC BUS 2(1) volts zero.	2		(1b.2) Motor Switch
	2	AC INVERTER MNB(A) - <u>OFF</u> .	3		
	3	AC INVERTER AC BUS 2(1) - <u>OFF</u> .	4		
	4	AC BUS 2(1) RESET - <u>OFF</u> .	5		
	5	CB INV SYNC PWR (3) - <u>CLOSE</u> .	6		
	6	PHASE LOCK - <u>ON</u> .	7		
	7	AC INVERTER 3 - MNB(A).	8		
	8	AC INVERTER 3 AC BUS 2(1) - <u>ON</u> .	9		
	9	AC BUS 2(1) RESET - <u>RESET</u> (Cntr).	10	10. Inverter 3 is now powering AC BUS 2(1).	
	10	Verify AC BUS 1 & 2 voltages and Frequencies.	11		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
12. (Cont)	11	PHASE LOCK - <u>OFF</u> .	12		
	12	CB INV SYNC PWR (3) - <u>OPEN</u> .			
	13	AC BUS 2(1) RESET - <u>OFF</u> .	14		
	14	AC INDICATORS - AC BUS 2(1).		(14.) The C/W indication and automatic disconnect capability is not functional with AC BUS 2(1) RESET - OFF	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
13. MN BUS A & B UNDervOLT light illuminates	1	AC INVERTER 1(2) - MNA(B) - OFF	2	1. Removal of shorted inverter	INVERTER DC INPUT shorted.
AC BUS 1 Fail light	2	AC INVERTER 2(1) - MNB(A) - ON	3	initially will prevent DC BUS	
illuminates	3	AC BUS 1 - RESET - OFF	4	problems. It will take 3 to	
AC BUS 2 Fail light	4	AC INVERTER 1(2) - AC BUS 1-OFF	5	9 seconds for 70 amp power	
illuminates	5	AC BUS 2 - RESET - OFF	6	breaker to an inverter to open.	
AC BUS 2 Fail light	6	AC INVERTER 1(2) - AC BUS 2-OFF	7	MN BUS B(A) volts will recover	
illuminates	7	AC INVERTER 2(1) - AC BUS 1 - ON	8	in APPROX 1 SECOND after short.	
F/C BUS disconnect	8	AC INVERTER 2(1) - AC BUS 2 - ON	9	The following F/C to BUS	
light illuminates	9	AC BUS 1 - RESET - RESET - (Center)	10	configuration is assumed:	
	10	AC BUS 2 - RESET - RESET - (Center)	11	F/C 1 - MNA - ON	
SINGLE INVERTER CONFIGURATION	11	F/C 2 - MAIN B(A) - ON	12	F/C 1 - MNB - OFF	
	12	MAIN BUS A(B) RESET - <u>RESET</u>	13	F/C 2 - MNA - ON	
CAUTION: Note that AC BUS OVERLOAD light is not illu- minated. Do not use this procedure if the overload light is illuminated	13	Verify normal systems operation. →		F/C 2 - MNB - ON	
				F/C 3 - MNA - OFF	
				F/C 3 - MNB - ON	

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
14. MN BUS A & B UNDERVOLT light illuminates AC BUS 1(2) FAIL light illuminates F/C BUS DISCONNECT Light ON DUAL INVERTER CONFIGURATION Caution: Note that AC BUS OVERLOAD Light is not illuminated in this case.		CAUTION: Total AC POWER LOSS may occur in less than 5 seconds.			
	1	AC BUS 1(2) RESET Sw - <u>RESET</u> (Centr).	2	This procedure assumes a two inverter configuration at time of failure and the following F/C to Bus configuration: F/C 1 - MNA - ON F/C 1 - MNB - OFF F/C 2 - MNA - ON F/C 2 - MNB - ON F/C 3 - MNA - OFF F/C 3 - MNB - ON	
	2	AC INVERTER 1(2) - MAIN A(B) - <u>OFF</u> .	3		
	3	AC INVERTER 1(2) - AC BUS 1(2) - <u>OFF</u> .	4		
	4	AC INVERTER 3 - MAIN A(B) - <u>ON</u> .	5		
	5	AC BUS 1(2) - <u>RESET</u> - <u>OFF</u> .	6		
	6	AC INVERTER 3 - AC BUS 1(2) - <u>ON</u> .	7		
	7	AC BUS 1(2) RESET Sw - <u>RESET</u> (Center).	8		
	8	F/C 2 - MAIN B(A) - <u>ON</u> .	9		
	9	MAIN BUS A & B RESET Sw - <u>RESET</u>	10		
	10	Verify normal systems operation	11		
11	If appropriate, MAIN BUS TIE - BAT A & C - <u>OFF</u> - BAT B & C - <u>OFF</u>				

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PROCEDURES ENTRY SHEET

SECTION 9.1.5

TELECOMMUNICATIONS MALFUNCTION PROCEDURES

SYMPTOMS	SYMPTOM NUMBER	STEP	PAGE
ONE CREWMAN HAS DEGRADED OR NO INTERCOM CAPABILITY	1	1	2
ALL CREWMEN HAVE DEGRADED OR NO INTERCOM CAPABILITY	2	1	4
CONTINUOUS BACKGROUND NOISE IN ONE OR MORE CREWMENS' HEADSET	3	1	4
ONE CREWMAN LOSS OF EITHER OF THE FOLLOWING TELECOMMUNICATIONS: VHF-AM OR S- BAND	4	1	6
ALL CREWMEN LOSE VHF-AM OPERATION (IN-FLIGHT)	5	1	7
ALL CREWMEN LOSE USBE VOICE OPERATION (MODES A,B1,B2,OR C)	6	1	8
ALL CREWMEN LOSE USBE VOICE OPERATION (MODES D OR E)	7	1	10
MSFN REPORTS VHF-FM TELEMETRY POOR OR LOST	8	1	11
UHF UPDATA AND REAL-TIME COMMANDS NOT RECEIVED BY S/C	9	1	12
S-BAND UPDATA AND REAL-TIME COMMANDS NOT RECEIVED BY S/C (S-BAND VOICE NORMAL)	10	1	14
MSFN REPORTS PARTIAL OR COMPLETE LOSS OF C-BAND TRACKING	11	1	14
MSFN REPORTS TV RECEPTION LOST (OR POOR) S-BAND VOICE & DATA NORMAL)	12	1	15.
NO VOICE RECORD FLAG INDICATION WHEN ATTEMPTING VOICE RECORDING (INTERCOM NORMAL)	13	1	15
VHF-AM POOR OR LOST AFTER SPLASHDOWN	14	1	17
HF VOICE POOR OR LOST AFTER SPLASHDOWN	15	1	18
MSFN REPORTS LOSS OF VHF-FM DATA AND C-BAND RANGING (VHF-AM AND S-BAND NORMAL)	16	1	19
MSFN REPORTS VHF-FM AND S-BAND PLAYBACK TLM POOR OR LOST	16	1	19

SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. One crewman has degraded or no intercom capability.	1	Audio Center (A/C) POWER sw - Alternate position - (<u>VOX</u> or <u>PTT</u>)			
		(a) Intercom normal - - After switching to PTT - After switching to VOX	2	(1a) Crewman limited to PTT mode of keying. Loss of "hot mike" capability.	(1a) VOX circuit failure.
		(b) No intercom	3		
	2	Key intercom using translational controller PTT button (without speaking.)		(2) This step can be accomplished only by the CP and SP. P should go directly to step 6.	
		(a) No background noise	7	(2a) Crewman limited to VOX mode of keying. Loss of VHF-AM and S-Band voice capability.	(2a) A/C PTT circuit failure.
		(b) Background noise present	6		(2b) Cobra cable PTT circuit failure.
	3	VHF-AM sw - (A/C) - <u>T/R</u> , verify VHF sidetone.		(3) VHF sidetone can be verified regardless of VHF-AM (MDC-20) switch position.	
		(a) Sidetone normal	4		(3a) A/C intercom circuit failure.
		(b) No sidetone	5		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE	
1. (Cont)	4	(a) Use VHF sidetone for intercom or,	→	(4a) All A/C VHF switches must be in T/R position.		
		(b) Cobra cable electrical connector - <u>EMER</u>	→	(4b) Two crewmen must share one A/C. (4a or b) Crewman may use whichever is more desirable.		
	5	Connect and utilize alternate headset		(5) Requires shirtsleeve environment.		
		(a) Intercom normal	→		(5a) Headset failure	
	6	(b) No intercom	6			
		Remove diode and filter assembly from cobra cable.				
	6	(a) Intercom normal	→	(6a) Removal of diode and filter assembly will result in increase background noise on intercom and down link voice.	(6a) Diode and filter assembly failure.	
		(b) Intercom not normal	7			
	7	Connect and utilize spare cobra cable				
		(a) Intercom normal	→		(7a) Cobra cable failure	
	8	(b) No intercom	8			
		Cobra cable electrical connector - <u>EMER</u>	→	(8) Two crewmen must share one audio center.	(8) Audio center module failure	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
2. All crewmen have degraded or no intercom capability.	1	INTERCOM sw (ALL) - <u>OFF</u>			
	2	VHF-AM sw (A/C) (ALL) - <u>T/R</u> Verify sidetone. (a) Normal (b) No sidetone	3 →	(2b) Refer to EPS malfunction symptom No. _____	(2a) Intercom bus shorted to ground (2b) Loss of Flight and Post Landing bus
	3	Use VHF sidetone for intercommunications.		(3) Sidetone may be used regardless of VHF-AM sw (MDC-20) position. The use of VOX keying will provide a "hot mike" sidetone intercom and PTT VHF-AM keying.	
3. Continuous background noise in one or more crewmen's headset.	1	Verify: S-BAND sw (MDC-23) - <u>MUTE</u> (up)	2	(1) USBE receiver unlock results in similar symptom.	
	2	Individually cycle all PTT buttons (3 cobra cable and 2 hand controller buttons) in sequence. (a) Noise removed (b) Noise continues	3 → 4 →		(2a) Sticking PTT button
	3	If failure was on cobra cable use spare cobra cable. If failure was on Hand Controller discontinue use of that PTT button.			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
3. (Cont)	4	POWER sw (A/C) (All) - <u>PTT</u> (one at a time)			
		(a) Noise removed	→	(4a) Keying limited to PTT mode on failed A/C.	(4a) One A/C VOX circuitry failure (continuous key)
		(b) Noise continues	5		
	5	All crewmen - all A/C T/R switches (except S-BAND) - <u>RCV</u>			
		(a) Single crewman retains noise	6		(5a) Ground in crewman's controller or cobra cable <u>PTT</u> circuitry; ground in A/C keying line
		(b) All crewmen lose noise	9		(5b) Ground on HF or VHF-AM keying line
	6	All A/C switches to original configuration (except failed A/C)	7		
	7	Failed A/C - Disconnect cobra cable and connect spare cobra cable.			
		(a) Noise removed	→		(7a) Cobra cable <u>PTT</u> circuit failure
		(b) Noise not removed	8	(7b) Hand controller failure possible for CP & SP only.	(7b) Hand controller <u>PTT</u> failure, or audio center keying circuit failure
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
3. (Cont)	8	Cobra cable electrical connector - <u>EMER</u>	→	(8) Two crewmen must share one A/C module.	
	9	Any crewman - A/C HF sw - <u>T/R</u> (a) Noise returns	→	(9a) HF usable only in beacon mode. Receive capability lost. Voice recorder will run continuously until end of tape. <u>CAUTION</u> Disconnecting tape recorder connector under power may result in dangerous arcing.	(9a) Ground on HF keying line
	10	(b) No noise Any crewman - A/C VHF-AM sw - <u>T/R</u> (a) Noise returns	10 →	(10a) VHF-AM usable only in duplex mode. (Notify MSFN). RF radiation is present any time that VHF-AM sw (MDC-20) is in <u>T/R</u> position.	(10a) Ground on VHF-AM keying line.
4. One crewman loss of either of the following communications: VHF-AM or S-Band	1	POWER sw - (A/C) - <u>PTT</u>	2	(1) VHF-AM keyed in PTT mode only.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
4. (Cont)	2	Verify normal intercom.			
		(a) Intercom normal	4		
		(b) No intercom	3		
	3	Follow Telecom procedure, "One crewman has degraded or no intercom" (Symptom No. 1).			
	4	Cobra cable electrical connector - <u>EMER</u>	→	(4) Two crewmen must share one A/C.	(4) A/C module failure
5. All crewmen lose VHF-AM operation (in-flight).	1	Energize USBE in mode A.	2	(1) Backup mode for VHF-AM voice	
	2	VHF-AM RCVR sw - <u>1</u>			
		(a) Signal regained	→	(2a) VHF-AM limited to the simplex mode.	(2a) VHF-AM front-end No. 2 failure
		(b) Signal not regained	3		
	3	VHF-AM RCVR sw - <u>2</u>			
		(a) Signal regained	→	(3a) When switching to No. 2 receiver, ground must be so informed. (MSFN requires a minimum of 5 min. to reconfigure.) MSFN will detect a continuous carrier if VHF keying relay has failed.	(3a) VHF-AM receiver No. 1 failure or VHF-AM keying relay failure (closed)
		(b) Signal not regained	4		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
5. (Cont)	4	VHF ANTENNA sw - Alternate position - (<u>UPPER</u> or <u>LOWER</u>)	5		
	5	Re-orient S/C for optimum antenna coverage, if necessary. (a) Signal regained	→	(5a) VHF voice, VHF-FM, and UHF data limited to one antenna & restricted S/C orientation.	(5a) Upper or lower VHF SCIN antenna failure
		(b) Signal not regained	→ 6	(5b) Voice limited to S-Band.	(5b) VHF-AM system failure
	6	VHF-AM sw (MDC-20) - <u>OFF</u>			
6. All crewmen lose USBE voice operation (modes A, B1, B2, or C)	1	Verify that A/C S-BAND sw (MDC-23) is <u>not</u> in MUTE (up) position.	2	(1) <u>MUTE</u> (up) position disables S-Band reception.	
	2	Observe S-BAND ANI meter for phase lock. (a) << half scale (b) > half scale	6 3	(2) << half-scale indicates loss or near loss of lock. > half-scale indicates receiver phase lock.	
	3	S-BAND POWER AMPL sw - <u>LOW</u>	4		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
6. (Cont)	4	S-BAND sw - <u>XPONDER PWR AMPL</u>			
		(a) Voice regained	→	(4a) S-Band transmitter limited to operation with power amplifier only.	(4a) Power amplifier by-pass mode failure
		(b) Voice not regained	5		
	5	S-BAND VOICE/TV sw - <u>TV</u>			
		(a) Voice regained	→	(5a) S-Band limited to FM mode. S-Band ranging lost.	(5a) FM mode failure
		(b) Voice not regained	9		
	6	S-BAND ANTENNA sw - Alternate position (<u>UPPER</u> or <u>LOWER</u>)	7		
	7	Re-orient S/C for optimum antenna coverage, if necessary.	8		
	8	Observe S-BAND ANT meter for USBE phase lock.			
		(a) << half scale	10		
		(b) > half scale	→	(8b) S-Band operation limited to one antenna & restricted S/C orientation.	(8b) Upper or lower 2 KMC SCIN antenna failure
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
6. (Cont)	9	Verify CTE operation with MSFN via VHF-AM.			
		(a) CTE normal	10		
		(b) CTE not normal	→	(9b) TIM operation continues, via S-Band or VHF-FM, but may be degraded. Voice limited to VHF-AM.	(9b) CTE failure
	10	Manually change to alternate transponder unit.	11	(10) Refer to abbreviated check-list for transponder turn-around procedure.	
	11	Configure S-Band switches to original mode.			
		(a) Voice regained	→		(11a) USBE primary transponder failure
		(b) Voice not regained	→	(11b) Voice limited to VHF-AM. TV, TIM, and ranging still available on S-Band.	(11b) PMP (voice circuit) failure
7. All crewmen lose USBE voice operation (modes D or E)	1	Verify that A/C S-BAND sw (MDC-23) is <u>not</u> in <u>MUTE</u> (up) position.	2	(1) <u>MUTE</u> (up) position disables S-Band reception.	
	2	S-BAND PWR AMPL sw - <u>HIGH</u>			
		(a) Voice regained	→	(2a) Power amplifier operation limited to high mode.	(2a) Partial power amplifier failure (Low mode)
		(b) Voice not regained	3		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE		
7. (Cont)	3	Configure S-Band switches for mode A. (a) Voice regained	→	(3a) Voice and R/T TIM limited to USBE FM mode or VHF. Playback TIM limited to VHF-FM. Loss of TV.	(3a) FM mode failure or total power amplifier failure.		
	4	(b) Voice not regained 4 Follow Telecom procedure, "All crewmen lose USBE voice operation, modes A, B1, B2, or C" (Symptom No. 6).	4				
8. MSFN reports VHF-FM telemetry poor or lost.	1	Energize USBE in mode A. (Notify MSFN).	2	(1) Enables R/T PCM via S-Band.			
	2	Verify normal VHF-AM voice operation. (a) Voice normal	5	(2) All VHF & UHF equipment share same antenna system (VHF SCIN antennas). (2a) Rules out antenna failure.			
		(b) No voice	3				
	3	VHF ANTENNA sw - Alternate position (<u>UPPER</u> or <u>LOWER</u>)	4				
	4	Re-orient S/C for optimum antenna coverage, if necessary. (a) VHF-FM TIM regained	→	(4a) VHF & UHF operation limited to one antenna & restricted S/C orientation.			
		(b) VHF-FM TIM not regained	5				
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
8. (Cont)	5	TIM INPUTS PCM sw - Alternate position (<u>HIGH</u> or <u>LOW</u>)			
		(a) VHF-FM TIM regained	→	(5a) Limits telemetry to one bit rate mode. If limited to low bit rate, many G&N TIM parameters are lost. If limited to high bit rate, long data dumps are required.	(5a) PCM TLM mode failure (High or Low)
		(b) VHF-FM TIM not regained	6		
	6	Check status of S-Band telemetry with MSFN			
		(a) Normal	→ 7	(6a) USBE must be used for all down data.	(6a) VHF-FM system failure
		(b) Not normal	→	(6b) MSFN may elect to use VHF-FM or S-Band telemetry if some data is salvageable.	(6b) PCM telemetry equipment failure or PMP (TIM circuit) failure
	7	VHF-FM sw - <u>OFF</u>			
9. UHF Updata and Real-time commands not received by S/C	1	Energize USBE in mode A.	2	(1) Enables updata backup mode.	
	2	Verify normal VHF-AM voice operation.		(2) All VHF & UHF equipment share same antenna system (VHF SCIN antennas).	
		(a) Normal	5	(2a) Rules out antenna failure.	
		(b) Not normal	3		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
9. (Cont)	3	VHF ANTENNA sw - Alternate position (<u>UPPER</u> or <u>LOWER</u>)	4		
	4	Re-orient S/C for optimum antenna coverage, if necessary			
		(a) Voice and updata regained	→	(4a) VHF & UHF operation limited to one antenna & restricted S/C orientation.	(4a) Upper or lower VHF SCIN antenna failure
		(b) Updata not regained (Voice normal)	5		
	5	UPDATA sw - <u>S-BAND</u>	6		
	6	Request MSFN to retransmit update.	7		
	7	Verify S-Band updata normal.			
		(a) Normal	→	(7a) Updata limited to S-Band only. Some stations not equipped for S-Band updata.	(7a) UHF receiver failure
		(b) Not normal	8		
	8	Repeat procedure over another ground station			
		(a) Normal	→		
		(b) Not normal	9	(8b) All updata capability lost. Voice updating required.	(8b) UDL equipment failure
	9	UPDATA sw - <u>OFF</u>			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
10. S-Band Updata and real-time commands not received by S/C. (S-Band voice normal).	1	UPDATA sw - <u>UHF</u>	2	(1) Coordinate with MSFN.	
	2	Verify UHF updata normal. (a) Normal	→	(2a) Updata limited to UHF.	(2a) 70KC updata demodulator failure
		(b) Not normal	3	→	
	3	Repeat procedure over another ground station. (a) Normal	→		
		(b) Not normal	4	(3b) All updata capability lost. Voice updating required.	(3b) UDL equipment failure
	4	UPDATA sw - <u>OFF</u>			
11. MSFN reports partial or complete loss of C-Band tracking.	1	Energize USBE in mode B1. (Notify MSFN).	2	(1) Enables backup ranging mode.	
	2	C-BAND sw - Alternate position - (1 <u>PULSE</u> or 2 <u>PULSE</u>) (a) C-Band tracking regained	→	(2) Coordinate with MSFN. Some stations are not equipped with 2 pulse mode capability.	(2a) 1 or 2 pulse mode failure
		(b) Not regained	3		
	3	Orient S/C to illuminate a different C-Band antenna. (a) C-Band tracking regained	→	(3) Coordinate with MSFN. (3a) Partial S/C attitude constraint due to loss of one antenna/receiver.	(3a) One of the four C-Band antennas or receivers failed
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
11. (Cont)		(b) Not regained	4 →	(3b) Ranging limited to S-Band and "skin track."	(3b) C-Band transponder failure
	4	C-BAND sw - <u>OFF</u>			
12. MSFN reports TV reception lost (or poor) (S-Band voice & data normal).	1	S-BAND PWR AMPL sw - Alternate position (<u>HIGH</u> or <u>LOW</u>)			
		(a) TV regained	→	(1a) Power amplifier operation limited to one mode.	(1a) Partial power amplifier failure (High or Low)
		(b) TV not regained	2		
	2	Connect TV cable to No. 1 TV receptacle.			
		(a) TV regained	→	(2a) Discontinue use of failed receptacle.	(2a) TV cabling or receptacle failure
		(b) TV not regained	3 →	(2b) Loss of TV capability	(2b) TV system failure or total power amplifier failure
	3	S-BAND-VOICE-TV sw - <u>OFF</u>			
13. No VOICE RECORD flag indication when attempting voice recording (intercom normal).				NOTE Absence of audio on track 1 (in excess of 4 seconds) will cause flag drop-out. If portions of track 1 were recorded in a PTT mode rather than a VOX mode, erratic or intermittent flag indications may appear on all other tracks.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
13. (Cont)	1	Verify instruments RCDR NON ESS C/B - <u>CLOSED</u>	2	(1) C/B powers flag mechanism.	
	2	If recorder not in use has tape available, transfer connector to that recorder.			
		(a) Flag indicates properly	→	(2a) Any recording time remaining on failed recorder is lost.	(2a) Failure of one voice recorder or recorder end of tape
		(b) No flag indication	3		
	3	Place hand on recorder. Push PTT button and note vibration from drive motor.			
		(a) Vibration	→ 4		(3a) Flag indicator failure or drive belt failure
		(b) No vibration	→ 5	(3b) Voice recording capability lost.	(3b) Voice recorder cable or connector failure
	4	Continue using recorder and check periodically for end of tape.		(4) Flag indicator failure is assumed (providing first recorder was not out of tape).	
	5	All A/C HF sw - <u>OFF</u>		(5) Switches may be energized post landing for HF operation.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE	
14. VHF-AM poor or lost after splash-down.	1	Verify VHF ANTENNA sw - <u>RECOVERY</u>	2			
	2	VHF-AM RCVR sw - Alternate position (<u>1</u> or <u>2</u>)		(2) Recovery forces must be informed via HF of change to duplex.		
		(a) Signal regained	→	(2a) VHF-AM limited to one mode (Simplex or duplex).	(2a) One receiver front-end inoperative.	
		(b) Signal not regained	3			
	3	VHF-AM RCVR sw - <u>1</u>	4	(3) Notify recovery forces of change to simplex mode via HF.		
	4	Coax connectors (MDC-9) - Reverse connectors.				
		(a) Signal regained	→	(4a) VHF Recovery beacon & VHF-AM must share antenna No. 1 (white) & cannot be used simultaneously.	(4a) VHF Recovery antenna No. 2 (black) failure	
		(b) Signal not regained	5	(4b) Recovery communications systems limited to VHF beacon & HF transceiver.	(4b) VHF-AM transmitter/receiver failure	
	5	If VHF-AM is unusable, VHF-AM sw (MDC-20) - <u>OFF</u>	6			
	6	Restore coax connectors to original configuration.		(6) S/C VHF recovery antenna No. 2 (black) available for use with survival transceiver, if desired.		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
15. HF voice poor or lost after splashdown.	1	Verify POSTLANDING ANTENNA - A & B sw - <u>DEPLOY</u>	2	NOTE HF propagation is relatively unpredictable. Weak signals may be a result of adverse propagation phenomena rather than equipment failure.	
	2	Verify visually HF antenna fully deployed.			
		(a) Fully deployed	3	(2a) Fully deployed HF antenna is approximately 14 feet in length.	
		(b) Not fully deployed	6	(2b) Continuous operation of transmitter in excess of 5 minutes results in probable transmitter damage. Avoid BCN mode.	(2b) HF antenna failure
	3	RECOVERY - HF sw - Alternate position (<u>SSB</u> or <u>AM</u>)			
		(a) Voice regained		(3a) HF limited to one mode of operation (SSB or AM). Loss of SSB limits comm distance. If AM available, BCN probably available.	(3a) HF mode failure
		(b) Not regained	4		
	4	RECOVERY - HF sw - <u>BCN</u>	5	(4) Voice recorder will not run due to absence of AC power.	

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
15. (Cont)	5	On VHF-AM verify with recovery forces that HF beacon received. (a) Received (b) Not received	→ 6	(5a) HF operation limited to Beacon only. (5b) Recovery communications limited to VHF.	(5a) HF voice section failure (5b) HF system failure
	6	RECOVERY HF sw - <u>OFF</u>			
16. MSFN reports loss of VHF-FM data and C-Band ranging (VHF-AM and S-Band normal)	1	TELCOM NON ESS sw - Alternate position (<u>AC1</u> or <u>AC2</u>)		(1) Flight qual recorder, voice recorder, and DSE will also be lost. Tripping of telecom GROUP 1 CB will have the same symptom.	(1) Probable loss of one AC power source to telcom nonessential switch or switch failure.
17. MSFN reports VHF-FM and S-Band playback TIM poor or lost.	1	Attempt subsequent recordings at different recording speeds and/or in the reverse tape direction. Coordinate any deviations from normal procedures with MSFN.		(1) Diagnostic tests for DSE malfunctions are quite limited.	(1) Some possible failures are: DSE drive failure, erase or record head failure, speed assurance failure, TIM input failure, or DSE system failure.
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PROCEDURES ENTRY SHEET

SECTION 9.1.6
ECS MALFUNCTION PROCEDURES

SYMPTOM	SYMPTOM NUMBER	STEP	PAGE
<u>OXYGEN SUPPLY SUBSYSTEM</u>			
O ₂ FLOW Hi C&W Lite - ON	1	1	3
FLOW O ₂ indicator - HIGH	1	4	3
FLOW O ₂ indicator - LOW	2	1	11
SURGE TANK PRESSURE HIGH	3	1	13
SURGE TANK PRESSURE LOW	4	1	14
100 psig O ₂ circuit pressure HIGH	5	1	15
100 psig O ₂ circuit pressure LOW	6	1	16
20 psig O ₂ circuit pressure HIGH	7	1	17
20 psig O ₂ circuit pressure LOW	8	1	18
<u>PRESSURE SUIT CIRCUIT SUBSYSTEM</u>			
CO ₂ PP Hi C&W Lite - ON	11	1	20
PART PRESS CO ₂ indicator - HIGH	11	2	20
LITHIUM HYDROXIDE CARTRIDGE SEIZURE	12	1	24
Ballooned P.G.A.	13	1	25
Clinging P.G.A.	14	1	28
LOW SUIT FLOW	15	1	31
Suit temperature HIGH	16	1	34
Suit humidity HIGH	17	1	36
<u>CABIN PRESS & TEMP CONTROL SUBSYSTEM</u>			
CABIN PRESS - HIGH	21	1	39
CABIN PRESS - LOW	22	1	45
CABIN TEMP - HIGH	23	1	47
CABIN TEMP - LOW	24	1	48

Cabin humidity HIGH	25	1	49
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WATER/GLYCOL COOLANT SUBSYSTEM

GLYCOL TEMP Low C&W Lite - ON	31	1	50
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ECS RAD OUTLET TEMP - LOW	31	2	50
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ECS RADIATOR TEMP 1 or 2 - LOW	31	21	53
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ECS RAD OUTLET TEMP - HIGH	32	1	55
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Glycol evaporator outlet temp - HIGH	33	1	56
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Glycol evaporator outlet temp - LOW	34	1	61
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PRESS GLY DISCH - LOW	37	1	64
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GLY ACCUM QUANTITY - LOW	37	2	64
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GLY ACCUM QUANTITY - HIGH	39	1	68
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WATER SUPPLY SUBSYSTEM

Potable HOT H ₂ O temperature LOW	41	1	69
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H ₂ O transfer failure	42	1	70
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WATER quantity decrease rate HIGH	43	1	71
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Gas leakage into H ₂ O subsystem	44	1	72
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Potable and Waste water pressure HIGH	45	1	74
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WASTE MANAGEMENT SUBSYSTEM

Unable to dump urine	51	1	76
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Low vacuum suction	52	1	77
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Fecal canister vacuum LOW	53	1	78
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POST LANDING SUBSYSTEM

Inadequate ventilation after landing	61	1	78
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Water inflow	62	1	81
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. O ₂ FLOW HI C & W Lite - ON				Trigger Valve: Flow > 1.0 lbs/hr for more than 16 sec. FLOW > 1.0 lb/hr may occur for short periods during normal operations. Flow > 1.0 lbs/hr for longer than 10-15 seconds indicates probable malfunction.	
	1	FLOW O ₂ :			
		a. NORMAL: < 0.45 lbs/hr	2		
		b. HIGH: > 0.45 lbs/hr	4		
	2	CABIN REPRESS or DIRECT O ₂ VALVE - OPEN/OFF	3	2. Monitor FLOW O ₂	
	3	FLOW O ₂			
		a. INCREASES	→		3a. O ₂ FLOW HI C & W circuitry failure.
		b. NO INCREASE	4		3b. FLOW O ₂ gage/circuitry failure.
FLOW O ₂ - HIGH: > 0.45 lbs/hr	4	CABIN PRESS:			
		a. NORMAL or above: > 4.8 psia	5		
		b. LOW: < 4.8 psia	→		4b. Possible C/M puncture.
	5	DIRECT O ₂ - CLOSED	6	5-7. Verify inadvertently opened valves haven't caused increased O ₂ flow.	
	6	CABIN REPRESS - CLOSED	7		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. (Cont)	7	WASTE MANAGEMENT SELECTOR VALVE - OFF	8		
	8	FLOW O ₂ :			
		a. Remains HIGH: >0.45 lbs/hr	9		
		b. NORMAL: <0.45 lbs/hr	→	8b. Corrected by steps 5-7.	
	9	EMERGENCY CABIN PRESS REG SELECT - OFF	10		
	10	FLOW O ₂			
		a. Remains HIGH: >0.45 lbs/hr	11		
		b. NORMAL: <0.45 lbs/hr	12		
	11	EMERGENCY CABIN PRESS REG SELECT - NORMAL	18		
	12	EMERGENCY CABIN PRESS REG SELECT - NO. 1	13		
	13	FLOW O ₂ :			
		a. HIGH: >0.45 lbs/hr	14		13a. No. 1 Emergency cabin pressure regulator failure
		b. NORMAL: <0.45 lbs/hr	15		
	14	EMERGENCY CABIN PRESS REG SELECT - NO. 2	→	14. Loss of redundancy regulator capability.	

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. (Cont)	15	EMERGENCY CABIN PRESS REG SELECT - NO. 2	16		
	16	FLOW O ₂ a. HIGH: >0.45 lbs/hr	17		16a. NO. 2 Emergency Cabin Pressure regulator failure.
		b. NORMAL: <0.45 lbs/hr	→	16b. Probable transient condition.	
	17	EMERGENCY CABIN PRESS REG SELECT - NO. 1	→	17. Loss of redundancy regulator capability	
	18	SUIT DEMAND REG SELECTOR - OFF	19		
	19	FLOW O ₂ a. Remains HIGH: >0.45 lbs/hr	27		
		b. NORMAL: <0.45 lbs/hr	20		
	20	SUIT DEMAND REG SELECTOR - NO. 1	21	20. Assumes initial 1 & 2 Regulator position.	
	21	FLOW O ₂ a. NORMAL: <0.45 lbs/hr	23		
		b. HIGH: >0.45 lbs/hr	22		21b. Suit Demand Regulator No. 1 failure.
	22	SUIT DEMAND REG SELECTOR - NO. 2	→	22. Loss of suit pressure regulation redundancy.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. (Cont)	23	SUIT DEMAND REG SELECTOR - NO. 2	24		
	24	FLOW O ₂			
		a. NORMAL: <0.45 lbs/hr	26		
		b. HIGH: >0.45 lbs/hr	25		24b. Suit Demand Regulator NO.2 failure
	25	SUIT DEMAND REG SELECTOR - NO. 1	→	25. Loss of suit pressure regulation redundancy.	
	26	SUIT DEMAND REG SELECTOR - 1 & 2	→	26. Possible transient condition.	
	27	SUIT DEMAND REG SELECTOR - 1 & 2	28		
	28	Pull Suit Hose Return Port Plug	29		
	29	FLOW O ₂			
		a. NORMAL: <0.45 lbs/hr	30		
		b. Remains HIGH: >0.45 lbs/hr	34		
	30	Re-install Suit Hose Return Port Plug	31		
	31	Vacuum SUIT CIRCUIT AIR RETURN CHECK VALVE SCREEN (Suit compressors off while vacuuming screen)	32		
	32	FLOW O ₂			
		a. NORMAL: 0.45 lbs/hr	→		32a. Dirty screen.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. (Cont)		b. Remains HIGH: >0.45 lbs/hr	33	32b. Open suit operation requires air return through suit hose. Closed suit operation normal.	
	33	Pull Suit Hose Return Port Plug	→		33. Suit circuit Return Check valve Restricted or failed closed.
	34	Re-install Suit Hose Return Port Plug	35		
	35	H ₂ O ACCUM - AUTO 2 (alternate)	36	35. Assumes initial AUTO - 1 position.	
	36	FLOW O ₂			
		a. Remains HIGH: >0.45 lbs/hr	37		
		b. NORMAL: <0.45 lbs/hr	→		36b. H ₂ O ACCUM NO. 1 auto cycle control failure
	37	H ₂ O ACCUM - MAN	38	37. Shuts off power to accumulator O ₂ solenoids.	
	38	FLOW O ₂			
		a. Remains HIGH: >0.45 lbs/hr	39		
		b. NORMAL: <0.45 lbs/hr	→	38b. Loss of auto cyclic H ₂ O ACCUM control.	38b. Probable central timer failure, giving false signal to auto cycle control units.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. (Cont)		b. HIGH: >0.45 lbs/hr.	48		
	48	WATER & GLYCOL TANKS PRESSURE INLET SELECT - NO. 1	49		
	49	FLOW O ₂			
		a. NORMAL: <0.45 lbs/hr	→	49a. Loss of redundant tank pressure and relief capability.	49a. Water & Glycol tanks pressure regulator & relief valve NO. 2 failure.
		b. HIGH: >0.45 lbs/hr	50		
	50	WATER & GLYCOL TANKS PRESSURE INLET SELECT - NO. 2	51		
	51	FLOW O ₂			
		a. NORMAL: <0.45 lbs/hr	→	51a. Loss of redundant tank pressure & relief capability	51a. Water & Glycol tanks pressure regulator & relief valve NO. 1 failure
		b. HIGH: >0.45 lbs/hr	→	51b. Loss of both tank <u>pressure and relief valves.</u>	51b. Both Water & Glycol tank pressure regulator & relief valves.
	52	WATER & GLYCOL TANKS PRESSURE INLET SELECT - NORMAL	53		
	53	Surge tank pressure		53. TANK PRESSURE O ₂ -1/PRESS IND - SURGE TANK. Normal pressure 900 ±35 psia.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. (Cont)		a. LOW: <865 psia	→	53a. LARGE LEAK. Unable to identify or isolate. Will result in loss of all O ₂ regulator control.	53a. Probable CABIN PRESS REGS leaking or 100 psi line leakage downstream of flow sensor.
		b. Pressure: NORMAL	→	53b. Leak present - leakage rate < supply rate therefore pressure regulation capability satisfactory; however, usage rate above normal. Monitor O ₂ usage to verify FLOW O ₂ indication.	
<p>NOTE: If leak is not isolated and the high O₂ flow rate continues to deplete O₂ supply - mission time may be extended by shutting off the main O₂ regulators and only opening valve as required to maintain cabin pressure and CO₂ level. Isolate Water & Glycol Tanks pressure to retain system operation. Open Water & Glycol tanks valve as required to maintain pressure.</p>					
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
2. FLOW O ₂ - LOW				FLOW O ₂ pegged at 0.2 lb/hr. Normal flow rate is >0.2 <0.45 lb/hr. FLOW O ₂ indicator cannot indicate <0.2 lb/hr.	
	1	Verify MAIN O ₂ REGULATOR - NORMAL	2	1. Unless in 1 or 2 due to previous failure.	
	2	FLOW O ₂ :			
		a. Increases	→	3a. If reg. valve was OFF, resume normal ops. If was positioned to 1 or 2, redundant reg. capability lost.	3a. Incorrect reg. valve position and/or single reg. failed closed.
		b. No change in status	3		
	3	O ₂ PRESS IND - SURGE TANK	4		
	4	TANK PRESSURE O ₂ - 1: (SURGE TANK)		4. Normal surge tank pressure 900 ±35 psia. Inlet pressure to MAIN REG <150 psia will result in loss of control of 100 psia O ₂ circuit.	
		a. LOW: <150 psia	→	4a. Refer to ECS Malfunction Procedure NO. 4	
		b. >150 psia	5		
NOTE: In step 5 monitor both the FLOW O ₂ gage and SURGE TANK (assumes surge tank on-line) pressure indications to isolate failure when DIRECT O ₂ valve is opened. If no flow indication with DIRECT O ₂ exercise EMER O ₂ INFLOW, DEMAND REG SUIT FLOW and EMER REPRESS.					
	5	DIRECT O ₂ - OPEN/OFF			
		a. FLOW O ₂ - increases SURGE TANK PRESSURE - decreases	6	5a. Verifies FLOW O ₂ indicator function.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
2. (Cont)		b. FLOW O ₂ - No change SURGE TANK PRESSURE - DECREASES	→	5b. FLOW O ₂ indication lost.	5b. FLOW O ₂ sensor/circuitry failure.
		c. FLOW O ₂ - No change SURGE TANK PRESSURE - No change	7		
	6	CABIN PRESSURE			
		a. LOW (or decreasing)	→	6a. Refer to ECS malfunction Procedure NO. 22.	
		b. Normal	→	6b. FLOW O ₂ indications invalid	6b. FLOW O ₂ meter out of calibration.
	7	PLSS O ₂ SUPPLY S/O VALVE CAP - REMOVED	8	7. Remove cap carefully to preclude blowing off if PLSS valve has leaked pressure.	
	8	PLSS O ₂ SUPPLY S/O VALVE - OPEN/OFF	9	8. Note O ₂ flow from valve.	
	9	TANK PRESSURE O ₂ 1 (SURGE TANK)			
		a. Decreases (and flow from PLSS valve)	→	9a. PLSS valve only O ₂ source to cabin. Monitor CABIN PRESSURE for flow control.	9a. Both MAIN REGS failed or line blockage.
		b. No change in status (and no flow from PLSS valve)	→	9b. CM O ₂ SUPPLY LOST with 0.25 lbs/hr cabin leakage and 5.0 psia cabin pressure aprox. 3 hrs remaining until 3.5 psia cabin pressure.	9b. O ₂ supply line blockage upstream of PLSS valve.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
3. SURGE TANK PRESSURE HIGH				TANK PRESSURE O ₂ - 1 > 935 psia with O ₂ PRESS IND TO SURGE TANK	
	1	O ₂ PRESS IND - TK 1	2		
	2	TANK PRESSURE 1 - O ₂			
	a.	HIGH	→	2a. See EPS CRYO malfunction procedures NO. 1 step 20, O ₂ TK1 (and/or 2) pressure high.	2a. CRYO O ₂ Storage Failure
	b.	NORMAL	3		
	3	TANK PRESSURE 2 - O ₂			
	a.	NORMAL	→	3a. Continue operation in TK 1 position.	3a. Surge tk pres- sure sensor & sig cond failure.
	b.	HIGH	→	3b. See EPS CRYO malfunction procedures. NO. 1 step 20, O ₂ TK1 (and/or 2) pressure high.	3b. Cryo O ₂ storage failure.

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
4. SURGE TANK PRESSURE LOW	1	PRESS - CABIN a. >5.2 psia (High) b. >4.8 <5.2 psia (Normal)	 → →	TANK PRESSURE O ₂ - 1 <865 psia with PRESS IND - SURGE TANK 1a. Surge tank pressure <865 psia may result (other than cabin repress mode) in increased cabin pressure. Refer to PRESS - CABIN ECS malfunction NO. 21. 1b. See EPS CRYO Malfunction Proc. NO. 1 step 2, O ₂ TK 1 (and/or 2) pressure low.	1b. Probable cryo subsystem failure.

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
5. MSFN CF0036P > 110 psig. Over-pressurization of 100 psig O ₂ circuit				Normal system pressurization 100 ± 10 psig. Only direct pressure readout is by MSFN CF0036P	
<i>why did we do this?</i>	1.	CF0036P > 110 psig	2		
	2.	O ₂ PRESS IND - SURGE TANK	3		
	3.	TANK PRESS O ₂ - 1 (SURGE TANK)			
	a.	Normal: 900 ± 35 psig	4		
	b.	HIGH: > 935 psig	→	Refer to ECS Malfunction Procedures No. 3.	
	4.	MAIN REGULATOR - # 1	5	4. Assumes NORMAL initial position	
	5.	CF0036P			
	a.	Normal: > 90 < 110 psig	→	5a. Main reg. redundancy lost. Continue operation on Reg. NO. 1.	5a. MAIN REG NO. 2 failed OPEN
	b.	HIGH: > 110 psig	6		
	6.	MAIN REGULATOR - # 2	7		
7.	CF0036P				
a.	Normal	→	7a. Main regulator redundancy lost. Continue operation on Reg. NO. 2.	7a. MAIN REG NO. 1 failed OPEN	
b.	Remains HIGH	8			

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
5. (Cont)	8	CABIN PRESS			
		a. HIGH: > 5.2 psia	→	8a. Refer to ECS Malfunction procedure No. 21	
		b. NORMAL	→		8b. Probable pressureducer failure.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
6. MSFN CF0036P < 90 psig. Under-pressurization of 100 psig O ₂ circuit				Normal system pressurization 100 ± 10 psig. Only direct press readout is by MSFN CF0036P	
	1.	CF0036P < 90 psig	2		
	2.	O ₂ PRESS IND - SURGE TANK	3		
	3.	TANK PRESS O ₂ - 1 (SURGE TANK)			
	a.	Normal: 900 ± 35 psia	4		
	b.	Low: < 865 psia	→	3b. Refer to ECS Malfunction Procedures NO. 4.	
	4.	FLOW O ₂			
	a.	NORMAL: 0.2-0.45 lb/hr.	→		4a. Reg. calibration shift of both regs. or transducer shift.
	b.	LOW: < 0.2 lb/hr.	→	Refer to ECS Malfunction Procedure NO. 2	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
7. CF0120P TM>27 psig. over- pressurization of 20 psig O ₂ circuit				Normal regulator pressure 20 [±] 2 psig. Normal system pressure 18-27 psig (relief valve setting 25 ± 2 psig). Only direct pres- sure readout is MSFN (FQ) CF0120P.	
	1.	Verify WATER & GLYCOL TANKS PRESSURE OUTLET SELECT VALVE - NORMAL	2.	1. Assumes no previous failure	
	2.	CF0120P			
		a. NORMAL: ≤27 psig	→	2a. Relief valve redundancy lost if selector was in posi- tion 1 or 2.	2a. Selector was OFF or single relief valve failure.
		b. Remains HIGH: >27 psig	3.		
	3.	POT WATER QUANTITY			
		a. 100%	4		
		b. <100%	5		
	4.	Use water gun until POT WATER QUANTITY <100%	5		
	5.	CF0326P			
		a. HIGH	6		5a. Both relief valves failed closed or line blockages.
		b. NORMAL	→		
	6.	Use water gun for system pressure relief.	→	6 Monitor MSFN	5b. CF0120P sensor failure.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
8. CF0120P TM <18 psig. Underpressurization of 20 psig O ₂ circuit				Normal system pressurization 20 ± 2 psig. Only direct pressure readout is MSFN (FQ) CF0120P. Relief valve setting 25 ± 2 psig.	
	1	CF0120P <18 psig	2		
	2	CF0326P & CF0327P		2. PRESS POTABLE H ₂ O DRAIN and PRESS WASTE H ₂ O TANK DRAIN.	
		a. Normal : >18 <27 psig	→	2a. CF0326P & CF0327P only other indication of pressure in 20 psig circuit	2a. CF0120P Sensor Failure
		b. LOW	3		
	3	CF0036P		3. 100 psig O ₂ circuit pressure	
		a. Normal: 100 ± 10 psig	4		
		b. LOW: <90 psig	→	3b. Refer to ECS Malfunction Procedure No. 6	
	4	WATER & GLYCOL TANKS PRESS REGULATOR SELECTOR - INLET AND OUTLET # 1 (or 2) alternate	5	4. Assumes initial position of one required.	
	5	CF0120P			
		a. Normal: >18 <27 psig	→	5. Loss of redundant pressure reg. and relief. Use No. 1 positions.	5a. Failure of No. 2 relief valve
		b. LOW: <18 psig	6		
	6	WATER & GLYCOL TANKS PRESS REGULATOR SELECTOR - INLET and OUTLET No. 2 (or 1) alternate.	7		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
8. (Cont)	7	CF0120P a. Normal: > 18 < 27 psig b. LOW: < 18 psig	→ →	7a. Loss of redundant reg. & relief. Use No. 2 positions 7b. Failure to maintain adequate positive pressure in water system will result in loss of water inflow to suit and glycol evaporators. Positive expulsion of glycol from glycol reservoir will also be lost.	7a. Failure of No.2 relief valve 7b. Failure of both regs to control tank pressure to 20 ± 2 psig
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
11. CO ₂ PP HI C & W lite - ON				Trigger value: CO ₂ PP >7.6 mm Hg.	
NOTE: CO ₂ PP level will vary with crew activity; short periods of high CO ₂ PP may trigger C & W lite briefly, but not necessarily indicate a dangerous situation.					
PART PRESS CO ₂ HIGH	1	PART PRESS CO ₂			
		a. NORMAL: <7.6 mm Hg.	16		
		b. HIGH: >7.6 mm Hg.	2		
	2	SUIT FLOW			
		a. LOW: - HIGH	→	2a. Insufficient flow in suit loop can cause excessive CO ₂ PP buildup. Accomplish ECS ² Malfunction Procedure 15.	
		b. NORMAL:	3		
	3	Check LiOH cartridge replacement log to determine time since last canister change:			
		a. If recent cartridge change:	6		
		b. If near time for replacement:	4		
	4	Change LiOH cartridge	5	4. Oldest cartridge.	
	5	PART PRESS CO ₂			
		a. NORMAL	→	5a. Resume normal operation; normal saturation of cartridge caused increase in CO ₂ PP.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
11. (Cont)		b. Remains HIGH	6	5b. Should begin decrease within one minute.	
	6	DIRECT O ₂ - FULL OPEN (ccw) for 10 seconds.	7	6. Purge CO ₂ PP sensor with O ₂ to clear possible stagnant CO ₂ near sensor.	
	7	PART PRESS CO ₂			
		a. NORMAL	→	7a. Resume normal operations	
		b. Drops to normal then increases >7.6 mm Hg.	8	7b. Confirms High CO ₂ partial pressure.	
		c. Remains - HIGH	17		
	8	Change LiOH cartridge	9	8. Change oldest cartridge.	
	9	PART PRESS CO ₂			
		a. NORMAL	→	9a. Resume normal operation. Loss of 12 hr. CO ₂ & odor removal capability.	9a. PROBABLE FAULTY LiOH cartridge
		b. Remains - HIGH	10		
	10	Monitor crew comfort			
		a. Crew Comfortable	17	10a. LiOH cartridge working properly.	
		b. Crew Uncomfortable	11	10b. Possible loss of CO ₂ removal capability for suit loop and cabin using LiOH canister assy.	10b. PROBABLE FAULTY LiOH cartridge supply
CAUTION: Possible LiOH cartridge supply faulty.					
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
11. (Cont)	11	Check all LiOH cartridges for possible uncontaminated cartridges.			
	a.	Partial Contamination	→	11a. CO ₂ removal capability unknown.	11a. CO ₂ removal capability degraded.
	b.	If all contaminated	12		
MANUAL CO ₂ PP CONTROL	12	Don PGA's, get on suit loop	13		
	13	SUIT CIRCUIT RETURN AIR CHECK VALVE - CLOSED	14	13. Isolate suit loop from cabin.	
NOTE: Periodic flowing of fresh O ₂ into suit loop purging it into cabin, and periodic relieving of cabin to space will control CO ₂ PP level in suit loop.					
	14	DIRECT O ₂ - OPEN (ccw) as required	15	14. Open direct O ₂ valve to maintain CO ₂ PP <7.6 mm Hg. O ₂ FLOW HI C & W lite may come on.	
	15.	CABIN PRESSURE RELIEF - Verify NORMAL	→	15. Cabin Pressure relief valve will relieve at 5.6 - 6.2 psia automatically. Manual dump available.	
CO ₂ PP INDICATOR SENSOR MALFUNCTION ISOLATION	16	IF:	→	16. Loss of CO ₂ PP level high C & W capability. Use PART PRESS CO ₂ meter.	16. PROBABLE C & W CIRCUIT FAILURE
	a.	CO ₂ PP HI lite - ON			
	b.	PART PRESS CO ₂ - <7.6 mm Hg.			
	c.	Crew Comfortable			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
11. (Cont)	17	IF: a. CO ₂ PP HI lite - ON after LiOH cartridge change and sensor purge. b. PART PRESS CO ₂ - >7.6 mm Hg after LiOH cartridge change and sensor purge. c. Crew Comfortable after a & b have existed for several minutes	→	17. Loss of all CO ₂ PP monitor capability, except crew physical senses. Gas chromatograph can be turned on to verify CO ₂ PP with ground.	17. PROBABLE CO ₂ PP SENSOR FAILURE
CO ₂ PP HI C & W life failure	18	IF: a. CO ₂ PP HI lite - OFF b. PART PRESS CO ₂ >7.6 mm Hg and no change with LiOH cartridge change and sensor purge with O ₂ .	→	18. Loss of CO ₂ PP meter indication for monitoring CO ₂ PP level.	18. PROBABLE CO ₂ PP meter failure.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
12. Lithium Hydroxide cartridge seizure within canister.		1. Pull on LiOH cartridge removal strap -- or apply mechanical advantage as required to remove the faulty cartridge.		1. LiOH is hygroscopic & cartridge swelling results due to water absorption. In addition H ₂ O is produced by $2\text{LiOH} + \text{CO}_2 = \text{Li}_2\text{CO}_3 + \text{H}_2\text{O}.$	1. Excessive swelling of LiOH cartridge.
<p>NOTE: Any delay in removing a seized cartridge will result in water saturation of the cartridge, increased pressure drop across seized cartridge with resulting reduced suit flow.</p> <p>CAUTION: Immediately following replacement of a LiOH cartridge -- the opposite canister should be momentarily opened & cartridge canister clearance be noted. Immediately replace a cartridge suspected of swelling.</p> <p>CAUTION: Continued use of a seized cartridge will aggravate situation. Establish single canister operation by positioning diverter valve to route suit flow thru good canister. Flow may be diverted thru seized cartridge momentarily when replacement of operational cartridge is required.</p>					
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
13. Ballooned P.G.A. (Closed Suit Loop)				Cabin-to-suit ΔP maintained at 2.5 to 3.5 in H_2O . Suit Pressure maintained at $3.75 \pm .25$ psia when Cabin Pressure ≤ 3.5 psia.	
	1	PRESS CABIN			
		a. Low: < 3.5 psia	→	1a. Refer to ECS Malfunction Procedure No. 22.	
		b. Normal	2		
	2	FLOW O_2			
		a. HIGH: > 0.45 lb/hr	→	2a. Refer to ECS Malfunction Procedure No. 1.	
		b. NORMAL: < 0.45 lb/hr	3		
	3	Verify DIRECT O_2 valve - CLOSED	4		
	4	Verify SUIT TEST SELECTOR - OFF	5		
	5	Suit Status			
		a. Remains ballooned	6		
		b. Normal	→	5b. Corrected by 3-4.	
	6	SUIT DEMAND REG SELECTOR - cycle OFF/1 & 2	7	6. Monitor suit status while OFF.	
	7	Suit Status		7. While SUIT DEMAND REG SELECTOR - OFF	
		a. Remains ballooned	13		
		c. NORMAL	8		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE	
13. (Cont)	8	SUIT DEMAND REG SELECTOR - 1	9			
	9	Suit Status				
		a. Ballooned	10			
		b. Normal	→	9b. Regulator redundancy lost.	9b. Suit Demand Regulator NO. 2 failed open.	
	10	SUIT DEMAND REG SELECTOR - 2	11			
	11	Suit Status				
		a. Remains Ballooned	12		11a. Both Suit Demand Regulators failed open.	
		b. Normal	→	11b. Regulator redundancy lost.	11b. Suit Demand Regulator NO. 1 failed open.	
	12	SUIT DEMAND REG SELECTOR - OFF	13			
	13	SUIT CONFIGURATION - OPEN	14			
	14	Verify SUIT CIRCUIT AIR RETURN CK VALVE SCREEN clean & flow path obstructed	15			
	15	Monitor CABIN HUMIDITY & CO ₂ PARTIAL PRESSURE				
		a. INCREASES	→	15a. Humidity CO ₂ & Odor removal capability lost. Closed suit configuration impossible.	15a. Clogged DEBRIS TRAP or plumbing downstream of DEBRIS TRAP	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
13. (Cont)		b. Remains NORMAL	→	15b. Closed suit configuration not possible.	15b. Clogged suit outlet manifold or plumbing obstruction upstream of debris trap.

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. PRESS-SUIT LOW (Closed Suit Loop). Evidenced by PGA clinging.				Normal Cabin to suit ΔP is 0.09 to 0.13 psia.	
NOTE: Other than periods of fault isolation DIRECT O_2 metering valve may be opened for suit purging.					
	1	PRESS-CABIN			
		a. High: > 5.2 psia	2	1a. Suit loop leakage into cabin.	
		b. Normal: 5.0 ± 0.2 psia	5		
		c. Low: 4.8 psia	→	1c. See ECS Malfunction Pro- cedure NO. 22.	
	2	Verify SUIT FLOW CONTROL Valves - SUIT FLOW	3		
	3	Verify suit hose connector integ- rity at PGAs & SUIT FLOW CONTROL VALVES.	4		
	4	Suit Status			
		a. Clinging	→	4a. Unable to isolate SUIT loop leakage into cabin. Unable to maintain suit loop press.	4a. Suit loop plumb- ing or Demand Reg. relief valve failed open.
		b. Not clinging	→	4b. Corrected by step 2 & 3.	
	5	Verify SUIT CIRCUIT RETURN AIR CK VALVE - CLOSED	6		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
14. (Cont)	6	PGA Status			
		a. Clinging	7		
		b. Not Clinging	→	6b. Corrected by step 5	
	7	ΔP SUIT COMP			
		a. Normal	10		
		b. < Normal	8		
	8	Check alternate bus & compressor with suit compressor selector & CB'S.	9		
	9	ΔP SUIT COMP			
		a. Normal	→	9a. If single compressor failure - redundancy lost.	9a. Circuitry or Compressor Failure.
		b. < Normal	10		
	10	Suit Demand Regulator Selector			
		a. If in 1 & 2	13		
		b. If in 1 (or 2)	11		
	11	SUIT DEMAND REG - Alternate reg.	12		
	12	ΔP SUIT COMP			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
13. (Cont.)		a. Normal	→	12a. Eliminates SUIT DEMAND REG redundancy. Continue operation on selected regulator.	12a. SUIT DEMAND REGULATOR 1 (or 2) failed CLOSED.
		b. < Normal	13		
	13	Verify SUIT FLOW RELIEF VALVE - CLOSED	14		
	14	PGA Status			
		a. Not Clinging	→	14a. Resume ops. with SUIT FLOW RELIEF Valve manually CLOSED.	14a. SUIT FLOW RELIEF valve was OPEN & relief function failed.
		b. Clinging	→	14b. Small leak not isolated Maintain positive suit by opening DIRECT O ₂ metering valve.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
15. LOW SUIT FLOW				Normal Suit Flowrate 35 cfm with 10 in H ₂ O pressure rise across suit fan.	
NOTE: For periods of high crew activity additional cooling may be required. Switch COMPR SELECTOR to AC 1/2					
	1	Verify Suit O ₂ Umbilical connections	2		
	2	Verify SUIT FLOW CONTROL VALVES (3) - SUIT FLOW	3		
	3	Verify SUIT TEST - OFF	4		
	4	Verify SUIT DEMAND PRESS REGULATOR - 1 & 2	5		
	5	Verify SUIT FLOW RELIEF VALVE - OFF	6		
	6	If open suit loop verify SUIT CIRCUIT RETURN AIR CHECK VALVE OPEN, screen clean & unobstructed flowpath	7	6. Suit compressors must be off while vacuuming return air screen.	
	7	SUIT FLOW a. Normal	→	7a. Continue normal operations. Corrected by steps 1 - 6.	
		b. Remains low	8		
	8	ΔP SUIT COMPR			
		a. Normal: <0.4 >0.3 psi	12		
		b. Low: <0.3 psi	9		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
15. (Cont)	9	Check alternate bus & compressor with suit compressor selector & CB's	10		
	10	ΔP COMPR			
		a. Normal	12	10a. If single compressor failure compressor redundancy lost.	10a. Electrical or Compressor Failure.
		b. Remains Low: <0.3 ΔP	11		10b. Probable both suit compressors and/or circuitry failure.
	11	Go to open suit	→	11. Normal suit loop functions are lost.	
	12	SUIT FLOW			
		a. Normal	→	12a. Suit Compressor redundancy lost.	12a. Single Suit Compressor failure.
		b. Remains Low	15		
	13	SUIT COMPRESSOR SELECTOR -AC 1/2	14		
	14	SUIT FLOW			
		a. Normal	→	14a. Two compressor operation required for crew comfort.	
		b. Remains Low	15		
	15	PGA status			
		a. Clinging	→	15a. DIRECT O ₂ metering valve may be opened ² (short duration) for additional suit flow. Suit doffing may be required for crew comfort. Suit loop functions may be lost. Monitor	15a. Obstruction between compressor outlet and suit inlet.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
15. (Cont)				cabin humidity & CO ₂ partial pressure.	
	b. Ballooned	→	15b. Monitor PGA CUFF PRESSURE INDICATORS (3). DIRECT O ₂ metering valve should not be opened while closed suit. Suit loop press relief capability probably lost.	15b. Obstruction between suit outlet and compressor inlet	
	c. Normal	→	15c. Suit Flowrate degraded - but functional.	15c. Small suit loop obstruction.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
16. TEMP SUIT HIGH ($>55^{\circ}\text{F}$ $<60^{\circ}\text{F}$)				NORMAL SUIT TEMP $51\text{--}55^{\circ}\text{F}$	
	1	Crew Comfort			
		a. TEMP COMFORTABLE	→		1a. Suit Temp sensor /circuitry failure.
		b. HIGH TEMP, crew discomfort.	2		
	2	Verify:	3		
		a. SUIT EVAP GLYCOL - ON			
		b. SUIT HT/EXCH - GLY/EVAP			
		c. SUIT EVAP SW - MANUAL			
		d. SUIT EVAP VALVE - OFF			
	3	TEMP SUIT			
		a. Returns to NORMAL	→	3a. Corrected by step 2	3a. Control mis- position.
		b. Remains HIGH: $>55^{\circ}\text{F}$	4		
	4	GLYCOL EVAP OUTLET TEMP			
		a. NORMAL ($40\text{--}43^{\circ}\text{F}$)	5		
		b. HIGH $>43^{\circ}\text{F}$	→	Refer to ECS Malfunction Pro- cedure NO. 33.	
	5	TEMP SUIT			
		a. $<60^{\circ}\text{F}$	→	6a. Possible transient over- temperature condition due to crew activity, equipment operation or S/C attitude.	
		b. $>60^{\circ}\text{F}$	7		
TEMP SUIT HIGH ($>60^{\circ}\text{F}$)	6	DOFF SUIT			
WARNING: Only if cabin temp cannot be controlled, Don suits and proceed to step 7.					
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
16. (Cont)	7	SUIT HT/EXCH - EVAP SUIT EVAP SW - AUTO SUIT EVAP VALVE - AUTO	8	7. Initiates SUIT HX evaporative mode	
	8	TEMP SUIT a. Returns to NORMAL (51-55°F)	→	8a. Continue evaporative mode.	8a. Loss of auto temp control of SUIT HX outlet or diverter valve failure.
		b. Remains HIGH	9		
	9	Isolate surge tank	10		
	10	Open direct O ₂ valve, as required for suit cooling	→		10. Loss of SUIT HX evaporative & glycol cooling modes.
NOTE: Open surge tank after CM/SM separation					
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
17. HIGH SUIT HUMIDITY (closed Suit Loop with SUIT FLOW & TEMP NORMAL)				High humidity evidenced by fogged visors and crew discomfort.	
	1	H ₂ O ACCUM Switch - MAN	2		
	2	H ₂ O ACCUM 1 and then 2 - ON 10 sec/OFF	3	2. Monitor FLOW O ₂ meter for increased flow while cyclic accumulator 1 and 2 solenoid valves are operated with ON/OFF switch	
	3	FLOW O ₂			
		a. Both increase Flow O ₂	4		
		b. NO. 1 or 2 increases (alternate) FLOW O ₂	8	3b. Auto and electrical control of NO. 1 or 2 lost.	3b. Electrical circuit failure of one accumulator
		c. No change in FLOW O ₂	12	3c. All auto and electrical control lost.	3c. Electrical circuit failure both accumulators
	4	H ₂ O ACCUM - AUTO 1 or 2 (alternate)	5		
	5	Suit Humidity			
		a. Decreases	→	5a. Use alternate accumulator in auto. Other accumulator useable with manual switch.	5a. Automatic control circuit 1 (or 2) accumulator failed.
		b. Remains HIGH	6		5b. Automatic control circuit of both accumulators lost.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE	
17. (Cont)	6	H ₂ O ACCUM Switch - MAN	7			
	7	H ₂ O ACCUM 1 or 2 - ON 10 sec/OFF (as required to maintain humidity control.)	→			
	8	H ₂ O ACCUM - AUTO 1 or 2 (alternate)	9			
	9	Suit Humidity a. Decreases	→	9a. Use alternate accumulator in auto.	9a. Automatic control circuit 1 (or 2) accumulator failed	
		b. Remains HIGH	10		9b. Automatic control circuit of both accumulators lost.	
	10	H ₂ O ACCUM Switch - MAN	11			
	11	H ₂ O ACCUM 1 or 2 - ON 10 sec/OFF (as required for humidity control)	→	11. Alternate accumulator.		
	12	H ₂ O ACCUMULATOR manual valve - MAN 1 (and then MAN 2) for 10 sec then OFF	13	12. Monitor FLOW O ₂ while valves open.		
	13	FLOW O ₂ a. Both increase FLOW O ₂	14			
		b. NO. 1 or 2 increase (alternate) FLOW O ₂	14	13b. Accumulator redundancy lost.	13b. Loss of cyclic accumulator NO. 1 or 2.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
17. (Cont)		c. No change in FLOW O ₂	18	13c. Moisture removal capability lost.	13c. Loss of both cyclic accumulators
	14	Manually cycle alternate accumulator as required for humidity control.	15		
	15	Suit humidity			
		a. Decreases	→	15a. Manual humidity control possible.	
		b. Remains HIGH	16		15b. Probable diaphragm rupture.
	16	Manually cycle original accumulator (if both gave FLOW O ₂ increase in step 13)	17		
	17	Suit humidity			
		a. Decreases	→	17a. Manual humidity control possible with one accumulator only.	
		b. No change	18	17b. Moisture removal capability lost.	17b. Probable rupture both diaphragms.
	18	Use DIRECT O ₂ to maintain crew comfort.	→		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. PRESS CABIN - HIGH	1	Verify CABIN PRESSURE RELIEF Valves (2) - NORMAL	2	1. Normal cabin pressure 4.8 - 5.2 psia. Cabin pressure relief valves open at 3.6 - 6.2 psia. With cabin pressure 5.6 - 6.2 O ₂ consumption will be excessive.	
	2	FLOW O ₂		2. O ₂ FLOW HI C & W lite On at flow rate >1.0 lb/hr.	
		a. HIGH: ≥ 0.45 lb/hr	→	2a. Refer to ECS malfunction procedure # 1 step 2	2a. Malfunction or leak downstream of oxygen flow transducer.
		b. NORMAL: < 0.45 lb/hr	3	2b. Malfunction or leak upstream of oxygen flow transducer.	
	3	O ₂ PRESS IND switch - SURGE TANK	4		

WARNING: When surge tank drops below 800 psia, isolate surge tank and verify entry tank isolated to maintain Entry O₂ supply and proceed to step 23.

NOTE: Surge tank pressure will give indication of leakage rate. For example: (Typical for S/C 008 - data not available for S/C 012 this date)

<u>Leakage</u>	<u>Surge Tank Press Drop</u>
4 lb/hr.	150 PSI
6 lb/hr.	499 PSI
7.5 lb/hr.	750 PSI

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
21. (Cont)	4	TANK PRESSURE - 1.O ₂ : SURGE TANK		4. Normal surge tank pressure 900 ± 35 psia.	
		a. NORMAL	23	4a. Leak within supply limits.	
		b. LOW	8	4b. Large leak	
		c. HIGH	5	4c. Surge Tank relief valve setting 1045 ± 25 psia.	
	5	O ₂ PRESS IND Switch - TANK 1	6		
	6	TANK PRESSURE 1 - O ₂ (TANK 1)			
		a. HIGH	→	6a. Refer to EPS CRYO malfunctions procedures NO. 1 step 20, O ₂ TK 1(and/or 2) pressure high.	
		b. NORMAL	7		
	7	TANK PRESSURE 2 - O ₂			
		a. HIGH	→	7a. High O ₂ Cryo supply pressure Refer to EPS CRYO malfunction procedures.NO. 1 step 20, TK1 (and/or 2) pressure high.	
		b. NORMAL	23	7b. Probable Surge Tank sensor/circuitry failure. Use TANK 1 & 2 for SURGE TANK PRESSURE.	
	8	MAIN O ₂ REG - 1	9		
	9	TANK PRESSURE 1 - O ₂ (Surge tank)			
		a. Pressure increases	→	9a. Regulator redundancy lost. Use regulator # 1.	9a. No. 2 Main regulator.
	b. No change in status	10			

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
21. (Cont)	10	MAIN O ₂ REG - 2	11		
	11	TANK PRESSURE 1 - O ₂ (Surge tank)			
		a. Pressure increases	→	11a. Regulator redundancy lost. Use regulator # 2.	11a. No. 1 Main regulator.
		b. No change in status	12		
	12	MAIN O ₂ REG - NORMAL	13		
	13	SURGE TANK PRESSURE RELIEF - OFF	14		
	14	TANK PRESSURE 1 - O ₂ (Surge tank)			
		a. Pressure increases	→	14a. Surge tank pressure relief lost. Requires monitoring of Surge TK pressure if surge TK isolated.	14a. Surge tank pressure relief valve leaking.
		b. No change in status	15		
	15	SURGE TANK PRESSURE RELIEF - NORMAL	16		
	16	SURGE TANK - OFF	17		
	17	TANK PRESSURE 1 - O ₂ (Surge tank)			
		a. Continues to decrease	→	17a. Gross leak protection and primary source of O ₂ after CSM separation eliminates or degraded. Entry tank will supply 1 lb O ₂ after CSM separation for reentry.	17a. Leak in surge tank.
		b. Steady readout	18		
	18	SURGE TANK - ON	19		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
21. (Cont)	19	Verify PLSS FILL valve - CLOSED and CAP - INSTALLED	20	19. Normally closed and capped	20a. PLSS FILL valve was not closed or was leaking through cap.
	20	TANK PRESSURE 1 - O ₂ (Surge tank)			
		a. Pressure increases	→	20a. Resume normal operation.	
		b. No change in status	21		
	21	Verify ENTRY O ₂ valve - OFF	22	21. Normally OFF.	
	22	TANK PRESSURE 1 - O ₂ (Surge tank)			22a. ENTRY FILL valve not OFF and leak in entry tank assembly.
		a. Pressure increases	→	22a. Redundant O ₂ supply lost after CSM separation.	
		b. No change in status	→	22b. Monitor O ₂ supply usage rate to determine mission status.	
<p>NOTE: If leak is not isolated and continues to deplete O₂ supply - mission time may be extended by shutting off the main O₂ regulators (or SM O₂ SUPPLY CONTROL if leak upstream of main regulator) and only opening valve as required. If SM O₂ SUPPLY CONTROL is turned OFF; isolate surge tank to maintain SURGE TANK PRESSURE. If main O₂ regulators are shut off; isolate Water & Glycol Tanks pressure to retain system operation. Cycle open each time O₂ cycled ON.</p> <p>NOTE: Due to large cabin volume cabin pressure changes for the following steps will require time to be detectable.</p>					
	23	MAIN O ₂ REG - 1	24		24a. No. 1 main regulator.
	24	CABIN PRESS			
		a. Decreases	→	24a. Regulator redundancy lost.	
		b. No change in status	25		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
21. (Cont)	25	MAIN O ₂ REG - 2	26		
	26	CABIN PRESS			
		a. Decreases	→	26a. Regulator redundancy lost.	26a. No. 1 main regulator.
		b. No change in status	27		
	27	MAIN O ₂ REG - NORMAL	28		
	28	SURGE TANK PRESS RELIEF - OFF	29		
	29	CABIN PRESS			
		a. Decreases	→	29a. Surge tank pressure relief lost.	29a. Surge tank pressure relief valve leaking.
		b. No change in status	30		
	30	SURGE TANK PRESSURE RELIEF - NORMAL	31		
	31	SURGE TANK - OFF	32		
	32	CABIN PRESS			
		a. Decreases	→	32a. Gross leak protection and primary source of O ₂ after CSM separation eliminated or degraded. Entry tank will supply 1 lb O ₂ after CSM separation.	32a. Leak in surge tank.
		b. No change in status	33		
33	SURGE TANK - ON	34			
34	Verify PLSS FILL valve - CLOSED and CAP - INSTALLED	35			

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
21. (Cont)	35	CABIN PRESS			
		a. Decreases	→	35a. Resume normal operations.	35a. PLSS FILL valve was not closed or was leaking through cap.
		b. No change in status	36		
	36	Verify ENTRY O ₂ TANK - OFF	37	36. Normally OFF	
	37	CABIN PRESS			
		a. Decreases	→	37a. Redundant O ₂ supply lost after CSM separation.	37a. ENTRY FILL valve not OFF and leak in entry tank assembly.
		b. No change in status	→	37b. Monitor O ₂ supply rate to determine mission status.	37b. Leaking O ₂ supply subsystem line upstream of oxygen flow transducer.
<p>WARNING: If the leak is not isolated, but CABIN PRESSURE returns to normal, the ENTRY O₂ TANK could have leaked to zero. To check the ENTRY O₂ TANK, monitor the surge tank O₂ pressure and place the ENTRY O₂ TANK valve to FILL. A decrease in surge tank pressure indicates the entry tank had leaked. Place ENTRY O₂ TANK valve OFF. If leak excessive SURGE TANK only supply after CSM separation.</p> <p>NOTE: If leak is not isolated and continues to deplete O₂ supply - mission time may be extended by shutting off the main O₂ regulators (or SM O₂ SUPPLY CONTROL if leak upstream of main regulator) and only opening valve as required. If SM O₂ SUPPLY CONTROL is turned OFF; isolate surge tank to maintain SURGE TANK PRESSURE. If main O₂ regulators are shut off; isolate Water & Glycol Tanks pressure to retain system operation (cycle open each time O₂ cycled on).</p>					
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
22. PRESS CABIN LOW (< 4.8 psia)				Normal cabin pressure $> 4.8 < 5.2$ psia.	
WARNING: Maintain full suited mode if cabin pressure ≤ 4.8 psia and decreasing.					
	1.	Verify both CABIN PRESS RELIEF valves - NORMAL	2		
	2.	Verify WMS OVBD DRAIN-OFF	3		
	3.	PRESS-CABIN			
	a.	Increases		3a. Corrected by valve verification.	
	b.	Still decreasing	4		
	c.	Stabilized < 4.8 psia	→		3c. Reg-colibration shift
	4.	Suit Pressure			
	a.	Normal	→	4. MDC or cuff pressure indicator	
	b.	Low	5	4b. Approximately same as cabin pressure	4a. Cabin Pressure sensor/indicator failure

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
22 (continued)	5	L. H. CABIN PRESS RELIEF VALVE-CLOSE	6		
	6	PRESS CABIN			
		a. Increases	→	6a. Maintain CLOSE position on L. H. Cabin Pressure Relief Valve and maintain auto cabin press. control by R. H. cabin press relief valve. Redundancy lost.	6a. L. H. Cabin Pressure Relief Valve failed open.
		b. Low and decreasing	7		
	7	L. H. CABIN PRESS RELIEF VALVE - NORMAL	8		
	8	R. H. CABIN PRESS RELIEF VALVE - CLOSED	9		
	9	PRESS CABIN			
		a. Increases	→	9a. Maintain CLOSE position on R. H. cabin pressure relief valve and maintain auto cabin press control by L. H. cabin press. relief valve. Redundancy lost.	9a. R. H. Cabin Pressure Relief Valve failed open
		b. Low and decreasing	→	9b. Maintain cabin pressure as required by opening DIRECT O ₂ valve.	9b. Both cabin pressure Regs and both emergency inflow valves failed or excessive cabin leakage.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
25. TEMP CABIN HIGH				NORMAL CABIN TEMP 70-80° F	
	1	Verify: a. CABIN HX exhaust flowpath unobstructed b. Verify individual operation of each CABIN AIR FAN. c. CABIN TEMP SWITCH - AUTO d. CABIN TEMP THUMBWHEEL - FULL DECREASE		1b. If one fan is inoperative, place fan closure over inlet of disabled fan.	
	2	CABIN TEMP a. Decreases to NORMAL b. Remains HIGH	→ 3	2. Check at outlet with hand held psychrometer 2a. Corrected by step 1	2a. Control misposition
	3	Crew Comfort a. Comfortable b. HIGH temp - Crew uncomfortable	→ 4	3. Unsited 3a. Crew comfort, or hand held psychrometer dry bulb reading used for cabin temp indications	3a. Cabin temp sensor /circuitry failure
	4	CABIN TEMP SWITCH - MAN	5		
	5	CABIN TEMP VALVE - FULL COOL	6	5. Manual valve	
	6	TEMP CABIN a. Decreases to NORMAL b. Remains HIGH	→ →	6a. Reposition manual valve as required (S/C coolant thermal change) to maintain cabin temp 6b. If uncomfortable Don PGA's for temp control.	6a. Auto control of cabin temp. 6b. All cabin temp control lost.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
24. Cabin Temperature low.	1.	Verify: a. CABIN HX exhaust flowpath unobstructed b. Verify individual operation of each CABIN AIR FAN c. CABIN TEMP SWITCH - AUTO d. CABIN TEMP THUMBWHEEL-FULL INCREASE	2	Normal cabin temp. 70-80°F 1b. If one fan is inoperative place fan closure over inlet of disabled fan.	
	2.	Cabin temperature a. Increases to NORMAL b. Remains LOW	→ 3	2a. Corrected by step 1 3. Unsited	
	3.	Crew comfort a. LOW TEMP (Crew discomfort) b. Comfortable	4.	→ 3b. Crew comfort, or handheld psychrometer dry bulb reading used for cabin temp. indication.	3b. Cabin temp. sensor/circuitry failure.
	4.	CABIN TEMP SWITCH - MANUAL	5.		
	5.	CABIN TEMP VALVE-FULL HOT	6	5. Manual valve	
	6.	TEMP CABIN a. Increases to NORMAL b. Remains low	→	6a. Reposition manual valve as required (S/C coolant thermal change) to maintain cabin temp. 6b. If uncomfortable don PGAS for temperature control.	6b. Cabin temp. control lost.
NOTE: Cabin temperature may be increased by powering up equipment and S/C orientation. Condensation will be evident with cabin temperature below 50°F.					
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
25. HIGH CABIN HUMIDITY				High humidity noted by crew discomfort or condensation within the C/M - probably on Cabin HX louvers. Determine relative humidity or dew point by using hand held pshchrometer.	
NOTE: Examine CABIN INTERIOR FOR WATER LEAKS & ISOLATE LEAKS					
	1.	Verify SUIT CIRCUIT RETURN AIR CHECK VALVE - OPEN & intake screen clean and flow-path unobstructed.	2	1. Suit compressors must be off while vacuuming return air screen.	
	2.	HUMIDITY			
	a.	No Decrease	→	2a. Refer to ECS Malfunction Procedure No. 17	
	b.	Decreases	→	2b. Corrected by Step 1.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
31. GLYCOL TEMP LOW C & W-Lite - ON				Lite trigger: -30° F. Glycol becomes slyshy @ <-30°F; if temp is not increased radiator freezing is probable with resulting loss of radiator cooling capability. However, radiator outlet temp should not be maintained <30°F for extended periods to preclude slow recovery response and progressively poorer performance.	
	1	ECS RAD OUTLET TEMP:			
		a. NORMAL: >30°F	30		
		b. LOW: <30°F	2		
ECS RAD OUT TEMP LOW 30°F	2	ECS RADIATOR TEMP 1+2		2. Try to ascertain which radiator may be causing problem	
		a. BOTH NORMAL	29		
		b. ONE LOW	21		
		c. BOTH LOW	3		
	3	Verify ECS RAD #1 (A) - OFF	4	3-6. Verify valve positions for condition of radiator outlet temp <35° F	
	4	Verify ECS RAD #1 (B) - Open	5		
	5	Verify ECS RAD #2 (A) - OFF	6		
	6	Verify ECS RAD #2 (B) - Open	7		
	7	ECS RAD OUTLET TEMP			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
31. (Cont)		a. LOW: < 30°F b. NORMAL: > 30°F	8 →	7b. Exercising radiator isolation valves has alleviated problem.	
<p>NOTE: Radiator temp can be increased by diverting a portion of the hot glycol from the pumps to the radiators by manually overriding the GLYCOL EVAP TEMP IN valve. However, caution should be used to maintain 40-48° F evaporator outlet temperature.</p> <p>NOTE: Normal evaporator outlet temperature varies with mode of operation 40-43° F in evap mode, 42-48° F in mixing mode until Glycol temp in (mixing) valve full closed, and then to 49-50.5° F before the evap mode is initiated.</p>					
	8	GLYCOL EVAP TEMP IN (sw) - MAN	9		
	9	GLYCOL EVAP TEMP IN - max. cool (CCW)	10	9. Divert max. hot glycol flow to radiators.	
	10	GLY EVAP OUTLET TEMP:		10. Allow time for max. hot glycol flow to circulate through ECS radiators.	
		a. NORMAL: > 40°, < 48° F	12		
		b. LOW: < 40° F	11		
	11	GLYCOL EVAP TEMP IN - to HEAT (CW)	10	11. Divert some hot glycol flow to evaporator to maintain EVAP outlet temp > 40° F < 48° F	
	12	ECS RAD OUTLET TEMP			
		a. NORMAL: > 30° F	13		
		b. LOW: < 30° F	9	12b. If ECS RAD OUTLET TEMP does not increase after several attempts, proceed to step 17.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
31. (Cont)	13	GLYCOL EVAP TEMP IN (sw) - AUTO	14	13. Reestablishes auto control	
	14	ECS EVAP OUTLET TEMP			
		a. NORMAL: $>40^{\circ}$ F	17		
		b. LOW: $<40^{\circ}$ F	15		
	15	Switch electrical plug from J38 to J39.	16	15. Switch to spare glycol inlet sensor that controls GLY EVAP TEMP IN (mixing) valve.	
	16	ECS EVAP OUTLET TEMP			
		a. NORMAL	→	16a. Loss of redundant sensor to Glycol Temp Control Unit.	16a. Glycol sensor that inputs to Glycol Temp Control Unit failure.
		b. LOW	→		16b. Probable GLYCOL EVAP TEMP IN valve or Glycol Temp Control Unit failure.
	17	ECS RAD OUTLET TEMP.			
		a. LOW: $<30^{\circ}$ F	18		
		b. NORMAL: $>30^{\circ}$ F	→	17b. Transient condition.	
	18	When possible: Slow roll S/C to maximize Sun, Moon, and/or Earth heating on both radiator surfaces.	19	18. Add external heat to radiator surfaces.	
	19	Power S/C to maximize heat into coldplates.	20	19. Add heat to glycol loop.	
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NOTE: Loss of auto inlet glycol temp. control to glycol evap. Manual override of GLY EVAP TEMP IN valve can maintain evap. outlet temp $>40^{\circ}$ F, but will require constant crew attention. Powering up S/C Electronics and initiating S/C "slow roll" to increase radiator outlet temp. will alleviate crew attention to GLYCOL EVAP TEMP IN valve. However, increased water usage will result due to glycol evap. operation to maintain glycol evap. outlet temp to 40-43° F.

SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
31. (Cont)					
	20	ECS RAD OUTLET TEMP. a. NORMAL: > 30°F b. LOW: < 30° F			
			→	20a. Monitor ECS radiator temperatures until stable condition established.	
			→	20b. Loss of radiator cooling capability should be expected. Glycol evaporator only cooling means available. If required, S/C can be oriented so one of the radiators receives maximum external heat from Sun, Moon or Earth.	
ECS RADIATOR TEMP 1 (or 2) LOW	21	ECS RAD #1 (or 2) A - OFF	22	21-23. Check for proper RAD configuration for one RAD outlet temp low. (A circuit closed and B circuit open)	
	22	ECS RAD #1 (or 2) B - Open	23		
	23	ECS RAD OUT TEMP 1 (or 2) a. NORMAL: > 30°F b. LOW: < 30° F	24 25		
	24	ECS RAD OUTLET TEMP: a. LOW: < 30° F b. NORMAL: > 30° F	25 →	31b. Exercising radiator isolation valves has alleviated	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
31. (Cont)				problem.	
	25	Orient S/C with cold radiator towards heat source.	26	25. Maximize Sun, Moon, Earth heating on radiator surface.	
	CAUTION: Monitor the other radiator to avoid loss due to being on the cold side and freezing completely.				
	26	Power up S/C	27	26. Maximize heat input to cold plates.	
	27	ECS RAD OUTLET TEMP: a. NORMAL: >30°F b. LOW: <30°F	→	27a. Problem alleviated.	27b. Probable frozen radiator #1 (or #2)
			28	27b. Loss of 50% of radiator cooling capability.	
	28	Periodically monitor for indication of recovery	→		
	29	IF: a. GLYCOL TEMP LOW C & W lite - ON b. ECS RAD OUTLET TEMP. LOW: <-30°F c. ECS RAD OUT TEMP 1 & 2: NORMAL: >-30°F	→	29. Loss of glycol temp C & W and combined ECS Rad outlet temp indication. Use ECS RAD OUT TEMP 1, 2 meter to monitor radiator outlet temperature.	29. PROBABLE FAILURE OF TEMP SENSOR driving C & W lite and ECS RAD OUTLET TEMP meter.
	30	IF: a. GLYCOL TEMP LOW C & W lite - ON b. ECS RAD OUTLET TEMP: NORMAL: >-30°F c. ECS RAD OUT TEMP 1 & 2: NORMAL: >-30°F	→	30. Loss of radiator glycol outlet temp. low C & W indication. Use meters to monitor temp.	30. Probable C & W circuitry failure.
RAD TEMP INDICATOR/ SENSOR MALFUNCTION ISOLATION.					
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
32. HIGH ECS RAD OUTLET TEMP >97° F				With ECS RAD OUTLET TEMP >97° F the evaporator will be unable to maintain normal EVAP OUTLET TEMP (40-43° F)	
	1	ECS RADIATOR OUTLET TEMP.			
	a.	BOTH NORMAL: <97° F	→		1a. RAD OUTLET TEMP SENSOR/CIRCUITRY FAILURE.
	b.	BOTH HIGH: >97° F	2.		
	c.	1 or 2 HIGH: >97° F	5.		
	2	ECS RAD INLET TEMP			
	a.	< 97° F	3.		
	b.	> 97° F	4.		
	3	GLYCOL TO RAD VALVE - CLOSE	→	3. Serious heating in S/M. Possible fire or RCS firing on RAD.	3. Excessive heating in S/M.
	4	Power down	→	4. Refer to EPS Malfunction Procedure NO. 7 section 9.1.4.3 (Inverter 1, 2, or 3 ≥ 190° F)	
	5	Verify RAD isolation valves (4) open	6.		
	6	Orient S/C with hot RAD away from heat source.	→	6. Monitor temps for recovery	6. Probable single radiator restriction or S/C orientation
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
33. HIGH GLYCOL EVAPORATOR OUTLET TEMP (>50.5°F)				Normal Glycol Evaporator Out-let temp 40-50. 5° F depending on mode of operation. In the Evap mode, 40-43° F; mixing mode, 42-48° F and then when mixing valve full closed, 49-50.5° F before the Evap mode is initiated.	
	1.	ECS RAD OUTLET TEMP			
		a. < 49° F	2	1a. Evaporator operation not required.	
		b. > 49° F	15		
		c. > 97° F	→	1c. Refer to ECS Malfunction Procedure No. 31.	1c. HIGH ECS RAD OUTLET TEMP.
	2.	GLYCOL PRESS RELIEF BYPASS valves 1 and 2 - OFF	3		
	3.	GLYCOL EVAP OUTLET TEMP			
		a. Decreases	4		
		b. No change	5		
	4.	GLYCOL PRESS RELIEF BYPASS valves 1 and 2 open one at a time to isolate failed open relief valve	15	4. Radiator auto bypass relief redundancy lost and possible evaporator malfunction. Refer to step 15 to verify EVAP operation.	4. GLYCOL PRESS RELIEF BYPASS valve 1 and/or 2 relief failed open. And possible EVAP MALFUNCTION.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
33. (continued) WARNING: While switching		J38-J39, electrically deactivate		evaporator and mixing valves.	
	5	Switch EVAP SNSRS plug to redundant receptacle (J38 or J39)	6	5. Check alternate set of sensors for control of mixing valve.	
	6	GLYCOL EVAP OUTLET TEMP			
		a. Decreases to NORMAL: $45 \pm 3^\circ \text{F}$	→	6a. Sensor redundancy lost.	6a. J38 or J39 sensors failed
		b. No change	7		
	7	GLYCOL EVAP TEMP IN switch - MAN	8		
	8	GLYCOL EVAP TEMP IN valve - COOL	9	8. Set carefully to keep GLY EVAP OUTLET TEMP $45 \pm 3^\circ \text{F}$.	
	9	GLYCOL EVAP OUTLET TEMP			
		a. Decreases: $45 \pm 3^\circ \text{F}$	10		
		b. No response	11	9b. All control of mixing valve lost or EVAP OUTLET TEMP gage failure.	
	10	Maintain $45 \pm 3^\circ \text{F}$ at GLY EVAP OUTLET TEMP with GLYCOL EVAP TEMP in valve	→	10. Manual control of GLY EVAP TEMP IN (MIXING) valve required in mixing mode.	10. Sensor or controller failure.
	11	Plug EVAP TEMP SENSOR UNIT into J38 or J39.	12		
	12	EVAP TEMP SENSOR UNIT switch - INLET	13		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
33. (Cont)	13	GLY EVAP INLET TEMP			
		a. $< 50.5^{\circ} \text{ F}$	→	13a. Auto mixing usable, monitor inlet temperature	13a. EVAP OUTLET TEMP gage failure
		b. $> 50.5^{\circ} \text{ F}$	14		13b. GLYCOL EVAP TEMP IN (MIXING) valve failure
	14.	Power down to maintain GLY EVAP OUTLET $< 60^{\circ} \text{ F}$ (while in mixing mode)	→	14. Temperatures $> 50.5 < 60^{\circ} \text{ F}$ indicates a malfunction, but are acceptable for limited operation.	
NOTE: If unable to reduce temperature $< 60^{\circ} \text{ F}$ or power up required, manually operate evaporator to control EVAP OUTLET TEMP.					
	15.	GLY EVAP STEAM PRESS			
		a. $< 0.09 \text{ psia}$	16.	15a. Pressure low.	
		b. $> 0.09 < 0.18 \text{ psia}$	52	15b. Pressure within operating range. Possible glycol evap outlet temp gage failure or erroneous steam pressure indication.	
		c. $> 0.18 \text{ psia}$	26	15c. Pressure high. Possible back pressure valve controller failure or blocked steam duct.	
	16.	GLYCOL EVAP STEAM PRESS-MAN	17		
	17.	GLYCOL EVAP STEAM PRESS Switch - INCR (full closed)	18	17. Check for frozen or dry wick.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
33. (Cont)	18	POWER DOWN S/C	19	18. Reduce electrical load to contain over temp condition	
	19	GLY EVAP STEAM PRESS			
		a. Increases: 0.12-0.14 psia	20	19a. Wick was frozen and not completely dry.	
		b. No increase	21	19b. Wick dry.	
	20	GLY EVAP WATER CONTROL BYPASS - ON 30 Sec/OFF	22		
	21	GLY EVAP WATER CONTROL BYPASS - ON 1 MIN/OFF	22	21. Wick servicing. Delay 5 min. before reactivating Glycol evaporator in auto mode.	
	22	Switch EVAP SNSRS plug to redundant receptacle (J38 or J39)	23		
	23	GLYCOL EVAP STEAM PRESS - AUTO	24		
	24	GLY EVAP STEAM PRESS			
		a. NORMAL	25		
		b. LOW	31		
	25	GLY EVAP OUTLET TEMP			
		a. NORMAL	→ 25a.	Sensor redundancy lost.	25a. J38 or J39 sensor or controller failure.
		b. HIGH	31		
	26	GLYCOL EVAP STEAM PRESS - MAN	27		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
33. (Cont)	27	GLYCOL EVAP STEAM PRESS switch	28		
	28	GLYCOL EVAP STEAM PRESS			
		a. Decreases	29	28a. Possible loss of automatic back pressure control	
		b. No change	45	28b. Steam duct blocked	
WARNING: While switching J38-J39, electrically deactivate evaporator and mixing valve.					
	29	Switch EVAP SNSRS plug to redundant receptacle (J38 or J39)	30		
	30	GLYCOL EVAP OUTLET TEMP			
		a. NORMAL	→	30a. Sensor redundancy lost.	30a. J38 or J39 sensors failed.
		b. HIGH	31		
	31	Plug EVAP TEMP SENSOR UNIT into EVAP SNSRS J38 or J39	32		
	32	EVAP TEMP SENSOR UNIT switch - WICK	33		
	33	WICK temp			
		a. <40° F	34	33a. Probable frozen wick.	33a EVAP Frozen
		b. >40° F	37		
	34	GLY EVAP STEAM PRESS switch - increase until WICK temp 40° F	35	34. Closes back pressure valve to thaw wick and reestablish boiling about 15-30 min. required.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
33. (Cont)	35	GLY EVAP STEAM PRESS switch - AUTO	36		
	36	GLYCOL EVAP OUTLET TEMP			
		a. 40-43° F	→	36a. Frozen evap probably caused by transient condition	
		b. >43° F	38		
	37	GLYCOL EVAP STEAM PRESS switch - AUTO	38		
	38	EVAP TEMP SENSOR UNIT - NULL	39		
	39	Manipulate GLY EVAP H ₂ O switch between ON and OFF.	40	39. Manual control of water to wick.	
	40	GLY EVAP OUTLET TEMP			
		a. 40-43° F	→	40a. Automatic EVAP control lost (water only). Manual control possible when required using NULL position of EVAP TEMP SENSOR UNIT to control water flow with switch.	40a. GLY EVAP controller (water section) controller failure.
		b. >43° F	41		
	41	EVAP H ₂ O valve - OFF	42		
	42	Manipulate GLY EVAP WATER CONTROL BYPASS valve between ON and OFF	43	42. Manual control of water to wick	
	43	GLY EVAP OUTLET TEMP			

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
33. (Cont)		a. 40-43° F	→	43a. Manual bypass only water control to evap wick. Continue manual operation as required. Requires crewman at LHEB.	43a. EVAP WATER valve electrical failure.
		b. >43° F	44		43b. EVAP failure
	44	Power down to maintain EVAP OUTLET TEMP <60° F			
	45	Cycle STEAM/URINE DUCT HTR CB's MN A & MN B.	46		
	46	GLY EVAP STEAM PRESS switch - AUTO	47		
	47	GLY EVAP H ₂ O switch - OFF	48	47. Prevents added water inflow to evaporator.	
	48	Orient S/C with steam duct outlet to heatsource.	49	48. Attempt to thaw frozen duct outlet. Time required may be excessive.	
	49	Monitor GLY EVAP OUTLET TEMP			
		a. Decreases	50	49a. Duct clear and boiling resumed.	
		b. No decrease	51		
	50	GLY EVAP H ₂ O switch - AUTO	→	50. EVAP operation reestablished.	
	51	Power down to maintain EVAP OUTLET TEMP <60° F	→	51. Evaporator unusable as long as steam duct blocked. Cabin Pressure relief may not be possible through steam duct.	51. Blocked steam duct.

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R. B. Bouchard

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
33. (Cont)	52	Plug EVAP TEMP SENSOR UNIT into J38 or J39.	53		
	53	EVAP TEMP SENSOR UNIT switch - INLET	54		
	54	GLY EVAP INLET TEMP			
		a. >GLY EVAP OUTLET TEMP	→		54a. Gly Evap outlet temp gage failure.
		b. ≤GLY EVAP OUTLET TEMP	16		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
34. LOW GLYCOL EVAPORATOR OUTLET TEMPERATURE: <40°F.				Normal temperature range 40-50.5°F depending on operation mode.	
	1	ECS RAD OUTLET TEMP			
		a. >49-50.5°F	12	1a. Evaporator operating, but improper boiling.	
		b. <42°F	2	1b. GLY EVAP TEMP IN (MIXING) VALVE not allowing adequate Glycol bypass.	
WARNING: While switching J38-J39, electrically deactivate evaporator and mixing valve.					
	2	Switch EVAP SENSOR to redundant plug (J38 or J39)	3		
	3	GLY EVAP OUTLET TEMP			
		a. Increases to normal (42-48°F)	→	3a. Loss of redundant sensors	3a. Sensor failure.. J38-J39.
		b. No change	4		
	4	GLYCOL EVAP TEMP IN switch - MAN	5		
	5	GLYCOL EVAP TEMP IN valve - CW (HEAT)	6		
	6	GLY EVAP OUTLET TEMP			
		a. Increases	7		6a. Automatic Glycol mixing control lost.
		b. No change	8	6b. Possible indicator failure	
	7	Adjust for 45° ±3°F at GLYCOL EVAP OUTLET TEMP.	→	7. Manual control of mixing valve required when ECS RAD OUTLET TEMP 40°F to prevent wick freezing.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
34. (Continued)	8	GLYCOL EVAP TEMP IN switch - AUTO	9		
	9	Plug EVAP TEMP SENSOR UNIT into EVAP SNSRS J38 or J39	10		
	10	EVAP TEMP SENSOR UNIT - INLET	11		
	11	Evaporator INLET TEMP	→		11a. GLY EVAP OUTLET TEMP indicator failure.
		a. 45°F ±3°F			
		b. <42°F	→	11b. Glycol bypass lost. Radiator outlet temperature must be maintained >40° to prevent evaporator wick freezing and out of tolerance evap outlet temp.	11b. GLYCOL EVAP TEMP IN (MIXING) valve failed closed.
	12	GLY EVAP STEAM PRESS			
		a. <0.09 psia	13	12a. Boiler cold or freezing.	
		b. >0.09 <0.12 psia	16		
		c. >0.12	19	12c. Probable Evap outlet temp gage failure.	
	13.	GLYCOL EVAP STEAM PRESS - MAN	14		
	14.	GLYCOL EVAP STEAM PRESS-INCR(full)	15.	14. Close back pressure valve.	
	15.	GLY EVAP STEAM PRESS			
		a. Increases: 70:12	16		
		b. No increase	→	15b. Control of evaporator lost.	15b. Back pressure valve failed open.
WARNING: While switching J38-J39, electrically deactivate evaporator and mixing valve.					
	16.	Switch evap sensor to redundant plug (J38 or J39) and GLYCOL EVAP STEAM PRESS AUTO			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
34. (continued)	17	GLY EVAP STEAM PRESS			
		a. NORMAL	18		
		b. LOW	19		
	18	GLY EVAP OUTLET TEMP			
		a. 40-43°F		18a. Sensor redundancy lost	18a. Sensor J38 or J39 failed.
		b. < 40°F			
	19	Plug EVAP TEMP SENSOR UNIT into EVAP SNSRS J38 or J39.	20		
	20	EVAP TEMP SENSOR UNIT - WICK	21		
	21	WICK TEMP			
		a. > 40°F	22		21a. GLY EVAP OUTLET TEMP indicator failure.
		b. < 40°F	23		
	22	GLYCOL EVAP STEAM PRESS - AUTO	→	22. Automatic operation of evaporator re-established.	
	23	GLYCOL EVAP H ₂ O FLOW switch - OFF	→	23. De-energizes Glycol Evaporator operation.	23. Back pressure controller failed.
<p><u>NOTE:</u> Maintain Radiator outlet temperature < 60°F. For high load conditions and entry the glycol evaporator can be used, but not recommended for normal operation due to probable freezing and inefficient H₂O usage.</p>					
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
37. PRESS GLY DISCH - LOW: <34 PSIA or decreasing	1	GLY ACCUM QUANTITY: a. NORMAL: 30-60% (and steady) b. LOW: < 30% (and/or decreasing)	18 2	1b. System leakage.	
GLY ACCUM QUANTITY LOW: < 30%	2	GLYCOL ACCUMULATOR valve - OFF (CW)	3	2. Isolates accumulator	
	3	GLY ACCUM QUANTITY a. Decreasing b. Stabilized	4 5	3b. Glycol accum not leaking.	3a. Glycol accumulator leaking
	4	GLYCOL RESERVOIR INLET valve-ON	→	4. Reservoir replaces accumulator for remainder of mission.	
	5	GLYCOL ACCUMULATOR valve-ON (CCW)	6		
	6	GLY TO RAD valve - CLOSE	7	6. Assumes GLYCOL PRESS RELIEF BYPASS valves - OPEN. Bypasses all glycol flow around radiator. Not to exceed 30 minutes to avoid radiator freezing.	
	7	PRESS GLY DISCH: a. Remains LOW b. NORMAL: > 34 psia	13 8	7b. Probable leak in ECS radiators.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
37. (Cont)	8	ECS RADIATOR (4) - OFF	9	8. Radiator isolation valves closed (17 sec required for valve travel).	
	9	GLY TO RAD valve - OPEN	10		
	10	PRESS GLY DISCH:			
		a. Remains NORMAL	12		
		b. Decreases: < 34 psia	11		10b. Leakage in S/M lines.
	11	GLY TO RAD valve - CLOSED	→	11. Leak cannot be isolated to individual radiator circuit. Radiators must be isolated to conserve glycol. Loss of all radiator glycol cooling. Glycol evaporator only cooling means available.	
	12	Open ECS Radiator Isolation valves one at a time (monitor glycol discharge pressure for decrease) to isolate leaking radiator circuits. Re-close valve where leak indicated.	→	12. Leaking sections of radiator isolated. About 25% cooling lost for each circuit isolated.	12. Partial Radiator failure; with leakage in Rad 1a, 1b, 2a and/or 2b.
	13	GLY TO RAD valve - OPEN	14	13. Re-establish flow to radiators.	
	14	Verify: SUIT EVAP switch - MAN SUIT EVAP water valve - OFF	15	14. Assure Suit Evaporator does not start when Glycol bypassed around suit heat exchanger.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
37. (Cont)	15	SUIT EVAP GLYCOL valve - OFF	16	15. Directs glycol flow around suit heat exchanger	
	16	PRESS-GLY DISCH	17	16a. Unable to isolate glycol system leakage. Eventual loss of entire glycol supply with resulting loss of total space-craft thermal control	16a. Glycol system leakage.
		a. Remains LOW:			
		b. NORMAL:	→	16b. Loss of suit cooling capability with suit heat exchanger Suit evap. only means available for suit circuit cooling.	16b. Glycol leak internal to suit heat exchanger.
	17	SUIT EVAP GLYCOL valve - ON	→		
	18	ECS GLYCOL PUMP SELECTOR SWITCH- Select alternate pump and/or bus and verify C/B's.	18		
	19	PRESS-GLYCOL DISC	→	19a. Pump or bus redundancy lost. Continue operation on active bus or functional glycol pump	19a. Electrical or pump failure.
		a. Normal: >34 psia			
		b. Remains LOW:	20		
20	MSFN CF0550P		20. Check glycol ΔP across cold plate net # 2.		
	a. NORMAL:	→	20a. Loss at glycol pump outlet pressure indication. Use CF0550P as glycol flow indication	20a. Glycol Pumps Outlet Press. Sensor /Circuitry Failure.	

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
37. (Cont)		b. LOW:	→	20b. Complete loss or degraded glycol pump capability. Probable loss of spacecraft thermal control.	20b. BOTH GLYCOL PUMPS or circuitry failure.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
39. GLY ACCUM QUANTITY - HIGH: increasing >70%	1	Verify a. GLYCOL ACCUM S/O valve-OPEN b. GLYCOL RESERVE valve-CLOSED c. GLYCOL RESERVOIR INLET/OUT- LET valves - CLOSED d. GLYCOL RESERVOIR BYPASS valve - OPEN	2	1. Establish system configura- tion	
NOTE: Glycol accumulator pressure is referenced to Cabin Pressure - hence any glycol accumulator quantity <100% cannot result in coolant loop overpressurization. Normal accumulator quantity 30-60%.					
	2	GLYCOL RESERVOIR INLET valve - OPEN	3	2. Permits transfer of glycol from accumulator to reservoir.	
	3	GLY ACCUM QUANTITY indicator a. 70% b. No decrease	4 → 5	3b. Quantity indication lost, use reservoir for positive accumulator action.	3b. Indicator failure
	4	GLYCOL RESERVOIR INLET valve - CLOSED			
	5	GLY ACCUM QUANTITY a. Remains normal or slow increase b. Rapid increase	→ 6	5a. Repeat steps 3-4 as re- quired to maintain normal pressure.	5a. Slow leakage of GLYCOL RESERVE valve
	6	GLYCOL RESERVOIR INLET valve - OPEN	→	6. Glycol reservoir used for accumulator action	5b. Large leakage of GLYCOL RESERVE valve.
PREPARED BY: <u>J. Baker</u> <u>T.O. Montgomery</u> <u>R. Boxler</u>		FLIGHT CREW SUPPORT DIVISION DATE: JAN 27, 1967		APOLLO OPERATIONS HANDBOOK ENVIRONMENTAL CONTROL SYSTEM MALFUNCTION PROCEDURES	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
47. POTABLE HOT H ₂ O TEMPERATURE LOW					
	1	POT H ₂ O HEATER			
		a. OFF	2		
		b. MN A or B	3		
	2	POT H ₂ O HEATER - MN A or B	→	2. Inadvertant switch position	
	3	POT H ₂ O HEATER - alternate Bus (MN A ² or B)	4		
	4	HOT H ₂ O TEMP.			
		a. Increases	→	4a. Power supply redundancy lost. Approx. one hour recovery time required.	4a. Circuitry failure from MN A or B bus.
		b. No Increase	→	4b. Hot H ₂ O supply lost or re- covery time extended.	4b. Heater failed or degraded. Loss of one or both heater elements.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
42. POTABLE H ₂ O QUANTITY fails to increase on transfer.				Assume proper valve configuration and H ₂ O IND switch - POT.	
		1. WASTE H ₂ O TK REFILL - 2 (alternate tank)	2.	1. Attempts transfer from redundant SM tank.	
		2. WATER QUANTITY (Potable)			
		a. INCREASES	→	2a. One SM WASTE H ₂ O TANK (56#) unusable or empty.	2a. No. 1 or 2 SM WASTE H ₂ O SOLENOID S/O Valve or circuitry failure.
		b. NO INCREASE	3.		
		3. Continue normal transfer procedure	4.	3. No evidence of transfer on quantity indicator; however, transfer may be in progress if indicator failed.	
		4. WATER QUANTITY (Potable)			
		a. NO CHANGE	→	4a. Monitor MSFN CF 0126 P for pressure increase to overcome WASTE TANK INLET & RELIEF VALVE ΔP - indicating full POTABLE TANK. Then monitor MSFN CF0127P for increase indicating potable tank full	4a. Gage failure
		b. DECREASES	→	4b. Water did not transfer. Potable water only sure water supply remaining.	4b. N ₂ transfer system failure or line blockage.
	WARNING: Monitor fuel cells for possible flooding				
PREPARED BY: J. Baker V.O. Montgomery R. Bulwara		FLIGHT CREW SUPPORT DIVISION		ENVIRONMENTAL CONTROL SYSTEM MALFUNCTION PROCEDURES	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
43. WATER QUANTITY DECREASE RATE HIGH	1	WASTE TANK WATER & RELIEF VALVE - CLOSE	2		
	2	WATER usage rate			
		a. Normal	→	2a. Potable water being used with waste water. Waste tank Inlet Relief valve must be operated manually, and closed for water transfer.	2a. Waste Tank Inlet Relief valve failure.
		b. High	3		
	3	WASTE TANK WATER & RELIEF VALVE - AUTO	4		
				Rate of decrease on Potable Water quantity indicator greater than expected for operation mode or as indicated by MSFN.	
	4	WATER CONTROL PRESSURE RELIEF - OFF	5		
	5	WATER QUANTITY			
		a. Decrease rate normal.	6		
		b. Decrease rate remains high	→	5b. Monitor cabin humidity. Check for water in CM.	5b. Line leakage.
	6	WATER CONTROL PRESSURE RELIEF-1	7		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
43. (Cont)	7	WATER QUANTITY			
		a. No change	→	7a. Relief valve redundancy lost.	7a. No. 2 WATER CONTROL PRESSURE RELIEF Valve failed OPEN.
		b. Excessive decrease rate	8		
	8	WATER CONTROL PRESSURE RELIEF - 2	9		
	9	WATER PRESSURE			
		a. Rate decreases	→	9a. Relief valve redundancy lost.	9a. No. 1 WATER CONTROL PRESSURE RELIEF valve failed OPEN.
		b. Rate remains high.	10		9b. Both WATER CONTROL PRESSURE RELIEF Valves failed open.
	10.	WATER CONTROL PRESSURE RELIEF - OFF	→	10. Automatic pressure relief lost. Refer to ECS Malfunction Procedure No. 45 to control Water pressure. Manual relief valve operation possible when MSFN water pressure information available.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
44. GAS LEAKAGE INTO H ₂ O SUBSYSTEM				It is possible to introduce O ₂ , N ₂ or H ₂ into the Potable or Waste Water subsystem.	
<p>WARNING: Gas in Waste H₂O subsystem is not readily identifiable however probable with gas in potable H₂O subsystem. Reduced evaporator performance may be expected as well as a false indication of quantity of on-board H₂O. Pressure measurements not indicative of H₂O quantity.</p>					
	1	GAS IN POTABLE H ₂ O SUBSYSTEM			
		a. Gas entrainment evidenced - but not excessive.	→	1a. Monitor H ₂ O/gas ratio for continued H ₂ O subsystem degradation.	
		b. Gas entrainment excessive	2		
	2	POTABLE WATER - Quantity			
		a. Constant 100% full	→	2a. Refer to ECS Malfunction Procedure NO. 1.	2a. O ₂ leakage into H ₂ O supply subsystem. Probable Potable tank bladder leak or rupture.
		b. < full	3		
	3	Fill fecal bag with gas and Gas chromatograph sniffer installed in bag.	4	3. 80 min cycle to determine type gas (H ₂ , N ₂ or O ₂)	
	4	Gas chromatograph indication			
		a. H ₂	→		4a. Excessive H ₂ inflow from F/C.
PREPARED BY: J. Barker		FLIGHT CREW SUPPORT DIVISION		ENVIRONMENTAL CONTROL SYSTEM	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
44. (Cont)		b. N ₂	→	4b. Use alternate S/M water tank for futher water transfer (if water had been transfered).	4b. N ₂ transfer system bladder rupture.
		c. O ₂	→		4c. Small O ₂ leak.

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
45. POTABLE & WASTE WATER SYSTEM PRESSURE HIGH (≥48 psid) MSFN CF0326P and CF0327P				Water not relieving overboard. Failure to dump water will probably be noted by failure to dump urine. Another indication will be MSFN overpressure of POTABLE & WATER TANKS. Loss of fuel cells may be a consequence of water system overpressurization.	
NOTE: Withdraw potable water as required to maintain safe water pressure.					
	1	Monitor MSFN for pressure indications until failure corrected			
		a. Pressure remains stable	→	1a. Overboard dump not obstructed or Waste Water tank never filled.	1a. Relief setting shift.
		b. Pressure increases	2	1b. Waste Water tank full and overboard dump obstructed.	1b. Overboard dump obstructed
	2	Withdraw Potable Water to maintain safe pressure	3	2. Continue to withdraw water as required until malfunction corrected or re-entry to preclude fuel cell flooding.	
	3	Waste Management selector Valve- URINE FECES	4	3. Check for suction to determine status of urine dump port.	
		OVBD VALVE - DUMP then both OFF.			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
45. (Cont)	4	SUCTION			
		a. NORMAL	6	4a. Dump port unobstructed	
		b. DEGRADED or NONE	5	4b. Refer to ECS Malfunction Procedure No. 51.	4b. Overboard dump port obstructed.
	5	Withdraw Potable Water to maintain safe pressure.	→	5. Continue to withdraw water as required until malfunction corrected or re-entry to preclude fuel cell flooding.	
	6	Cycle PRESSURE RELIEF SELECTOR Valve	7	6. Attempt to clear possibly clogged valve posts.	
	7	WATER PRESSURE		7. MSFN indication	
		a. DECREASES	→	7a. Failure corrected and normal relief available.	7a. Clogged PRESSURE RELIEF SELECTOR Valve
		b. NO DECREASE	8		7b. Relief line blockage or both relief valves failed closed.
	8	Withdraw Potable Water to maintain safe pressure.		8. Continue to withdraw water as required until re-entry to preclude fuel cell flooding. Relief capability lost. Dump excess water through waste management system or store in urine bags.	

NOTE: If one or both SM WASTE H₂O TANKS have been transferred to CM tanks place the WASTE H₂O TK REFILL switch in position 1 or 2 (used tank). Excess fuel cell water will be stored in SM WASTE H₂O TANKS (56 lb each) until filled. Water pressure will increase again when SM tanks fill. Normal water transfer available when required; however MSFN pressure monitoring required to preclude overpressurization of water system.

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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
51. UNABLE TO DUMP URINE.	1	Verify WASTE MANAGEMENT SELECTOR-URINE FECES.	2		
	2	Verify WASTE MANAGEMENT OVBD DRAIN - DUMP	3		
	3	Verify Q/D and urine hose/receptacle	4		
	4	URINE OVERBOARD DUMP			
	a.	DUMPS	→	4a. Resume normal ops. Corrected by steps 1 - 3.	
	b.	DOES NOT DUMP	5		
	5	Cycle ECS STEAM DUCT HTR MN A C/B			
	6	URINE OVERBOARD DUMP.		6. Allow time for urine tip htr. operation.	
	a.	DUMPS	→	6a. Continue normal ops.	6a. Open C/B circuit
	b.	DOES NOT DUMP	→	6b. Orient S/C for max. heat on urine overboard dump port to clear probable ice blockage. Use onblard urine containers if line remains blocked.	6b. URINE TIP HTR failure or line blockage.
<p>NOTE: BATTERY VENT, fecal canister vacuum and OVERBOARD WATER DUMP capability loss probable. Monitor RAD INLET and OUTLET temp limits (due to S/C orientation restrictions).</p>					
PREPARED BY: <u>J. Baker</u> <u>T.O. Montgomery</u> <u>R. Bondure</u>		FLIGHT CREW SUPPORT DIVISION DATE: JAN 27, 1967		ENVIRONMENTAL CONTROL SYSTEM MALFUNCTION PROCEDURES	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
52. LOW VACUUM SUCTION	1	Verify WASTE MANAGEMENT SELECTOR-VACUUM CLEANER	2		
	2	Verify hose integrity	3		
	3	SUCTION			
	a.	NORMAL	→	3a. Resume normal use. Corrected by steps 1 & 2.	
	b.	No change in status	4		
	4	Change FILTER	5		
	5	SUCTION			
	a.	NORMAL	→	5a. Resume normal use.	5a. Filter clogged or expended.
	b.	No change in status	6		
	6	Cycle ECS CABIN AIR FAN AC 1 (3) C/B's	7		
	7	SUCTION			
	a.	NORMAL	→	7a. Resume normal use.	7a. C/B circuit failure.
	b.	No change in status	→	7b. Vacuum cleaner use lost or degraded.	7b. Vacuum cleaner FAN failure or line blockage.
	NOTE: Suit circuit return air ck valve assy screen must be cleaned manually as required.				
PREPARED BY: <i>J. Baker</i> <i>T.O. McFarlane</i> <i>R. Boulware</i>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
53. FECAL CANISTER VACUUM -- LOW	1	Verify FLUSH VALVE - OPEN	2		
	2	Verify FECAL CANISTER, hose assembly, and Q/D integrity.	3		
	3	Verify WASTE MANAGEMENT SELECTOR- URINE FECES	4		
	4	Verify WASTE MANAGEMENT OVERBOARD DRAIN - DUMP	5		
	5	FECAL CANISTER VACUUM			
		a. NORMAL	→	5a. Resume normal ops. Corrected by steps 1 - 4.	
		b. Remains LOW	6		
	6	Cycle ECS STEAM DUCT HTR MN A C/B	7		
	7	FECAL CANISTER VACUUM		7. Allow time for urine tip htr operation.	
		a. NORMAL	→	7a. Continue normal ops.	7a. Open C/B circuit
	b. Remains LOW	→	7b. Orient S/C for max. heat on urine overboard dump port to clear probable ice blockage. Use Fecal bags without canister if vacuum remains low.		
<p>NOTE: BATTERY VENT, URINE DUMP and OVERBOARD WATER DUMP capability loss probable. Refer to ECS Malfunction Procedure NO. 45. Monitor RAD INLET and OUTLET temp limits (due to S/C orientation restrictions)</p>					
PREPARED BY: <u>J. Baxen</u> <u>T.O. Montgomery</u> <u>R. Bondufara</u>		FLIGHT CREW SUPPORT DIVISION DATE: JAN 27, 1967		APOLLO OPERATIONS HANDBOOK ENVIRONMENTAL CONTROL SYSTEM MALFUNCTION PROCEDURES S/C 012 SECTION 9.1.6 REV FINAL PAGE 78	

SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
61. Inadequate Ventilation after landing.				ATTITUDE CONTROL SWITCH will automatically close EXTERIOR AIR INTAKE and CABIN AIR EXHAUST valves and shut off fan if C/M tilts > 60° from vertical. Assume stable 1 position.	
	1	Visually verify valve positions (2).			
		a. Open	3		
		b. Closed	2		
	2	Verify EXTERIOR AIR INTAKE and CABIN AIR EXHAUST valve LOCK PINS - REMOVED.	3		
	3	POST LANDING VENT FAN - OFF/HIGH and LOW	4	3. Try both HIGH and LOW positions for operation. Assume PLVC switch - NORMAL.	
	4	Visually verify valve positions.			
		a. Open	7		
		b. Closed	5		
	5	PLVC switch - OPEN	6		
	6	Valve positions (2)			
		a. OPEN	7		
		b. CLOSED	→	6b. Alternate ventilation required. Egress may be required.	6b. POST LANDING VENT valves failed closed.
PREPARED BY: <u>J. B. [Signature]</u>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
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<u>R. [Signature]</u>				S/C 012 REV FINAL	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
62. Water inflow after landing. (after cabin press relief valves closed)				ATTITUDE CONTROL SWITCH will automatically close EXTERIOR AIR INTAKE and CABIN AIR EXHAUST valves and shut off fan if C/M titlts >60° from vertical.	
NOTE: Some water inflow expected until pressure relief valve closed.					
	1	Verify PLVC Switch - Normal	2		
	2	Verify CABIN PRESSURE RELIEF VALVES - CLOSED	3		
	3	Water C/M inflow			
		a. Terminates	→	3a. PLVC switch misposition.	
		b. Continues	4		
	4	POST LANDING VENT FAN - OFF	5		
	5	WATER C/M INFLOW			
		a. Terminates	→	5a. Resume ops. Manual control of Vent valves required.	5a. Pendulum Ring switch did not close Vent valves.
		b. Continues	→	5b. Reopen POST LANDING VENT Valves for ventilation (may increase leakage rate). Egress may be required.	5b. Probable C/M pressure vessel failure.
PREPARED BY: <u>J. Baker</u> <u>T.O. Montgomery</u> <u>R. Boxer</u>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
DATE: <u>JAN 27, 1967</u>		ENVIRONMENTAL CONTROL SYSTEM MALFUNCTION PROCEDURES		S/C <u>012</u>	REV <u>FINAL</u>
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PROCEDURES ENTRY SHEET

SECTION 9.1.7 SEQUENTIAL MALFUNCTION PROCEDURES

SYMPTOM	SYMPTOM NUMBER	STEP	PAGE
LIFT - OFF lightout & DET's not counting	1	1	2
NO AUTO ABORT light - ON	2	1	2
LET fails to JETT	3	1	2
SIVB fails to shutdown	4	1	5
SLA seperation not sensed	5	1	5
SLA seperation sensed but L/V ENGINE #1 light ON	5b	1	6
C/M - S/M fault to seperate	6	1	6
APEX COVER fails to automatically jettison	7	1	7
One or both drogue chutes fail to deploy automatically	8	1	7
Drogue chute fails to release or pilot chute fails to deploy automatically	9	1	8
One or more pilot chutes fail to deploy automatically	10	1	8
One or two drogue chutes fail to release	11	1	9
Main chutes fail to release	12	1	9
C/M in stable II position with no audible sound of 1 and 2 compressor	13	1	10
C/M in stable II position and compressors are running	14	1	10
Audible sound of two compressors but not in stable I condition in 10 min.	14a	2	11
Audible sound of one compressor but not in stable I condition in 15 min.	14b	1	12

SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
1. LIFT OFF light not illuminated & DET's - not counting	1	LIFT OFF/NO AUTO ABORT light - <u>press</u> .	2	(1) EDS auto abort circuit will be activated from alternate source. (2) DET's will start counting.	(1 & 2) Neither of the redundant lift off signals received from SIVB IU - therefore EDS auto abort circuit is inactive.
NOTE: 61 sec TD's will never be activated (no effect on mission since OX DUMP AUTO switch will be used as back-up at 61 sec elapsed time from lift off). LIFT/OFF light will remain extinguished.					
2. NO AUTO ABORT light - illuminates at lift off	1	LIFT OFF/NO AUTO ABORT light - <u>press</u> . (a) NO AUTO ABORT light - <u>extinguishes</u> . (b) NO AUTO ABORT light - remains <u>illuminated</u> .		(1a) EDS auto abort circuit is fully enabled. (1b) One or both of the EDS auto abort circuits is inactive & any subsequent abort should be initiated manually.	(1) One or both of the redundant EDS enable circuits is not activated.
3. Launch escape tower fails to jettison when LES MODE/TWR JETT SPS MODE switches 1 & 2 are placed to <u>TWR JETT SPS MODE</u> . a. Firing of frangible nuts only (audible)	1	LES MOTOR FIRE sw - <u>press</u> . (a) Tower jettisons.		(1a) Tower jettisoned with LE motor.	(1) TJM failed to operate.
PREPARED BY: <u>KBBenson</u>		FLIGHT CREW SUPPORT DIVISION		APOLLO OPERATIONS HANDBOOK	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
3a. (Cont)		(b) Tower fails to jettison.	2		(1b) Probable dual umbilical disconnect.
	2	LES MODE/TWR JETT SPS MODE - 1 & 2 sw - <u>TWR JETT SPS MODE</u> .	3		
	3	ABORT - THC - <u>CCW ROT</u> (Mode II) NOTE Modified SPS ABORT MODE II procedure to be established.	→		
b. Firing of tower jettison motor only (visual & audible)	1	Cycle LES MODE/TWR JETT SPS MODE 1 & 2 sw - from <u>TWR JETT SPS MODE</u> to <u>LES MODE</u> then back to <u>TWR JETT SPS MODE</u> .			(1) Frangible nuts failed to fire.
		(a) Frangible nuts fire.	2	(1a) Audible indication of frangible nuts firing can be detected.	
		(b) Frangible nuts did not fire.	3		
	2	LES MOTOR FIRE PB - <u>press</u> .	→	(2) Tower jettisoned with LE motor.	
	3	LES MODE/TWR JETT SPS MODE - 1 & 2 sw - <u>LES MODE</u> .	4		
	4	ABORT - THC - <u>CCW ROT</u> (Mode 1C)	5		
	5	Follow abort mode 1C until frangible nuts fire and tower is jettisoned with apex cover thrusters.	6	(5) Frangible nuts will fire through separate circuit path by ELS baroswitch closure.	
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
3b. (Cont) c. Firing of tower jettison motor but only partial firing of frangible nuts.	6	Set ELS-AUTO/MAN sw - <u>MAN</u> at $t < 1.6$ seconds after apex cover jettison	7	(6) Inhibits drogue parachute deployment after tower is jettisoned with apex cover to assure drogues do not deploy into tower structure.	(1) Partial failure of tower frangible nuts firing circuits (2 or more).
	7	Allow CM to free fall for 20 seconds.	8	(7) Allows time to gain distance between CM and tower structure.	
	8	ELS-AUTO/MAN sw - <u>AUTO</u> (approximately 15,000 feet).	9	(8) Drogue parachutes will deploy within 2 seconds.	
	9	Complete descent.	→		
	1	Cycle LES MODE/TWR JETT SPS MODE 1 & 2 sw - from <u>TWR JETT SPS MODE</u> to <u>LES MODE</u> then back to <u>TWR JETT SPS MODE</u> .			
		(a) Remaining frangible nuts fire.	2	(1a) Audible indication of frangible nuts firing can be detected.	
		(b) Remaining frangible nuts did not fire.	2		
	2	LES MOTOR FIRE PB - <u>press</u> .			
		(a) Tower jettisons.	→	(2a) Tower jettisoned with LE motor.	
		(b) Tower fails to jettison but CM separates from SM.	3	(2b) Tension ties and umbilical fails.	
	3	Proceed to Symptom 3b, step 3.	→		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
3c. (Cont) d. Neither the frangible nuts or the tower jettison motor fire.	1	Cycle LES MODE/TWR JETT SPS MODE 1 & 2 switches from <u>TWR JETT SPS MODE</u> to <u>LES MODE</u> & back to <u>TWR JETT SPS MODE</u> .			(1) Tower jettison motor has failed to ignite & frangible nuts have failed to fire via redundant tower jettison circuits.
		(a) Tower jettisons.	→	(1a) Tower has been jettisoned via redundant tower jettison circuits.	
		(b) Tower fails to jettison.			
	2	LES MODE/TWR JETT SPS MODE - 1 & 2 sw - <u>LES MODE</u>	3		
	3	ABORT - THC - CCW ROT (MODE 1C)	→	Frangible nuts & tower jettison motor will fire thru separate circuit path by ELS Baroswitch closure.	
4. SIVB fails to shutdown at proper time during orbital insertion-(L/V ENGINE #1 light does not come on.)	1	Rotate THC full <u>CCW</u> & return to <u>neutral</u> within one (1) second.	→	(1) SIVB engine will shut down via the SPS abort circuitry and a S/M direct ullage will take place during the time the THC is in the CCW position.	(1) Loss of SIVB engine cutoff signal.
WARNING: If THC is held CCW for 1.7 sec, an SPS abort will be initiated.					
5a. SLA separation not sensed, & L/V ENGINES #1 light fails to go out 1.7 sec after THC is rotated CCW while in earth orbit.	1	Return THC to <u>neutral</u> .	2	(1) Adapter separation will take place utilizing backup procedures.	(1) Redundant SPS abort circuits have failed to function.
	2	DIRECT ULLAGE PB - <u>press & hold</u> .	3		
	3	ADAPT SEP PB - <u>press</u> .	4		
	4	REACTION CONTROL SYS-CMD sw - <u>ON</u>	5		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
5a. (Cont)	5	Initiate +X translation with THC.	6		
	6	DIRECT ULLAGE PB - <u>release</u> . (a) Separates. (b) Does not separate.		(6b) Refer to procedure for S/M RCS Deorbit with SIVB attached.	
b. SLA separation is sensed but L/V ENGINES #1 light remains ON 1.7 sec after THC is rotated CCW while in earth orbit.	1	Procedure will be added.		(1) Non rigid attachment of harness between CSM & SIVB.	(1) S/M - SIVB/ adapter umbilical disconnect failed to separate.
6. C/M-S/M fails to separate when C/M-S/M SEP sw's are placed on.	1	Reset any of the following CB's & sw's that may be open. a. MESC A ARM BAT A (MDC-22) b. MESC B ARM BAT B (MDC-22) c. MESC A LOGIC BAT A (MDC-22) d. MESC B LOGIC BAT B (MDC-22) e. PYRO A SEQ A (MDC-150) f. PYRO B SEQ B g. RCS C/M-S/M TRANSFER MNA h. RCS C/M-S/M TRANSFER MN B i. C/M PROP JETT sw - <u>LOGIC</u> j. MESC LOGIC ARM 1 & 2 sw - <u>ON</u> k. MESC PYRO ARM 1 & 2 sw - <u>ON</u>		There is no other backup to C/M-S/M separation; therefore the only procedure is to check sw's & CB's and repeat the manual function.	Redundant C/M-S/M separation circuitry has failed to function.
	2	C/M-S/M SEP switches - back to <u>ON</u> .			
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
7. APEX COVER fails to jettison automatically between 24,900 & 21,500 feet during entry.	1	APEX COVER JETT PB - <u>press</u> .			(1) Redundant automatic ELS activate circuits have failed to function.
		a. Apex Cover jettisons.	→	(1a) Apex cover jettisons via back up circuit. Subsequent ELS EVENTS may have to be accomplished manually.	
		b. Apex Cover fails to jettison.	2		
	2	CANARD DEPLOY PB - <u>press & hold</u> for 4 seconds.		(2) Apex cover will jettison in 3.4 seconds. This procedure will operate the ELS activate circuits bypassing the ELS LOGIC switch, and permit automatic operation of APEX COVER & subsequent ELS EVENTS.	
8. One or both drogue chutes fail to deploy automatically 1.6 seconds after Apex Cover jettisons during entry.	1	DROGUE DEPLOY PB - <u>press</u> .		(1) Drogues will deploy via alternate redundant source which will bypass 2 sec timers. Subsequent ELS EVENTS may have to be accomplished manually.	(1) Redundant automatic drogue deploy circuits in SECS failed to function properly.
		(a) One or two drogues deploy.	→	(1a) Continue earth landing normally with one or two chutes.	
		(b) Neither of the drogues chutes have deployed.	2		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
8. (Cont)	2	Continue descent to 10,000 feet & at same time accomplish the following to enable SCS/RCS rate damping. (a) REACTION CONTROL SYS CMD sw - <u>ON</u> . (b) SCS CHANNEL sw (3) - B&D <u>ROLL</u> , <u>PITCH</u> , & <u>YAW</u> (up).	3		
	3	At indicated altitude of 10,000 feet, accomplish the following: (a) REACTION CONTROL SYS CMD - sw - <u>OFF</u> . (b) SCS CHANNEL - B&D ROLL, PITCH, & YAW sw (3) - <u>OFF</u> . (c) MAIN DEPLOY PB - <u>press</u> .			
9. Droogie chutes fail to release & pilot chute or chutes fail to deploy automatically at an indicated altitude of 9,000 feet during entry.	1	MAIN DEPLOY PB - <u>press</u> .	→	(1) Drogues will release & pilot chutes will deploy via alternate redundant source which will bypass 14 sec timers & 10K baro-switches.	(1) Redundant automatic drogue release & pilot chute deploy circuits in SECS failed to function properly.
10. One or more pilot chutes fail to deploy automatically.	1	MAIN DEPLOY PB - <u>press</u> .	→	(1) Pilot chutes will deploy via alternate redundant source which will bypass 14 sec timers & 10K baroswitches.	(1) Redundant automatic pilot chute deploy circuits in SECS failed to function properly.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE	
10. (Cont)						
CAUTION: The Main Deploy PB is to be operated within 1.0 sec after automatic pilot chute firing to insure simultaneous deployment of the main chute.						
11. One or two drogue chutes fail to release with main chutes deploying via pilot chutes.	1	No attempt should be made to release drogue chutes.		(1) Release of drogue chutes could damage or foul main chutes.	(1) Redundant automatic drogue chute release circuits failed to function properly.	
12. Main chutes fail to release when MAIN CHUTE RELEASE switch is placed <u>on</u> (up) after touch down.	1	(a) C/M in Stable I condition (APEX UP).	2		(1a) One or both of the release circuits in ELSC failed to function.	
		(b) C/M in Stable II condition (APEX DOWN).	4			
	2	Repeat actuation of MAIN CHUTE RELEASE sw - <u>on</u> (up).				
		(a) Main chutes release.	→			(2a) Go to Touchdown & Stabilization Procedure.
		(b) Main chutes fail to release.	3			
	3	Remove forward hatch, climb to top deck, and cut chutes loose with machete from survival kit.	→			
	4	Repeat actuation of MAIN CHUTE RELEASE sw.				
		(a) Main chutes release.	→			(4a) Go to Touchdown & Stabilization Procedure.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
12. (Cont)		(b) Main chutes fail to release.	5		
	5	Actuate flotation system,			
		(a) C/M uprights	2		
		(b) C/M does not upright		(5b) Go to Stable II egress checklist.	
13. C/M in Stable II condition (APEX DOWN) and a medium audible sound of 1 or 2 compressors is not heard when FLOAT BAG 1, 2 & 3 switches are placed to <u>FILL</u> position.	1	Set DC INDICATOR sw - <u>BAT BUS A(B)</u> .	2	(1) Nominal voltage should be 27-29 VDC (complete system draws approximately 35A).	(.) Batteries weak.
	2	Reduce battery loads by pulling CB's & switching off the functions that are not req'd.	3		
	3	Repeat actuation of FLOAT BAG switches.			
		(a) Compressors operate & C/M assumes Stable I.	→	(3a) Go to Post Stabilization & Ventilation Procedure.	
		(b) Compressors do not operate.	→	(3b) Go to Stable II Egress Procedure.	
14. C/M in Stable II condition (Apex down) - POST LAND-IND FLOAT BAG 1, 2, & 3 switches <u>FILL</u>	1	DC INDICATOR sw - <u>BAT BUS A (B)</u>		(1) No communications in Stable II.	
		(a) Battery voltage low.	2	(1a) Nominal voltage should be 27-29 V DC (complete system draws approximately 35 amps).	(1a) Batteries weak & causing low compressor output.
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
14a. Audible sound of two compressors heard but C/M does not upright to Stable I condition in 10 minutes NOTE Nominal upright time with two compressors = 6 minutes. Upright with one bag fail = 10 minutes.		(b) Battery voltage normal.	3		(1b) Possible leak in +Z, -Y, or +Y bag.
	2	Reduce battery loads by pulling CB's & switching off any functions not required.	3		
	3	POST LANDING FLOAT BAG 1 & 2 sw - <u>OFF</u> .	4		
	4	POST LANDING FLOAT BAG 3 sw - <u>FILL</u> . (a) C/M uprights to Stable I within 3 minutes. (b) C/M remains in Stable II after 3 minutes.	→	(4) Compressors will furnish air to +Z bag only. (4a) Comply with Post Stabilization & Ventilation Procedure & BAG 3 sw - <u>OFF</u> .	(4a) Possible leak in +Y and/or -Y bag. (4b) Possible leak in +Z bag and/or weak battery causing low compressor output.
	5	POST LANDING FLOAT BAG 2 sw - <u>FILL</u> .	6		
	6	POST LANDING FLOAT BAG 3 sw - <u>OFF</u> . (a) C/M uprights to Stable I within 3 minutes. (b) C/M remains in Stable II.	→	(6) Compressors will furnish air to -Y bag only. (6a) Comply with Post Stabilization & Ventilator Procedure & BAG 2 sw - <u>OFF</u> . (6b) Prepare for Stable II Egress Checklist.	(6a) Possible leak in +Z and/or +Y bag. (6b) Possible leak in -Y bag &/or weak battery causing low compressor output.
	7				
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
14a. (Cont) b. Audible sound of one compressor heard but C/M does not upright to Stable I in 15 minutes. NOTE Nominal upright time with one compressor = 12 minutes.	7	POST LANDING FLOAT BAG 1 sw - <u>FILL</u> .	8		
	8	POST LANDING FLOAT BAG 2 sw - <u>OFF</u> . (a) C/M uprights to Stable I within 3 minutes. (b) C/M remains in Stable II after 3 minutes.		(8) Compressors will furnish air to +Y bag only. → (8a) Comply with Post Stabilization & Ventilation Procedure & BAG 1 sw - <u>OFF</u> . → (8b) Comply with Stable II Egress Checklist.	(8a) Possible leak in +Z and/or -Y bag. (8b) Possible leak in +Y bag and/or weak battery causing low comp. output.
	1	DC INDICATOR sw - <u>BAT BUS A & B</u> . (a) Battery voltage low. (b) Battery voltage normal.		(1) No communications in Stable II. Nominal voltage should be 27-29 V DC.	(1) One compressor has failed.
			2		(1a) Batteries weak & causing low output on good compressor.
			3		(1b) Possible leak in +Z, -Y, or +Y bag.
	2	Reduce battery loads by pulling CB's & switching off any functions not req'd.	3		
	3	UPRIGHTING SYSTEM - COMPR NO. 1 or COMPR NO. 2 - pull CB's on bad compressor.	4		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
14b. (Cont)	4	POST LANDING FLOAT BAG 1 & 2 sw - <u>OFF</u> .	5		
	5	POST LANDING FLOAT BAG 3 sw - <u>FILL</u> . (a) C/M uprights to Stable I within 4 minutes. (b) C/M remains in Stable II after 4 minutes.	5 → 6	(5) Compressor will furnish air to +Z bag only. (5a) Comply with Post Stabili- zation & Ventilation Procedures & BAG 3 sw - <u>OFF</u> .	(5a) Possible leak in +Y and/or -Y bag. (5b) Possible leak in +Z bag and/or weak battery causing low output on com- pressor.
	6	POST LANDING FLOAT BAG 2 sw - <u>FILL</u> .	7		
	7	POST LANDING FLOAT BAG 3 sw - <u>OFF</u> . (a) C/M uprights to Stable I within 4 minutes. (b) C/M remains in Stable II after 4 minutes.	7 → 8	(7) Compressor will furnish air to -Y bag only (7a) Comply with Post Stabili- zation & Ventilation Pro- cedures & BAG 2 sw - <u>OFF</u> . (7b) Prepare for Stable II Egress Checklist.	(7a) Possible leak in +Z and/or +Y bag. (7b) Possible leak in -Y bag and/or weak battery causing low output on compressor.
	8	POST LANDING FLOAT BAG 1 sw - <u>FILL</u> .	9		
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SYMPTOM	STEP	PROCEDURE	NEXT STEP	REMARKS	FAILURE
14b. (Cont)	9	POST LANDING FLOAT BAG 2 sw - <u>OFF</u> . (a) C/M uprights to Stable I within 4 minutes. (b) C/M remains in Stable II after 4 minutes.	 → →	(9) Compressor will furnish air to +Y bag only. (9a) Comply with Post Stabilization & Ventilation Procedures & BAG 1 sw - <u>OFF</u> . (9b) Comply with Stable II Egress Checklist.	 (9a) Possible leak in +Z and/or -Y bag. (9b) Possible leak in +Y bag and/or weak battery causing low output on compressor.
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MALFUNCTION PROCEDURES

FORMAT PREFERENCE

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Logic Flow

1. SCHIERA

EITHER

2. EISELE

✓

3. CUNNINGHAM

✓

4. COLLINS

FOR COMPLICATED PROCESSES

5. ARMSTRONG

✓

6. STAFFORD

✓

7. WILLIAMS

✓

9.

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