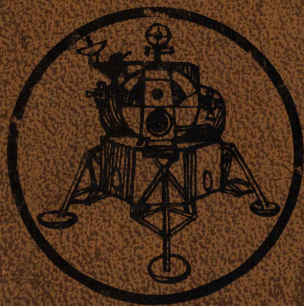


**LUNAR MODULE
ENVIRONMENTAL CONTROL
SUBSYSTEM**



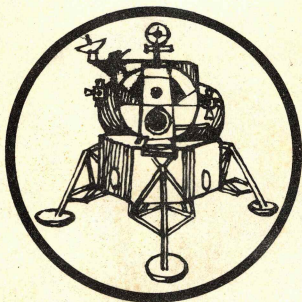
**Hamilton
Standard**

DIVISION OF UNITED AIRCRAFT CORP.



CARY BERMAN
X 3352

**LUNAR MODULE
ENVIRONMENTAL CONTROL
SUBSYSTEM**



**Hamilton
Standard**

U
DIVISION OF UNITED AIRCRAFT CORP.
A[®]

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LIST OF ABBREVIATIONS

ARS	- Atmosphere Revitalization Section
CB	- Circuit Breaker
CM	- Command Module
CSM	- Command and Service Module
CO ₂	- Carbon Dioxide
C&W	- Caution and Warning
CPS	- Cold Plate Section
ECS	- Environmental Control Subsystem
EMI	- Electromagnetic Interference
EVA	- Extravehicular Activity
GFE	- Government Furnished Equipment
O ₂	- Gaseous Oxygen
GSE	- Ground Support Equipment
HTS	- Heat Transport Section
H/X	- Heat Exchanger
I.D.	- Inside Diameter
IRIG	- Inter Range Instrument Group
LCA	- Lighting Control Assembly
LCG	- Liquid Cooling Garment
LM	- Lunar Module
LiOH	- Lithium Hydroxide
MESS	- Modular Equipment Storage System
O.D.	- Outside Diameter
OSPCPS	- Oxygen Supply and Cabin Pressure Control Section
OSS	- Oxygen Supply System
PAT	- Production Acceptance Test
PLSS	- Portable Life Support System
PPH	- Pounds per hour
psia	- Pounds per square inch absolute
psid	- Pounds per square inch differential
psig	- Pounds per square inch gage
rpm	- Revolutions per minute
S/C	- Spacecraft
SSA	- Space Suit Assembly
STP	- Standard Temperature and Pressure
v d. c.	- Volts Direct Current
VPI	- Valve Position Indicator
WMS	- Water Management Section
W/B	- Water Boiler
W/G	- Water-Glycol
WQMD	- Water Quantity Measuring Device
ΔP	- Pressure Drop

INTRODUCTION

This booklet intended for field personnel explains the basic function and operation of the LM Environmental Control Subsystem (ECS) and lists the salient parameters of the subsystem components.

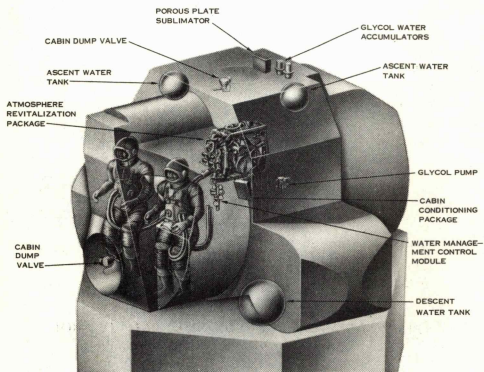
The subsystem is developed through a summary of requirements and a series of simplified block diagrams in which redundant loops, instrumentation, and other items unnecessary for understanding of basic operation of the system are omitted. These are followed by simplified piping and electrical schematics.

The booklet is divided into sections that are color coded as follows:

Atmosphere Revitalization Section	- Yellow
Heat Transport Section	- Green
Oxygen Supply Section	- Orange
Water Management Section	- Blue
Instrumentation	- White

Two cross-reference indexes are provided: one by ECS component number listing name, location of component, and page number where further information is listed; and the other cross-reference of the components by function.

1.0 LUNAR MODULE ENVIRONMENTAL CONTROL
SUBSYSTEM DESCRIPTION



LM ENVIRONMENTAL CONTROL SYSTEM

Figure 1-1. LM Environmental Control Subsystem

1.0 LUNAR MODULE ENVIRONMENTAL CONTROL SUBSYSTEM DESCRIPTION

OVERALL SYSTEM FUNCTION

The LM ECS, developed by Hamilton Standard for Grumman Aircraft Engineering Corporation, LM prime contractor, provides two lunar astronauts with a livable and comfortable environment inside the Lunar Module for up to 49.5 hours, during which they man the Lunar Module to land on the moon, explore its surface, and return to the orbiting Command Module.

The ECS performs the following functions:

1. Provides breathing oxygen to the astronauts' suits at specified levels of temperature, pressure and humidity.
2. Provides suit ventilating oxygen to the astronauts to warm or cool them as required.
3. Provides cabin ventilating oxygen to allow the astronauts to work with helmets and gloves off during certain phases of the mission.
4. Removes carbon dioxide, odors and other contaminants from the recirculating oxygen to allow reuse of the oxygen.
5. Cools all of the electronic equipment located throughout the LM vehicle.
6. Rejects all vehicle waste heat to deep space.
7. Provides water for drinking, food preparation and fire control.
8. Has sufficient oxygen and water to recharge the portable life support systems the astronauts will wear with their space suits when they leave the LM for lunar surfaces exploration.

Figure 1-1 shows the major subsystems and their approximate location in the LM vehicle.

Figure 1-2 shows the system as a black box and identifies all inputs and outputs required for it to perform its functions.

SECTION DESCRIPTION

The LM ECS comprises four main sections: atmosphere revitalization, heat transport, oxygen supply and cabin pressure control, and water management. The LM's 28 volt d.c. batteries power the system.

Figure 1-3 shows the interconnections between the sections and the inputs and outputs of each section.

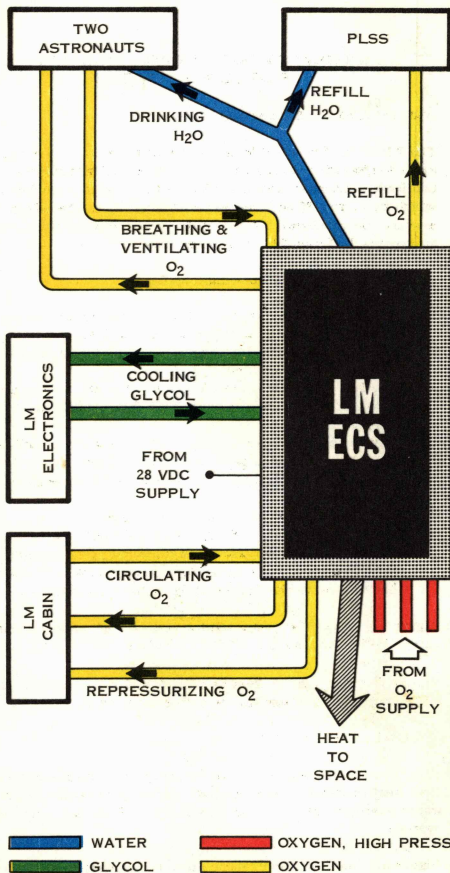


Figure 1-2. The ECS as a Black Box

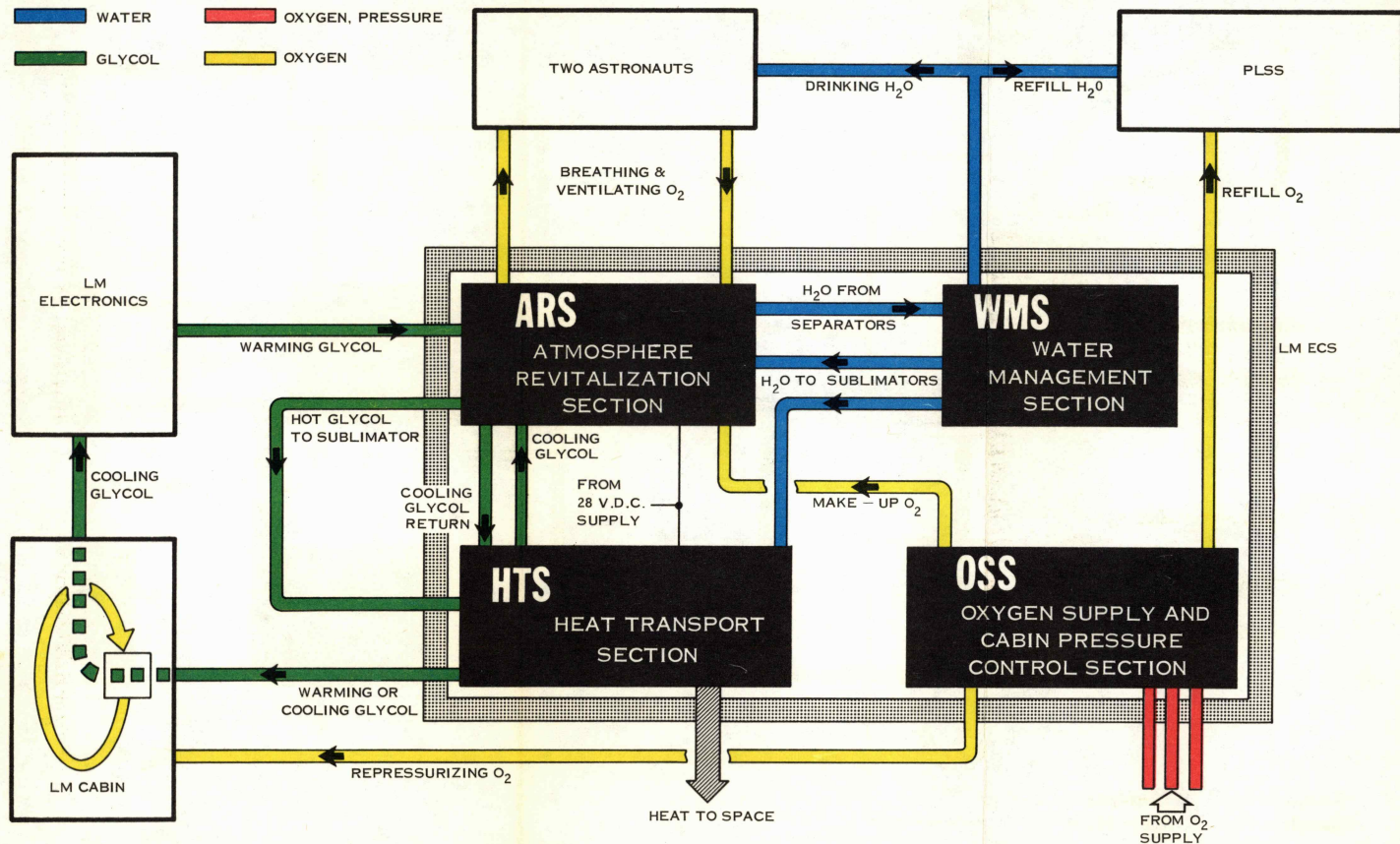


Figure 1-3. ECS Sections

1.1 ATMOSPHERE REVITALIZATION

The heart of the ECS, this section circulates oxygen pressurized at 4.8 psia first to the space units, then to the cabin. The space suit and cabin oxygen stream circuits are connected. They are isolated from each other, however, when the cabin is depressurized to allow the astronauts to leave or enter the LM vehicle.

Temperature of the oxygen entering the suit is controlled by a manual valve. After leaving the suits, oxygen then passes through a cartridge containing lithium hydroxide and activated charcoal which remove carbon dioxide, odors, and particles.

A pair of parallel redundant fans circulate the oxygen through the section. Downstream of the fans, a heat exchanger that contains cold ethylene glycol from the heat transport section cools the oxygen to approximately 40°F and condenses the excess moisture. Moisture is extracted from the oxygen by the spinning drum of one of two water separators before the oxygen is warmed to the required suit inlet temperature in a second heat exchanger containing warm glycol. Pure oxygen is automatically introduced to the flow to assure an adequate pressure at all times.

The atmosphere revitalization section is installed in the cabin in back of the astronauts. Two valves located in front connect to umbilical hoses on the astronauts' space suits. These manually operated valves direct oxygen flow to each suit or can bypass the flow around each suit when an astronaut is performing EVA. The valves will automatically go to the bypass mode if suit loop pressure falls below a prescribed limit.

Figure 1-4 shows the closed loop aspect of this section and identifies the major components.

1.2 HEAT TRANSPORT

This section contains the equipment which heats or cools the gas flow to the space suits and cabin, cools the electronics equipment on board and rejects heat from the LM vehicle. It consists of a primary coolant loop and a redundant loop which cools critical equipment in the event the primary system fails.

During flight the primary cooling circuit's porous plate sublimators reject heat by freezing the heat-carrying water into ice, sublimating the ice directly into vapor and discharging the vapor to space. These cooling devices are located in the aft equipment bay. Heat rejection is performed by GSE prior to launch.

Heat picked up by the redundant cooling circuit is rejected by another porous plate sublimator. A pump circulates the glycol coolant through the cold plates which serve as heat sinks and mounts for the electronics equipment.

Figure 1-5 shows the primary loop and identifies the major components.

1.3 OXYGEN SUPPLY AND CABIN PRESSURE CONTROL

This section controls oxygen flow to the atmosphere revitalization package to make up for losses due to the metabolic consumption by the astronauts and normal leakage of oxygen out of the cabin. It also repressurizes the cabin after it has been depressurized to allow entry into or exit from the LM vehicle, and supplies six refills for the oxygen tanks on the two life support backpacks carried on board. The LM cabin is automatically repressurized when cabin pressure unintentionally drops below 4.45 psia max. When the cabin is intentionally depressurized during ingress or egress from the LM, this section maintains suit loop pressure at 3.8 psia. The normal cabin mode pressure is maintained at 4.8 psia.

The oxygen is stored at 850 and 3,000 psia pressure in tanks supplied by Grumman. The tanks are located in both the ascent and descent stage.

Figure 1-6 show the arrangement of the section and identifies the major components.

1.4 WATER MANAGEMENT

This section supplies water used by the sublimators for cooling, and the water needed for drinking and food preparation. It also refills water tanks on the astronauts' life support packs. It delivers the water removed from the atmosphere revitalization section to the heat transport section where it is used in the sublimators.

Water is stored in three separate tanks. The largest, located in the descent or lower section of the LM, holds 332 pounds of water and is used throughout the landing and lunar mission. Two smaller tanks, carrying 42.5 pounds of water each, are located in the ascent stage and are used during ascent from the moon and rendezvous with the Command Module. Each tank consists of an aluminum outer shell with a synthetic rubber bladder inside that holds the water. Nitrogen pressure between the bladder and shell forces the water out of the tanks to a regulating and distribution system. Instruments mounted on each of the tanks monitor water quantity.

Figure 1-4. Atmosphere Revitalization Section

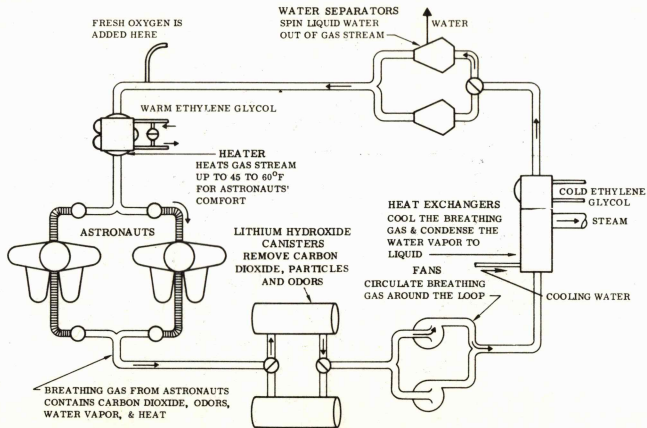


Figure 1-5. Heat Transport Section - Primary Loop

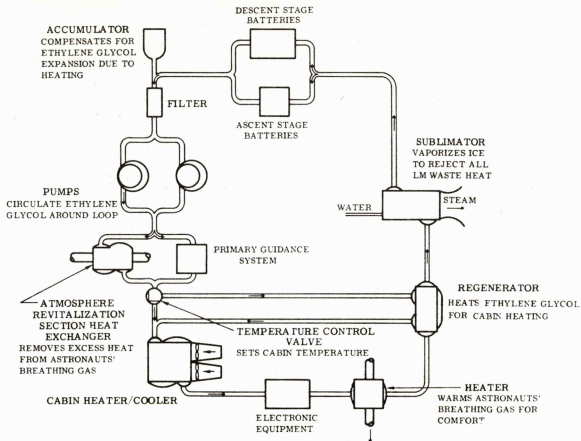


Figure 1-6. Oxygen Supply Section and Cabin Pressure Control

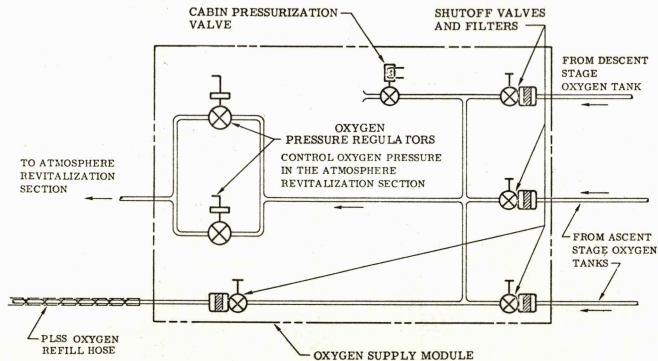


Figure 1-7. Water Management Section

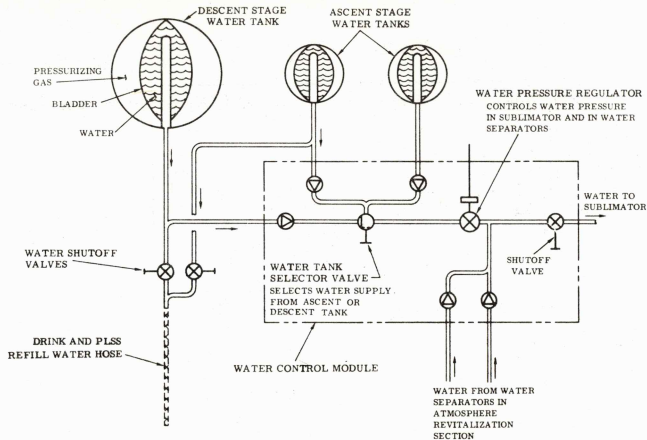


Figure 1-7 shows the arrangement of the section and identifies the major components.

Significant Pressure Relationships

Items 117, 306 and 323 sense absolute pressure. Item 307 senses differential pressure relative to ambient pressure, which is equivalent to absolute pressure in space. Figure 1-8 shows the operating bands for these items.

Item 415 controls water management system pressure of 0.5 to 1.0 psi above the pressure Item 306 maintains in Item 190.

Piping Schematics

A complete piping schematic is included as a fold-out in figure 1-9.

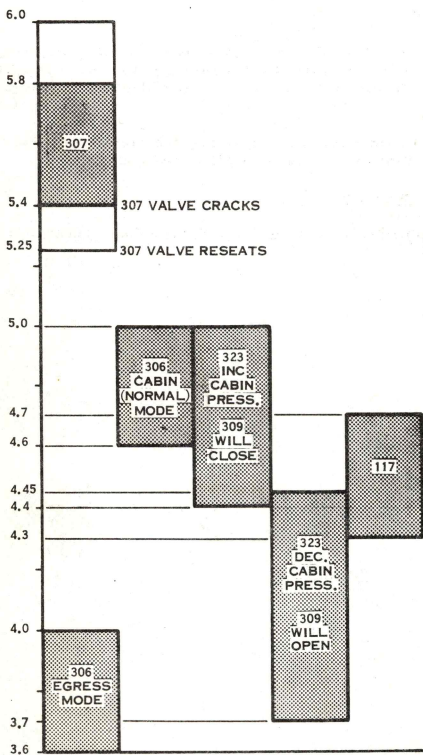


Figure 1-8. Absolute Pressure Operating Bands

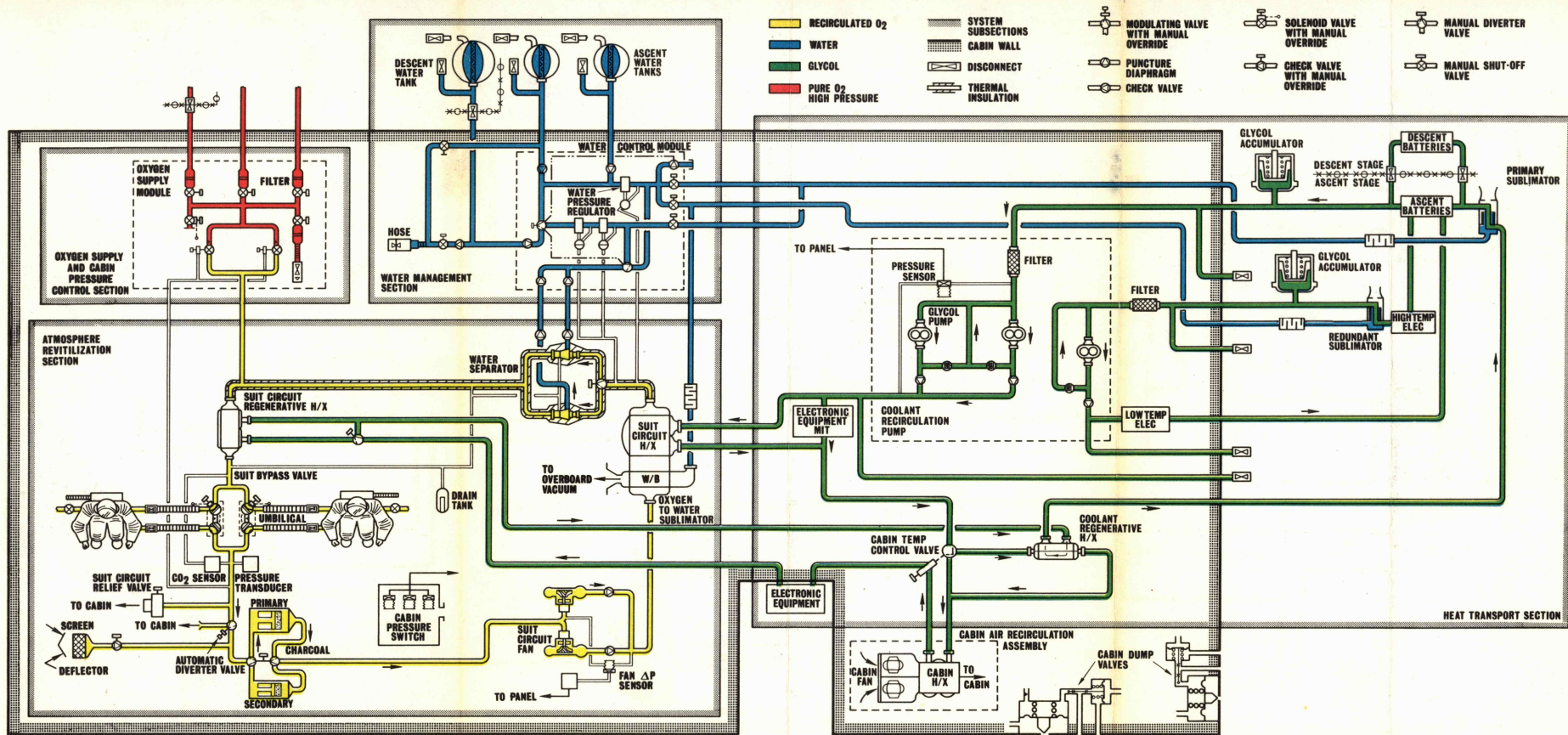


Figure 1-9. LM-ECS

1.5 SIGNIFICANT ELECTRICAL RELATIONSHIPS

The ECS contains instrumentation and four electrical logic groups. The electrical logic groups and associated items are listed in the following table:

ELECTRICAL LOGIC GROUP INDEX

<u>Logic Group</u>	<u>HS Items</u>	<u>GAEC Items</u>
1. Suit Fan	118 124 134 I-108	7S4 Switch 7DS1 Lamps 4CB119 } 4CB120 } Breakers 4CB138 }
2. Cabin Fan	102	7K5 Relay (contacts) 4CB107 } 4CB108 } Breakers
3. Glycol Pump	218 290	7S3 Switch 7DS3 Lamps 4CB96 } 4CB117 } Breakers 4CB141 }
4. Pressure Control	112 138 306 309 323 I-307	7K5 7K6 } Relays 7K7 7K10 7CR14 } 7CR15 } Diodes 7CR22 } 7CR23 } 4CB109 } 4CB113 } Breakers 4CB234 } 4CB235 }

123A HS Item

123 GAEC Item

 Solenoid or
Relay Coil


 Connector Pin

 Capacitor

 Diode


 Relay
Contact

 Differential
Pressure Sensor

 Switch


 EMI Suppressor

 Circuit Ground

 Wire Junction

 Wires not in
Contact

 Circuit Breaker

 "Press-to-Test"
Panel Lamp

A - automatic

N - normal (cabin)

O - open (direct)

C - closed

S - secondary

P - primary (normal)

L - low pressure

E - egress

M - manual

B - bypass

HS ELECTRICAL CONNECTOR DESIGNATION

<u>Connector No.</u>	<u>Item</u>	<u>Use</u>
1	190	Instrumentation
2	190	Instrumentation
3	190	Power and Control
4	190	GSE
10	290	Power
11	290	Instrumentation
12	323	Power and Control
13	191	Power and Control
14	290	Control
15	190	Suit Fan Power

123A HS Item

123 GAEC Item

Solenoid or
Relay Coil

33 Connector Pin

Capacitor

Diode

Relay
Contact

Differential
Pressure Sensor

A - automatic
N - normal (cabin)
O - open (direct)
C - closed
S - secondary



Switch



EMI Suppressor



Circuit Ground



Wire Junction



Wires not in
Contact



Circuit Breaker



"Press-to-Test"
Panel Lamp

P - primary (normal)
L - low pressure
E - egress
M - manual
B - bypass

HS ELECTRICAL CONNECTOR DESIGNATION

Connector No.	Item	Use
1	190	Instrumentation
2	190	Instrumentation
3	190	Power and Control
4	190	GSE
10	290	Power
11	290	Instrumentation
12	323	Power and Control
13	191	Power and Control
14	290	Control
15	190	Suit Fan Power

Figure 1-10 shows electrical logic group schematics. The operation of all the logic groups is apparent from the figures except for the pressure control logic group, explained in the next following text pages.

Figure 1-11 shows the electrical states of the position-indicating instrumentation switches.

Pressure Control Logic

Operation of 306's - Each Item 306 (306A and 306B) has two functional switches which are actuated by the valve handle. The electrical switching logic includes the following features:

Both 306's are usually operated together.

However, if either 306 fails open and has to be locked closed (handle in (c) position), the electrical logic is unaffected.

If either valve fails closed and has to be periodically opened manually (handle in (o) position), there is no effect on the electrical circuitry when the cabin is at normal pressure.

A 306 valve placed in egress (handle in (e) position) will electrically override the other 306 in controlling 112. A 306 placed in the Cabin or Open (handle in the (n) or (o) position) will override the other 306 in controlling 309 in a depressurized cabin.

Intentional Cabin Depressurization - This takes place prior to EVA and is a normal operating mode. The electrical functioning is as follows:

Both 306's are switched to egress (handle in (e) position).

This completes the ground circuit to 112, causing it to close, isolating the suit loop from the cabin. It also energizes relay 7K5 and opens 306 functional switch circuit, shutting off the cabin fans.

Diode - 7CR15 prevents actuation of 309 and Relay 7K6.

Emergency Cabin Depressurization - This situation is typified by meteorite puncture. Prior to depressurization 323 is open and the 306's are in normal. The following takes place after puncture:

As cabin pressure drops below 4.45 to 3.85 psia, the 323 contacts close, completing the ground circuits for relay 7K6 and for Items 112 and 309.

This opens 309, maintaining cabin pressure; closes 112, isolating the suit loop; and energizes 7K6 to light a cabin warning light. 7CR14 and 306 open switch circuits prevents actuation of 7K5, keeping the cabin fan operating.

During this time 309 raises the cabin pressure, satisfying 323 and de-energizing 309. 309 comes on again when the cabin pressure drops down again. This cycle continues as the astronauts cope with the emergency and prepare to depressurize the cabin.

When the astronauts are prepared, they turn the 306's to egress. This de-energizes 309 and 7K6, allows the cabin to depressurize, and permits the suit loop to operate at 3.8 psia.

Suit Isolation - This function is required during depressurized cabin mode if one astronaut's suit becomes torn. Given this situation the following conditions exist:

306's are in egress, 323 contacts are closed, and the suit pressure, as sensed by Grumman Item 326, is dropping. At 2.5 psia suit pressure the 326 responds to the low suit pressure by energizing the 138 valve solenoids.

This releases the latches and closes the valves and their functional switches, which, in turn, complete a ground leg for 309 through 323, initiating cabin repressurization.

With the suits isolated from the ARS, 190 pressure builds up rapidly causing 326 to de-energize the 138 solenoids. However, the 138's are spring-loaded shut, and their functional switches keep 309 energized until the cabin pressure rises to 4.4 to 4.9 psia to satisfy 323.

With suit and cabin pressures now up at safe levels, the 138's are manually opened and latched.

- 2.0 COMPONENT ITEM NUMBER INDEX

2.0 COMPONENT ITEM NUMBER INDEX

<u>Item No.</u>	<u>Name</u>	<u>Qty</u>	<u>Location</u>	<u>Page</u>
<u>100 SERIES — ATMOSPHERE REVITALIZATION SECTION</u>				
101	Oxygen-to-Glycol Cabin Heat Exchanger	1	191	4-3
102	Cabin Fan	2	191	4-6
106	Oxygen-to-Glycol Suit Circuit Heat Exchanger	1	190	4-6
107	Oxygen-to-Water Sublimator	1	190	4-9
109	Centrifugal Water Separator	2	190	4-11
110	LiOH (CO ₂ and Odor Removal) Canister	1	190	4-13
111	Suit Circuit Regenerative Heat Exchanger	1	190	4-16
112	Automatic Diverter Valve	1	190	4-19
113	Cabin Gas Return Check Valve	1	190	4-21
114	LiOH Selector Valve	1	190	4-23
115	Separator Selector Valve	1	190	4-23
117	Suit Circuit Relief Valve	1	190	4-25
118	Suit Circuit Fan	2	190	4-27
119	Check Fan Valve	2	190	4-28
122	Lithium Hydroxide Cartridge	1	190	4-30
	Modular Equipment Storage System	1	MESS	
124	Pressure Sensor	1	190	4-31
125	Lithium Hydroxide Cartridge	1	190	4-30
127	Small Canister	1	190	4-13
134	Fan Condition Signal Control	1	190	4-32

2.0 COMPONENT ITEM NUMBER INDEX (Continued)

<u>Item No.</u>	<u>Name</u>	<u>Qty</u>	<u>Location</u>	<u>Page</u>
138	Suit Bypass Valve	2	190	4-33
190	Suit Circuit Package Amidship, halfway up right wall in cabin, behind LM pilot	1		4-35
191	Cabin Air Recirculation Assembly Amidship, on floor, just to right of the ascent engine tunnel	1		4-39

200 SERIES — HEAT TRANSPORT SECTION

201	Glycol Pump	3	290	4-56
202	Glycol Pressure Relief Valve	3	290	4-56
203	Cabin Temperature Control Valve Top left hand corner of the front of 191	1		4-41
204	Coolant Regenerative Heat Exchanger Under rear portion of 190, forward of 290	1		4-43
208	Temperature Control Valve Lower right hand corner of the front of 191	1		4-46
209	Thermal Control Sublimator Top center of front wall of aft equipment bay	1		4-48
210	Glycol Accumulator To the left of 209 in the aft equipment bay	2		4-50
212	Glycol Filter	1	290	4-56
213	Glycol Check Valve	3	290	4-56
214	GSE Quick Disconnect Amidship, halfway up left cabin wall, outside cabin	2		4-52
218	Pressure Sensor	1	290	4-53
222	Redundant Loop Filter Below rear edge of 190 on inside cabin wall	1		4-56

2.0 COMPONENT ITEM NUMBER INDEX (Continued)

<u>Item No.</u>	<u>Name</u>	<u>Qty</u>	<u>Location</u>	<u>Page</u>
223	GSE Quick Disconnect Next to 214	2		4-52
224	Redundant Water Evaporator To the right of 209	1		4-54
290	Coolant Recirculation Pump Under rear portion of 190 on cabin wall	1		4-56
<u>300 SERIES — OXYGEN SUPPLY SECTION</u>				
304	Manual Shutoff Valve	4	390	4-59
306	O ₂ Inflow Regulator Valve	2	390	4-61
307	Cabin Dump Valve One in forward hatch, one in upper hatch	2		4-63
309	Manual Solenoid Override Valve	1	390	4-66
315	Oxygen Filter	4	390	4-69
316	Oxygen Hose and Fitting Amidship, on left cabin wall, behind commander	1		4-68
323	Cabin Pressure Switch Rear cabin wall behind 190	1		4-69
390	Oxygen Supply Module Top front of 190	1		4-69
<u>400 SERIES — WATER MANAGEMENT SECTION</u>				
401	Water Check Valve	5	490	4-73
402	Water Shutoff Valve WMS panel under front edge of 190	2	490	4-76
404	Descent Tank In aft end of descent stage	1		4-79
406	Water Shutoff Valve WMS panel under front edge of 190	1	490	4-76
409	Ascent Tank Top of front wall of aft equipment bay, one on right side and one on left side	2		4-79

2.0 COMPONENT ITEM NUMBER INDEX (Continued)

<u>Item No.</u>	<u>Name</u>	<u>Qty</u>	<u>Location</u>	<u>Page</u>
410	Coolant Isolation Valve	1	490	3-12
414	Water Tank Selector Valve WMS panel under front edge of 190	1	490	4-82
415	Water Pressure Regulator	3	490	4-84
416	Water Hose Fastened to front edge of 191	1		4-87
418 & 419	Ground Servicing Disconnect (ascent tanks) Left side, low, and to the rear of the cabin wall, outside the cabin	2 ea.		4-88 4-88
419 & 418	Ground Servicing Disconnect (descent tank) On ascent stage, below and to the rear of the ascent stage 418 and 419's	1 ea.		4-88 4-88
420	Water Shutoff Valve Assembly WMS panel under front edge of 190	2		4-90
425	Flow Limiter One in 190 pkg, other two are line-mounted about 12 in. from the 209 and 224, bracketed to the aft equipment bay front wall	3		4-91
490	Water Control Module Under front edge of 190	1		4-92
492	Water Check Valve Assembly Two in 190, line mounted between 190 and 490; one line mounted between ascent and descent water supply lines	3		4-73

Note: Right and left are defined for an observer facing forward.

3.0 FUNCTIONAL CROSS-REFERENCE INDEX

3.0 FUNCTIONAL CROSS-REFERENCE INDEX

This index cross-references function and component item number. Portions of components having special functions also are entered and are referenced to the component.

1. ABSORBERS, CHEMICAL

- a. 122 CO₂ absorber element, primary
- b. 125 CO₂ absorber element, secondary. Identical to PLSS CO₂ absorber.

2. ACCUMULATORS, FLUID

- 210 Provides expansion volume and leakage makeup in primary and redundant glycol loops. One accumulator in each loop.

3. CAPS, FLUID

- Refer Integral part of Item 214, 223, 418 and 419 fluid to 6. disconnects. Seals disconnect against fluid leakage and contamination.

4. CANISTERS

- a. 110 Contains the Item 122 LiOH cartridge
- b. 127 Contains the Item 125 LiOH cartridge

5. CONTROL, FAN SIGNAL

- 134 Actuates panel lights and vehicle discrete measurements in response to low suit fan pressure rise. Actuation is via Item 124. Refer to 21 b.

6. DISCONNECTS, FLUID

- a. 214 Male
 - b. 223 Female
 - c. 418 Male
 - d. 419 Female
- } Evacuate, charge and test primary and redundant glycol loops. Two each.
- } Evacuate and charge water tank ullage volume (nitrogen). Three each.
- } Evacuate and fill water tank (water). Three each.

7. FANS

- a. 102 Circulate cabin atmosphere through cabin and cabin heat exchanger. Two fans.
- b. 118 Circulate ventilation flow through atmosphere revitalization section package and astronants' space suits. Two fans.

8. FILTERS, PARTICLE

- a. Refer Trap suit loop debris. Part of Items 122 and 125. to 1.
- b. 212 Primary glycol loop filter.
- c. 222 Redundant glycol loop filter.
- d. 315 High pressure oxygen filter. Four each.

9. FLOW LIMITERS, FLUID

- a. 425-1 Water flow limiter to 209.
- b. 425-3 Water flow limiter to 224.
- c. 425-5 Water flow limiter to 107.

10. HEAT EXCHANGERS

- a. 101 Heat exchanger for cabin heating or cooling.
- b. 106 Primary heat rejection means from suit loop.
- c. 107 Emergency heat rejection means from suit loop.
- d. 111 Reheat means in suit loop for astronaut comfort.
- e. 204 Regenerative heat exchanger in glycol loop for cabin heating.
- f. 209 Primary heat rejection means for LM.
- g. 224 Emergency heat rejection means from glycol loop.

11. HOSES

- a. 316 Conveys oxygen for PLSS refill.

- b. 416 Conveys water for astronauts' food preparation, drinking, fire control, and PLSS refill.

12. MOTORS

- a. Refer Drive Item 102 cabin fans
to 7a.
- b. Refer Drive Item 118 suit loop fans
to 7b.
- c. Refer Drive Item 201 glycol pumps
to 14b.

13. PACKAGES/MODULES

- 190 Atmosphere revitalization package.
- 191 Cabin air recirculation package.
- 290 Glycol loop pump package.
- 390 Oxygen supply section controls package.
- 490 Water management section controls package.

14. PUMPS, LIQUID

- a. Refer Item 109 pumps suit loop condensate to water
to 17 management section.
- b. 201 Primary and redundant glycol loop circulating
pumps. Three each.

15. REGULATORS, PRESSURE

- a. 306 Maintain proper suit pressure level, 4.6 to
5.0 psia in normal mode, and 3.6 to 4.0 psia
in egress mode. Two each.
- b. 415 Maintain WMS pressure at levels compatible
with water separators and sublimators. Three
each.

16. SENSORS, SPEED AND TEMPERATURE

- a. I 111 Sensor - Measures speed of Item 109 Water Separator. Two each.
- b. I 128 Sensor - Measures suit inlet temperature

17. SEPARATOR, WATER

- 109 Separates suit loop condensate from the suit gas stream. Two each.

18. SOLENOIDS

- a. 112 When energized, retracts pin which allows a spring to close the Item 112 valve, isolating the suit loop from the cabin.
- b. 309 When energized, opens the Item 309 cabin repressurization valve.
- c. 138 When energized, retracts a latch which allows a spring to close the Item 138 valve, isolating the astronaut from the suit loop. Two each.

19. SUPPRESSOR, EMI

a. <u>5v d.c. Single</u>	<u>Quant/Item</u>	<u>Item</u>	<u>Function</u>
I 120	1	138	Maintains EMI generated at VPI below specified limits
I 122	1	112	
I 124	2	114	
I 204	1	210	
I 308	1	309	

b. <u>5v d.c. Dual</u>	<u>Quant/Item</u>	<u>Item</u>	<u>Function</u>
I 121	1	117	Maintains EMI generated at VPI within specified limits
I 123	1	113	
I 307	1	306	

c. <u>28v d. c. Control</u>	<u>Quant/Item</u>	<u>Item</u>	<u>Function</u>
	1	112	Maintains EMI generated at the solenoid below specified limits

d. <u>28v d. c. Control</u>	<u>Quant/Item</u>	<u>Item</u>	<u>Function</u>
	1	190	Maintains EMI generated at the Item 306 functional switches below specified limits

20. SIGNAL CONDITIONERS, ELECTRONIC

	<u>Quant/Item</u>	<u>Item</u>	<u>Function</u>
I III	1	190	Converts pulse train from I 111 speed sensor to output of 0-5 volts d. c.

21. SWITCHES, ELECTRICAL

- a. 112 Control Switch - Removes power to 112 solenoid after solenoid initiates closure of the valve. Refer to 24.8a.
- b. 124 Electrical contacts close when Item 118 suit fan pressure rise drops to less than 6.0 in. H₂O. Contacts open when pressure rise exceeds 8.0 in. H₂O. Switch actuates Item 134. Refer to 5.

- c. 138 Functional switches actuated when the solenoid initiates closure of valve. Switch closure maintains continuity of Item 309 circuit, repressurizing the cabin until cabin pressure switch Item 323 is satisfied. Refer to figure 1-11 for switching logic and 24.8c for function of Item 138.
- d. 218 Electrical contacts close when Item 290 pressure rise drops to less than 3.0 psid causing the secondary pump in the primary loop to turn on a panel warning light. Contacts open when pressure rise exceeds 7.0 psid.
- e. 306 Functional switches are actuated when the Item 306 handle is positioned. The switches complete or open the circuits from Items 323, 309, and 112 thus arming or disarming the automatic operation of cabin repressurization and isolation of the suit loop from the cabin. Refer to figure 1-11 for switching logic and 15a for function of Item 306.
- f. 323 Electrical contacts close when cabin pressure drops below 4.45 to 3.70 psia, causing the Item 112 valve to close, the Item 309 valve to repressurize the cabin, activate the cabin warning light, and de-energize the Item 102 cabin fans. Electrical contacts open when cabin pressure exceeds 4.40 to 5.00 psia. Minimum dead band is 0.05 psi.

21.1 Position Indicator Switches

Item & Reference	Handle Position	Measurement No. GF ---- X	Switch Contact Position
a. 112 Refer to 24.8a	Closed	1221	Closed
	Cabin	1221	Open
b. 113 Refer to 24.1a	Closed	1231	Closed
	Closed	1232	Open
	Auto	1231	Open
	Auto	1232	Open
	Open	1231	Open
	Open	1232	Closed

Item & Reference	Handle Position	Measurement No. GF ---- X	Switch Contact Position
c. 114 Refer to 24.2a	Pri	1241	Open
	Pri	1242	Open
	Sec	1241	Closed
	Sec	1242	Closed
d. 117 Refer to 24.4a	Closed	1211	Closed
	Closed	1212	Open
	Auto	1211	Open
	Auto	1212	Open
	Open	1211	Open
	Open	1212	Closed
e. 138 (CDR) Refer to 24.8c	Normal	1201	Open
	Bypass	1201	Closed
	138 (LMP)	1202	Open
	Refer to 24.8c	1202	Closed
f. 210 (Pri) Refer to 2	Normal	2041	Open
	Level		
	Low	2041	Closed
	Level		
	210	2042	Open
	(Red'nt)		
Refer to 2	Low	2042	Closed
	Level		
g. 306 (a) Refer to 15a	Closed	3071	Closed
	Closed	3070	Closed
	Egress	3071	Open
	Egress	3070	Closed
	Cabin	3071	Open
	Cabin	3070	Open
	Direct O ₂	3071	Closed
	Direct O ₂	3070	Open
	306 (b)	3073	Closed
	Refer to	3075	Closed
	15a	3073	Open
	Egress	3075	Closed
	Cabin	3073	Open
	Cabin	3075	Open
	Direct O ₂	3073	Closed
	Direct O ₂	3075	Open

Item & Reference	Handle Position	Measurement No. GF ---- X	Switch Contact Position
h. 309	Closed	3081	Open
Refer to	Auto	3081	Open
24. 8b	Manual	3081	Closed

22. TANKS, WATER

a) 404 (descent) - Supplies water for astronauts' food preparation, drinking, and fire control, PLSS refill, and vehicle cooling during use of the LM Descent Stage.

b) 409 (ascent) - Supplies water for astronauts' food preparation, drinking, fire control and vehicle cooling during use of the LM Ascent Stage. Two each

23. TRANSDUCERS

I 202 - Measures pressure rise across primary and secondary glycol pumps. Output is 0-5 v d. c.

I 130 - Measures suit loop absolute pressure at inlet to Item 190 package. Output is 0-5 v d. c.

24. VALVES

24.1 Check Valves

a) 113 - Allows cabin gas flow into the suit loop when the cabin is pressurized, but prevents escape of suit loop gas into the cabin when the cabin is depressurized.

b) 119 - Prevents suit loop gas backflow through the Item 118 fan that is off the line. Three each.

c) 213 - Prevents backflow of glycol through the Item 203 pump that is off the line. Three each.

d) 401 - Prevents backflow of water from the water management section into depleted ascent or descent H₂O tanks and into the suit loop. Five each.

e) 492 - Prevents backflow of water from the water management section into the suit loop or into the depleted descent water tank. Three each.

24.2 Selector Valves

- a) 114 - Selects primary or secondary LiOH cartridge.
- b) 115 - Selects primary or secondary water separator.
- c) 414 - Selects ascent, descent, or secondary mode of water management system.

24.3 Shutoff Valves

- a) 304 - Allows high pressure O₂ into the O₂ control module from the ascent or descent O₂ tanks. There is an interlock system to prevent O₂ flow from ascent O₂ tank to the depleted descent O₂ tank. One of these valves permits flow from the O₂ control module for PLSS refill. Four each.
- b) 402 - Allows water flow from the primary and redundant loops into the Item 209 sublimator. Two each.
- c) 406 - Allows water flow to the Item 224 glycol loop sublimator and Item 107 suit loop sublimator under emergency conditions.
- d) 420 - Allows direct feed of water from either the descent or ascent tanks to the Item 416 water hose. Two each.

24.4 Relief Valves

- a) 117 - Acts as absolute pressure relief of suit loop when suit loop pressure rises to 4.7 psia. Valve is fully closed when suit loop pressure falls to 4.3 psia.
- b) 202 - Prevents damage to pump due to excessive back pressure. It bypasses a portion or all of the pump outlet directly back to the inlet if excessive back pressure occurs. Valve cracks open at 33 psid, is fully open at 39 psid, and reseats at 32 psid. Three each.

24.5 Temperature Control Valves

- a) 203 - Maintains cabin temperature within specified limits by varying amount of glycol to the Item 204 regenerative heat exchanger.

- b) 208 - Controls suit inlet temperature by diverting glycol through the Item 111 heat exchanger.

24.6 Dump Valves

307 - Prevents excessive cabin pressure. Permits deliberate cabin depressurization. Valve is fully open at 5.8 psid and closed at 5.4 psid. Servo actuator cracks open at 5.25 psid. During lift-off, valve limits short-term cabin pressure spike to 6.0 psid.

24.7 Isolation Valves

410 - Contains a metal diaphragm which is punctured when the secondary mode of the water management section is selected to admit water to the redundant glycol loop. The fluid supply function has been replaced by an accumulator making the 410 unnecessary. Item 410 is now capped.

24.8 Solenoid Valves

- a) 112 - Diverts all suit loop flow to the cabin when the cabin is pressurized. When closed, the valve retains all suit loop flow within the suit loop.
- b) 309 - Permits repressurization of the cabin directly from the O₂ control module.
- c) 138 - Permits each astronaut to be isolated from the suit loop and the other astronaut should suit loop pressure fall below prescribed limits with the cabin depressurized.

4.0 COMPONENT DESCRIPTION

4.0 COMPONENT DESCRIPTION

ATMOSPHERE REVITALIZATION SECTION

101 HEAT EXCHANGER

Spec. no. SVHS 2401

PAT no. SVHS 3500-12

Type - Oxygen-to-glycol

Spec. wt. - 14.57 lb

Actual wt. - 12.69 lb

Leakage - Internal to external - Less than 1.11×10^{-5} cc/sec of helium at STP when pressurized to 45 psia.

Construction - Fluxless brazed aluminum, plate and fin.

Performance -

	<u>Condition I</u>	<u>Condition II</u>	<u>Condition III</u>
	<u>Two cabin fans, condensing</u>	<u>Two cabin fans, non-condensing</u>	<u>One cabin fan, non-condensing</u>
Q sensible - Btu/hr	2280	2275	1790
Q latent - Btu/hr	315	0	0
Q total - Btu/hr	2595	2275	1790
Absolute Humidity - in. -lb H ₂ O/lb O ₂	0.0276	0.0203	0.0203
Pressure O ₂ in - psia	5.0	5.0	5.0
Weight flow O ₂ - lb/min	10.0	10.15	5.0
Temperature O ₂ in - °F	77.2	93.8	104.3

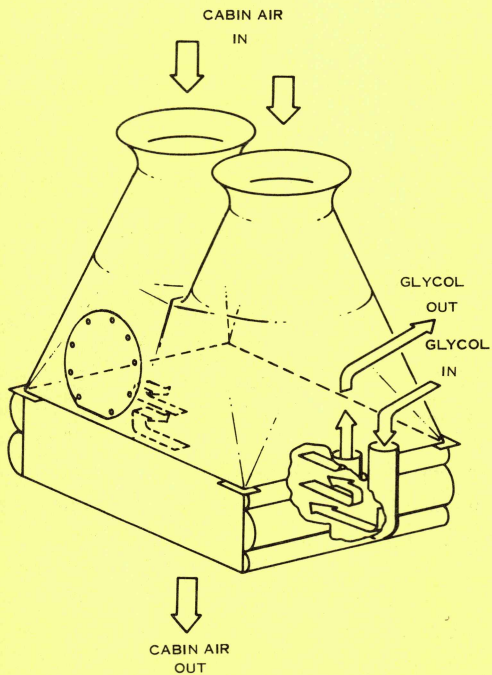


Figure 4-1. Heat Exchanger Item 101

	<u>Condition I</u>	<u>Condition II</u>	<u>Condition III</u>
	<u>Two cabin fans, condensing</u>	<u>Two cabin fans, non-condensing</u>	<u>One cabin fan, non-condensing</u>
Weight flow glycol - lb/min	3.7	3.7	3.7
Temperature glycol in - °F	52	72.6	74.4
Pressure glycol in - psia	7.5-27.0	7.5-27.0	7.5-27.0
With above inlet conditions, the following conditions exist:			
Temperature O ₂ out - °F	60.8	77.4	78.1
Pressure drop O ₂ (includes headers) - in. H ₂ O	0.38	0.33	0.33
Pressure drop glycol (includes headers) - psi	1.1	1.1	1.1
*Effectiveness	0.718	0.773	0.877

$$*Effectiveness = \frac{T_{cold\ out} - T_{cold\ in}}{T_{hot\ in} - T_{cold\ in}} \times 100$$

Ports - Inlet and outlet glycol - Gamah-type JT-15
Inlet oxygen - flange connection 4-in. diameter

Type of Flow -

Glycol

Oxygen

Cross counter
One path
Four passes

One pass in each of the two O₂ sections.

102 BRUSHLESS D. C. MOTOR

Spec. no. - SVHS 2331
PAT no. - SVHS 3500-23

Spec. wt. - 1.55 lb
Actual wt. - 1.40 lb

Speed - 13,000 nominal, overspeed to 17,000 without permanent deformation.

Power and Performance (Design Point)

Input power	28.0 volts d. c.	30 watts
Speed		13,000 \pm 250 rpm
Ambient and inlet temp.		75°F
Ambient pressure		5.0 psia

Ground Checkout - Motor operates at 14.7 psia inlet and 15 volts.
(No specific flow or power consumption requirements.)
Check is by listening for motor hum.

External Leakage - From or into hermetically sealed portion of the motor shall not exceed 1×10^{-8} scc of helium/sec at any combination of operating temperatures and pressures.

106 HEAT EXCHANGER

Spec. no. SVHS 2406
PAT no. SVHS 3500-14

Type - Oxygen-to-glycol

Spec. wt. - 2.96 lb
Actual wt. - 2.08 lb

Leakage - Gas side external - Less than 0.0002 lb/hr of O₂ at 3.5 psid

Coolant side external and internal - Less than 1.11×10^{-5} cc/sec helium at STP at 45 psia

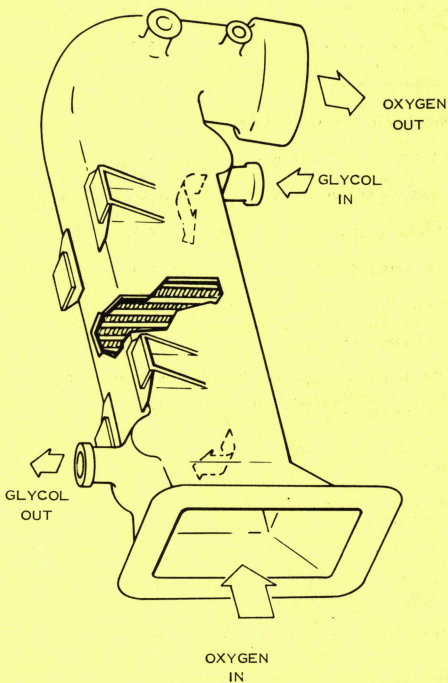


Figure 4-2. Heat Exchanger Item 106

Construction - Fluxless brazed aluminum, plate and fin.

Performance -

	<u>Condition I</u>
Weight flow O ₂ - lb/min	0.692
Inlet pressure O ₂ - psia	5.39
Inlet temperature O ₂ - °F	136.4
Absolute humidity - lb H ₂ O/lb O ₂	0.0437
Weight flow coolant - lb/min	1.85
Inlet pressure coolant - psia	34-12.5
Inlet temperature coolant - °F	40.0
Heat load total - Btu/hr	2095.0
Heat load sensible - Btu/hr	893.3
Heat load latent - Btu/hr	1201.7

With the above inlet conditions, the following conditions exist:

Outlet temperature O ₂ - °F	45.0
Pressure drop O ₂ - in. H ₂ O (including headers)	1.00
Pressure drop coolant - psi (including headers)	0.5
*Effectiveness	0.948

$$*Effectiveness = \frac{T_{\text{cold out}} - T_{\text{cold in}}}{T_{\text{hot in}} - T_{\text{cold in}}} \times 100$$

Ports - Inlet and outlet glycol - JT-15 Gamah

Outlet oxygen - solid machined, two inch diameter

Inlet oxygen - flange (2.90 x 4.20 inches)

Type of Flow -

Glycol

Counterflow
Six paths
One pass

Oxygen

Elbow bend
Five paths
One pass

107 SUBLIMATOR SUIT CIRCUIT

Spec. no. SVHS 2408
PAT no. SVHS 3500-15

Type - Oxygen-to-water

Spec. wt. - 8.10 lb
Actual wt. - 7.65 lb

Leakage - Water side external - Does not exceed 3.40 scc/hr of
N₂ at 6.5 psig and room ambient temperature.

Gas side external and internal - Less than 0.0002 lb/hr
at 3.5 psid and room ambient temperature.

Construction - Stainless steel with sintered nickel porous plates.

Performance -

Condition I

Weight flow O ₂ - lb/min	0.454
Inlet pressure O ₂ - psia	3.76
Inlet temperature O ₂ - °F	160.0
O ₂ inlet dewpoint - °F	72
Weight flow H ₂ O - lb/min	0.0321
Inlet pressure H ₂ O - psia	4.7
Inlet temperature H ₂ O - °F	85
Discharge pressure H ₂ O - mm Hg	0.40

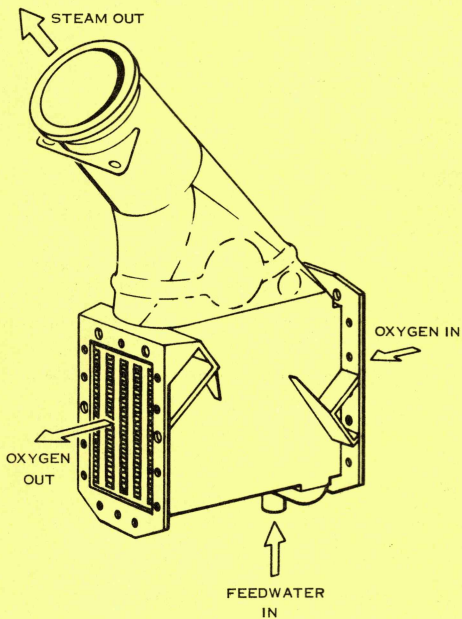


Figure 4-3. Sublimator Item 107

Condition I

Heat load - Btu/hr (total)	1968.5
Heat load - Btu/hr (latent)	1217.2
Heat load - Btu/hr (sensible)	751.3

With the above inlet conditions, the following conditions exist:

Outlet temperature O_2 - °F	45
Pressure drop O_2 (including headers) - in. H_2O	1.10

Ports - Inlet and Outlet O_2 - 3 in. x 4 in.

Inlet water port - JT15-025 Gamah

Outlet steam port - 3 in. O.D. Gamah - type JT-48

Type of Flow -

Water

Oxygen

One pass
Eight paths

One pass
Four paths

109 WATER SEPARATOR

Spec. no. SVHS 2475
PAT no. SVHS 3500-16

Type - Centrifugal flow, gas driven

Spec. wt. - 2.91 lb
Actual wt. - 2.22 lb

Construction - Aluminum sheet metal, nickel mesh-filled drum.
Integral variable reluctance speed pickup.

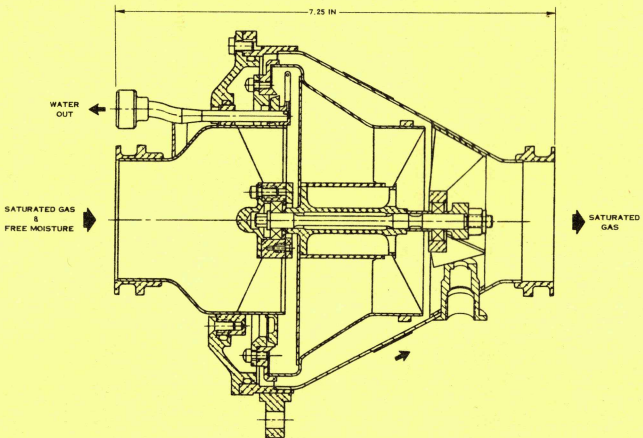


Figure 4-4. Centrifugal Water Separator Item 109

Performance -

Title	Inlet O ₂	Inlet Pressure - psia \pm 0.5	Inlet T - $^{\circ}$ F	O ₂ Flow lb/min	Entrained H ₂ O lb/hr \pm 0.002	Nominal rpm	Pumping head in. H ₂ O - min
Egress	Saturated	3.9	40-50	0.460-0.465	0.03	1440	77.5
Restart		3.9	40-50	0.460-0.465	0.03	1440	39.0
Normal		5.3	40-50	0.750-0.755	0.03	2050	77.5

Suit loop pressure drop = 3.0 inches of H₂O - maximum

Porting -

Inlet and outlet oxygen - 2 in. Gamah
 Outlet water - 0.25 in. Gamah
 Drain port - 0.25 in. Gamah

110, 127 CANISTER

110, 127 Spec. no. SVHS 2499

110, 127 PAT no. SVHS 3500-25

Spec. wt. - 110 - 4.56 lb, 127 - 2.90 lb

Actual wt. - 110 - 4.34 lb, 127 - 2.83 lb

Features - There is an interlock mechanism to prevent the 110 canister (primary) and 127 (secondary) from being opened simultaneously. The canister cover is attached to the canister with Teflon-covered stainless steel cables. The canisters incorporate a pressure relief valve to equalize the pressure across the lid and facilitate removal.

Ports - Inlet and outlet oxygen - 2.0 in. diameter - Gamah

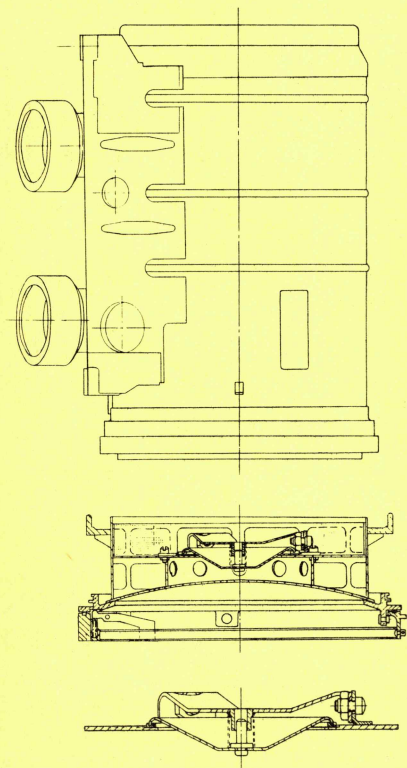


Figure 4-5. Lithium Hydroxide Canister Item 110

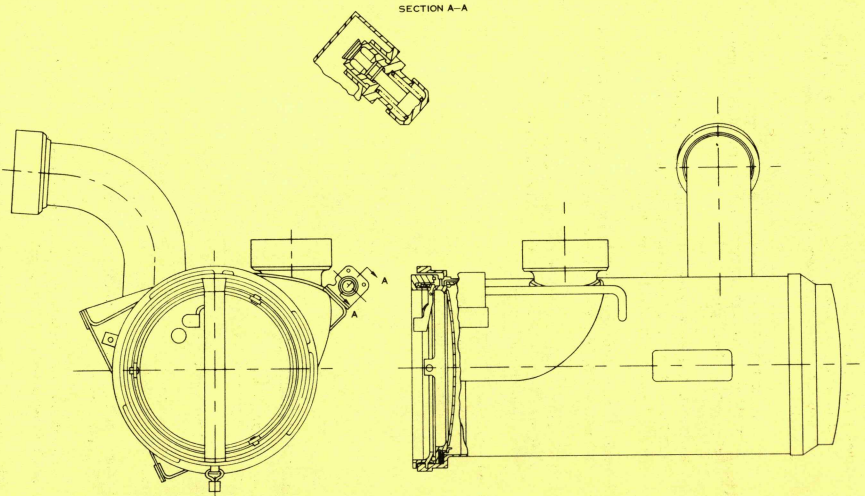


Figure 4-6. Sectional View of Small Lithium Hydroxide Canister
Item 127

Leakage - External leakage from each canister does not exceed 0.001 lb/hr of O₂ at inlet pressure of 3.9 psia at 70°F and any ambient pressure between 10⁻¹⁴ mm Hg absolute and 3.9 psia.

External leakage into each canister does not exceed 0.008 lb/hr air at an ambient pressure of 14.7 psia at 70°F internal pressure of 3.5 psia.

Internal leakage with cartridge installed and normal flow path blocked and flow bypassing the cartridge, is no more than 0.1 lb/hr with ΔP of 1.4 in. H₂O.

Pressure Drop - With flow of 0.7 lb/min O₂ at inlet conditions of 5.0 psia and 90°F ΔP is no more than 1.40 in. H₂O.

Debris Trap - The 110 canister incorporates a debris trap system. There is a bypass relief valve should the debris trap become clogged.

Handle Torque -

110 - 45 in.-lb maximum

127 - 35 in.-lb maximum

111 HEAT EXCHANGER

Spec. no. SVHS 2404

PAT no. SVHS 3500-17

Type - Glycol-to-oxygen

Spec. wt. - 0.96 lb

Actual wt. - 0.78 lb

Leakage - Suit gas side - External - Less than 0.000125 lb/hr O₂ at 3.5 psia

Coolant side - External and internal less than 1.11×10^{-5} cc/sec helium at STP and 45 psia

Construction - Fluxless brazed aluminum, plate and fins

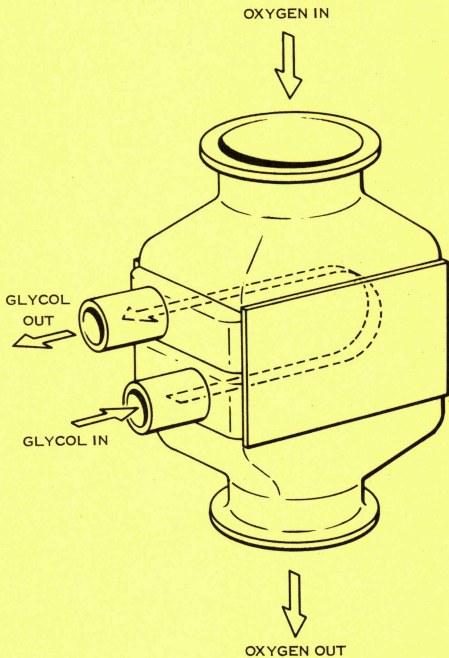


Figure 4-7. Heat Exchanger Item 111

Performance -

	<u>Gas Side</u>	<u>Coolant Side</u>
Weight flow - lb/min	0.84	1.6
Pressure - psia	5.42	7.0 - 17.0
Temperature - °F	42	72.7
Absolute humidity - lb H ₂ O/lb O ₂	0.01423±5%	-----
Heat load total - Btu/hr	228.2	-----
Heat load latent - Btu/hr	0.0	-----
Heat load sensible - Btu/hr	228.2	-----

With the above inlet conditions, the following conditions exist:

Temperature out - °F	62.0	-----
Pressure drop (including headers)	0.31 in. H ₂ O	0.22 psi

*Effectiveness 0.78

$$*Effectiveness = \frac{T_{\text{cold out}} - T_{\text{cold in}}}{T_{\text{hot in}} - T_{\text{cold in}}} \times 100$$

Ports - Inlet and outlet glycol - JT Gamah 0.375 in. O.D.
Inlet and outlet oxygen - 2 in. O.D. Gamah

<u>Glycol</u>	<u>Oxygen</u>
Two-pass cross-counter	One pass
Six paths	Five paths

VALVES - SOLENOID

112 SOLENOID VALVE

Spec. no. SVHS 2489, 2541

PAT no. SVHS 3500-13

Spec. wt. - 2.28 lb

Actual wt. - 2.23 lb

Function - The suit circuit diverter valve is used in the oxygen recirculation circuit to direct the flow in such a manner as to provide a closed recirculation circuit in one of its two positions or to divert the flow into the open recirculation circuit when in the other position.

Construction - Cast aluminum housing, solenoid and control switch, VPI switch

Ports - Inlet oxygen, outlet oxygen to cabin or suit loop - 2 in. O.D. Gamah-type JT-15.

Handle Positions -

Normal - Suit circuit flow opens to cabin.

Closed - Suit circuit flow closed to cabin.

Handle Force - 10-lb force to depress handle

Pressure Drop - 0.13 in. H₂O at 0.7 lb/min flow at 5.0 psia and 75° F.

Leakage -

Positive Pressure Differential - With the valve in the closed recirculation circuit position, the external leakage does not exceed 0.001 lb/hr of O₂ at a valve inlet pressure of 3.9 psia at 70° F with an ambient pressure of 10⁻¹⁴ mm Hg.

Negative Pressure Differential - The external leakage into the valve does not exceed 0.008 lb/hr of air at a valve inlet pressure of 3.5 psia and any ambient pressure of 3.5 psia to 14.7 psia at 70° F. The valve is maintained manually in the closed recirculation circuit position with a 65-lb external force.

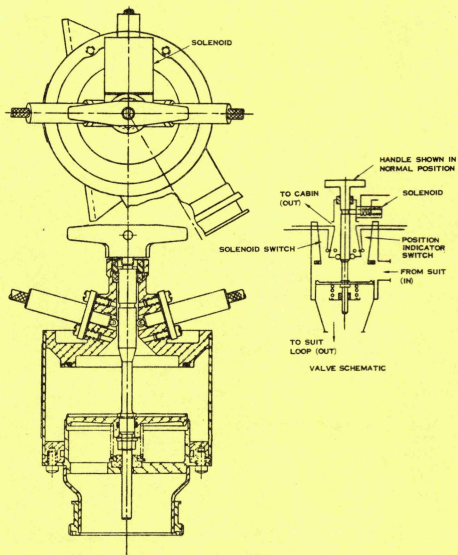


Figure 4-8. Automatic Diverter Valve Item 112

Internal - With the valve in the open recirculation circuit position, the internal leakage does not exceed 3.0 lb/hr of O₂ at a pressure differential of 0.5 in. H₂O , an inlet temperature of 70° F, and an inlet pressure of 5.0 psia.

Power Required by Solenoid - Not to exceed 16.0 watts for 6.0 seconds at 28 volts d.c. at 75° F.

Solenoid Response Time - 50 milliseconds at 28 volts d.c.

113 CHECK VALVE

Spec. no. SVHS 2399

PAT no. SVHS 3500-19

Spec. wt. - 1.00 lb

Actual wt. - 0.94 lb

Construction - Cast aluminum housing. Two VPI switches

Ports - Inlet and Outlet Oxygen - 2-in. diameter Gamah

Handle Position -

Full Counterclockwise - Valve locked open.

Midposition - Normal operation.

Full Clockwise - Valve locked closed.

Operating Pressures -

Internal - 0 to 4.8 psig

External - 0 to 11.2 psig

Operating Fluid - Oxygen

Pressure Drop - Not more than 0.16 in. H₂O at 0.8 lb/min O₂ at 5.0 psia and 75° F

Cracking Pressure - No requirement

Handle Torque - 10 in.-lb

Leakage - The total leakage from the valve does not exceed 0.001 lb/hr O₂ with an outlet pressure of 3.9 psia at 80° F and an ambient and inlet pressure of 10⁻¹⁴ mm Hg absolute to 3.9 psia.

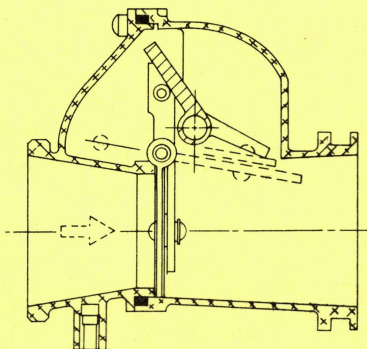
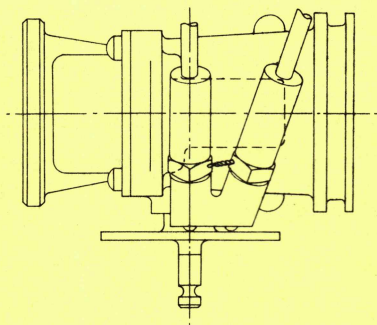


Figure 4-9. Cabin Gas Return Check Valve Item 113

114 CANISTER SELECTOR VALVE

Spec. no. SVHS 2455

PAT no. SVHS 3500-20

Spec. wt. - 3.48 lb

Actual wt. - 2.96 lb

Construction - Aluminum sheet metal, 2 VPI switches

Ports -

1 inlet to valve	1 inlet to 127	1 outlet from 127
1 inlet to 110	1 outlet from 110	1 valve out

all 2-inch Gamah connections

Handle Position -

Full Clockwise - Oxygen flow is through 110

Full Counterclockwise - Oxygen flow is through 127

Operating Pressure Differentials -

0-4.8 psig - Internal pressure exceeds external pressure.

0-11.2 psig - External pressure exceeds internal pressure.

Operating Temperatures - 0° to 160°F

Handle Torque - 30 in.-lb max. for differential pressures from 0 to 4.4 psi across sealing element of the valve

Leakage - External - No more than 0.00008 lb/hr oxygen at inlet pressure of 3.9 psia at 70°F and ambient pressure of 10^{-14} mm Hg to 3.9 psia. External leakage into the valves does not exceed 0.00064 lb/hr air at valve inlet pressure of 3.5 psia and ambient pressure from 3.5 to 14.7 psia at 70°F.

Pressure Drop - The sum of pressure differentials through the inlet or outlet valve body less the rig tare does not exceed 0.311 in. H_2O in an oxygen flow of 0.8 ± 0.1 lb/min at 5.0 psia and 75°F.

115 WATER SEPARATOR SELECTOR VALVE

Spec. no. SVHS 2456

PAT no. SVHS 3500-24

Construction - Aluminum shell

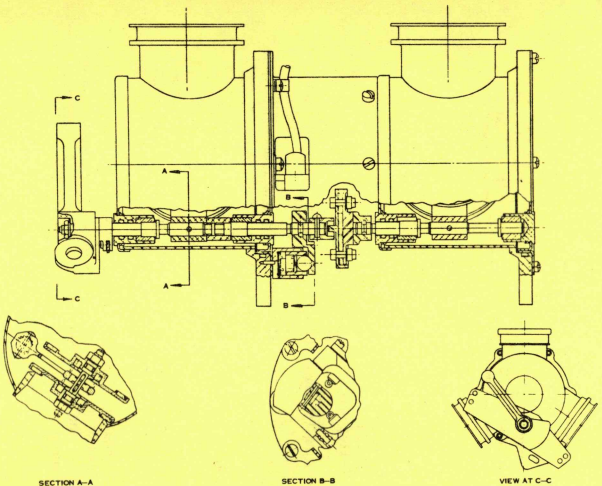


Figure 4-10. Sectional View of Lithium Hydroxide Selector Valve
Item 114

Ports - 1 Inlet oxygen }
2 Outlet oxygen } 2 in. O.D. Gamah

Handle Position - Valve actuation is by pushing or pulling a lever.
Fully in - Primary water separator is selected.
Fully out - Secondary water separator is selected.

Fluid Temperature - 0° to 160°F
Fluid Pressures - 3.7 to 5.8 psia

Handle Force - 15 lb max.

Leakage - External - With positive pressure differential, leakage does not exceed 0.00004 pounds of oxygen per hour at 3.9 psia and 70°F at an ambient pressure of 10^{-14} mm Hg to 3.9 psia with the valve in either position. Leakage in with negative pressure differential does not exceed 0.00032 pounds of air per hour at a valve inlet pressure of 3.5 psia and ambient pressure from 3.5 psia to 14.7 psia at 70°F .

Internal - Does not exceed 0.01 pounds of oxygen per hour at a pressure differential of 1.0 in H_2O across the valve element at an inlet pressure of 5.0 psia at 70°F with the valve in either position.

Pressure Drop - Does not exceed 0.163-in. H_2O for an oxygen flow of 0.08 lb/min at 5.0 psia and 75°F .

117 RELIEF VALVE

Spec. no. SVHS 2458
PAT no. SVHS 3500-26

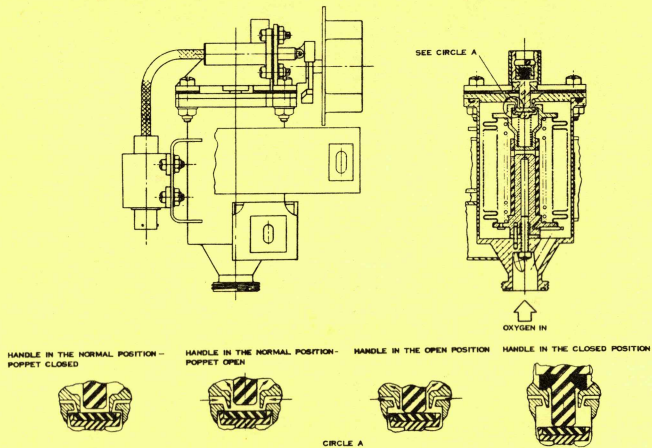
Spec. wt. - 1.75 lb
Actual wt. - 1.57 lb

Function - The suit circuit relief valve is used to prevent overpressurization of the suit loop.

Construction - Aluminum housings, beryllium-copper bellows, and 2 VPI switches.

Ports - Inlet oxygen (sensing port) — JT28-065 Gamah
Outlet oxygen to cabin - Unthreaded hole -0.375 in. I.D.

Figure 4-11. Sectional View of Suit Circuit Relief Valve Item 117



Handle Positions - 180° handle rotation

Normal position - Relief valve actuated by pressure of an aneroid bellows. Discharge is vented into the cabin.

Closed position - Manual override closes valve to cabin and closes switch which activates a VPI switch.

Flow capacity - 7.8 lb/hr minimum at 4.7 psia maximum and $75 \pm 5^\circ\text{F}$ at ambient pressure of 0.2 psia.

Actuation Pressures - Valve fully open at 4.7 psia, and valve fully closed at 4.3 psia

Handle Torque - 10 in. -lb

Leakage -

Positive Pressure Differential - With override in closed or normal position, total leakage of valve does not exceed 0.001 lb/hr of O_2 with an inlet pressure of 3.9 ± 0.02 psia at $75 \pm 10^\circ\text{F}$ and an ambient pressure of 10^{-14} mm Hg absolute.

Negative Pressure Differential - With override in closed position, total leakage into valve does not exceed 0.008 lb/hr of air with ambient pressure of 14.7 psia at 70°F and internal pressure of 3.5 psia.

118 SUIT CIRCUIT FAN ASSEMBLY

Spec. no. SVHS 2330, 3463, 2465

PAT no. SVHS 3500-22, 54

Spec. wt. - 5.31 lb

Actual wt. - 4.69 lb

Function - The suit circuit fan provides recirculation of oxygen through the suit atmosphere revitalization circuit.

Type - Centrifugal

Speed - Nominal 25,000 rpm. Overspeed to 36,000 rpm without permanent deformation

Power and performance -	Condition I	Condition II
Input power at 28.0 volts	160 watts max	160 watts max
Speed	25,000 rpm	25,000 rpm
Flow (total)	0.731 lb/min	0.5 min
Pressure rise (inlet to outlet)	15.3 in. of H ₂ O	11.1 in. of H ₂ O
Inlet temperature	75° F	75° F
Inlet pressure	4.95 psia	3.5 psia
Ambient pressure	5.0 psia	5.0 psia
Ambient temperature	75° F	75° F

Ground Checkout - At 14.7 psia and 14-16 volts, motor must operate. With 138 in bypass position, checkout is to confirm that water separator rpm is at least 800 with 118 running.

Leakage -	External Motor <u>Housing</u>	Internal Motor <u>Housing</u>	External Fan <u>Assy.</u>	Internal Fan <u>Assy.</u>
Leakage Rate	<0.00003 lb/hr O ₂	<0.00024 lb/hr air	<0.00005 lb/hr air	<0.0004 lb/hr air
Internal Pressure	3.7 psia	3.5 psia	3.7 psia	0.2 psia
Internal Temperature	75° F	75° F	75° F	75° F
Ambient Pressure	0.2 psia	14.7 psia	0.2 psia	14.7 psia
Ambient Temperature	75° F	75° F	75° F	75° F

119 CHECK VALVE

Spec. no. SVHS 2334
PAT no. SVHS 3500-28

Spec. wt. - 0.25 lb
Actual wt. - 0.10 lb

Construction - Aluminum housing.

Ports - Inlet and Outlet Oxygen - 2 in. O.D. tubing

Operating Pressures - 1.0 to 14.1 in. of H₂O

Operating Fluid - Oxygen

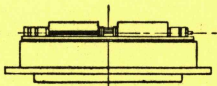
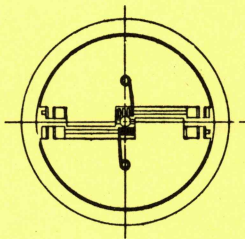


Figure 4-12. Suit Circuit Fan Check Valve Item 119

Pressure Drop - No more than 0.18 in. of H₂O at 0.8 lb/min O₂ at 75°F and inlet pressure of 5.0 psia

Cracking Pressure - Valve shall pass minimum flow of 0.10 lb/min O₂ at pressure differential of 0.15 inches of H₂O at 75°F and 5.0 psia inlet.

Leakage - Internal leakage in flow-checked direction does not exceed 0.15 lb/hr O₂ at pressure differential pressure from 1.0 to 14.1 inches of H₂O at 75°F and inlet pressure of 5.0 psia.

122, 125 LiOH CARTRIDGES

Spec. no. SVHS 2498

PAT no. SVHS 3500-4

	Spec. wt.	Actual wt.
122	9.25 lb	9.10 lb
125	4.80 lb	4.71 lb

Construction - Each cartridge is a replaceable sheet titanium cylinder containing LiOH and charcoal. The LiOH removes CO₂ and the charcoal removes odors.

Operating Pressures - 3.7 to 5.8 psia

Operating Temperature - 55° to 90°F

Activated Charcoal

122 - 0.52 - 0.55 lb

125 - 0.32 lb

LiOH

122 - 5.3 lbs min.

125 - 3.0-3.5 lb

Pressure Drop - 122 - 1.4 in. H₂O max at 0.7 lb/min flow and 5.0 psia inlet at 90°F

125 - 3.50 in. H₂O at 0.7 lb/min and 5.0 psia inlet at 80 ± 10°F

Endurance - The specified endurance times for the following conditions are:

Flow lb/min	Total pressure - psia	CO ₂ add lb/hr	Inlet temperature - °F	Inlet relative humidity - %	Minimum endurance time* -hours	
					Item 122	Item 125
0.7	5.0	0.20	55 - 90	40	20.5	5.3
0.7	5.0	0.20	55 - 90	80	20.5	5.3
0.52	3.8	0.20	55 - 90	40	20.5	5.3
0.52	3.8	0.20	55 - 90	80	20.5	5.3

* Endurance time is defined as the time in hours required for the cartridge CO₂ outlet partial pressure to reach 7.6 mm Hg.

124 FAN DIFFERENTIAL PRESSURE SENSOR

Spec.no. SVHS 2335

PAT no. SVHS 3500-30

Spec. wt. - 0.60 lb

Actual wt. - 0.57 lb

Construction - Aluminum sheet metal housing, hermetically sealed switch

Ports - Upstream and downstream O₂ sensing ports - 0.25 in.
O. D Gamah

Operation - When pressure rise across 118 fans drops below 6 in. of H₂O, the switch provides a closed circuit to the 134 which lights a cabin warning light.

Current - 1 ampere max.

Voltage - 25 to 31.5 volts

Leakage - External - With 3.7 psia at sensing ports, external leakage does not exceed 0.00002 lb/hr O₂ at ambient of 0.2 psia maximum. O₂ temp. is 75°F.

Internal - With oxygen at 5.0 psia and 75°F supplied to upstream port, and with downstream port 14.9 inches of H₂O higher than upstream port, internal leakage does not exceed 0.001 lb/hr O₂.

Negative Pressure Differential - The leakage into the sensor housing does not exceed 0.00016 pounds of air per hour at 75°F and at an ambient pressure of 14.7 psia and a sensing port pressure of 3.5 psia.

134 FAN SIGNAL CONTROL

Spec. no. SVHS 3237

PAT no. SVHS 3500-84

Spec. wt. - 1.3 lb

Actual wt. - 0.88 lb

Function - The fan signal control provides a closed contact for advisory and warning signals in the cabin to indicate malfunction of either suit fan.

Construction - Hermetically sealed, suppressor integral with unit.

Operation - Relay contacts are in open position when either suit fan is operating normally. When suit fan ΔP drops below 6 in. H₂O, the 124 sends a signal to the 134 energizing coil of relay K12, closing the contacts and activating an advisory light in the cabin. The closing of this circuit is immediate when either fan is low. Should fan number one have a low pressure rise, an advisory light and a yellow caution light are activated and the master alarm sounds. Should fan number two have a low pressure rise, the advisory light and a red warning light are activated and the master alarm sounds. Relay K12 is de-energized when Item 124 senses a suit fan pressure rise exceeding 8 in. H₂O.

Leakage - Leakage from or into the hermetically sealed portion of the control does not exceed 1×10^{-8} scc/sec of helium.

Actuation Time - Relay K12 has maximum drop time of 20 milliseconds.

138 SOLENOID VALVE

Spec.no. SVHS 4063

PAT no. SVHS 3500-84

Spec. wt. - 3.65 lb

Actual wt. - 3.61 lb

Construction - Aluminum housing, 1 solenoid, 1 VPI switch, 1 switch functional

Ports - Inlet and outlet oxygen to 190 - flange

Inlet and outlet oxygen to suit - 1.5 in. I. D. Gamah

Handle Position -

Normal - Full counterclockwise and locked. Flow is through the suit.

Bypass - 90° clockwise from normal. Flow bypasses the suit and returns to 190 package.

Handle Torque - 30 in.-lb

Pressure Drop - Not more than 0.30 in. H_2O for 0.35 lb/min O_2 flow at 5 psia and $50^\circ F$.

Leakage - Internal - Normal to Bypass - Does not exceed 0.085 lb/hr of O_2 at a pressure differential of 5.6 inches of H_2O with the valve in the normal flow position and an inlet pressure of 5.0 psia at 70° . Inlet to Outlet - Does not exceed 0.001 lb/hr/seat of oxygen at 4.0 psia at $70^\circ \pm 5^\circ F$ and pressure differential across the seat from 0 to 4.0 psi with the valve in the bypass position.

External - Positive Pressure Differential - Does not exceed 0.0021 lb/hr of oxygen when the valve is in the bypass position with an internal pressure of 4.0 psia at 70° and ambient pressure of 10^{-14} mm Hg to 4.0 psia.

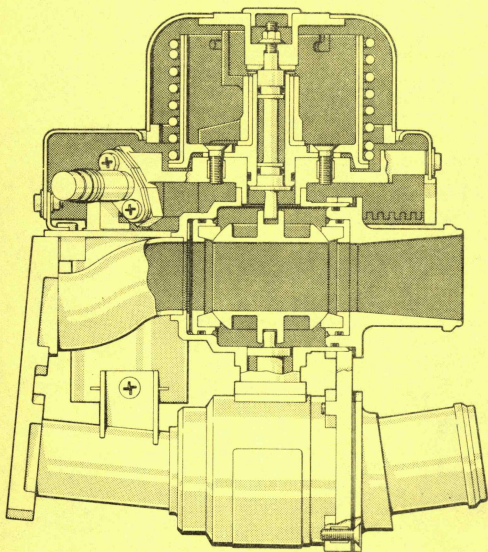


Figure 4-13. Solenoid Valve Item 138

The suit hose connector port leakages are not considered a part of this leakage value. Negative Pressure Differential - Does not exceed 0.008 lb/hr of oxygen with the valve in the bypass or normal flow position at an internal pressure of 3.5 psia and ambient pressure of 3.5 to 14.7 psia at 70°F.

Power Required by Solenoid - Not more than 22 watts at 31.5 volts d.c. at 70°F

Response Time - Not more than 250 milliseconds

190 SUIT CIRCUIT ASSEMBLY

Spec. no. SVHS 2476

PAT no. SVHS 3500-18, 85

Spec. wt. - 108.58 lb.

Actual wt. - 102.13 lb.

Function - The suit circuit assembly performs the following functions:

Maintains the level of carbon dioxide in the atmosphere breathed by the crew within prescribed limits.

Removes odors and noxious gases from the atmosphere breathed by the crew.

Removes foreign objects originating within or entering the package which are capable of causing malfunction of the package or impairment of crew performance.

Removes excess moisture from the atmosphere breathed by the crew.

Provides temperature control of the gas delivered to the space suits of the crew.

Provides a minimum of 12 cfm flow at 70°F and 3.5 psia for ventilating each space suit.

Provides for positive pressure relief of the suit loop.

Provides instrumentation for monitoring system performance.

Provides emergency cooling.

Provides means for isolating or communicating the recirculation loop from or with the cabin.

Provides means for connecting the space suit supply hoses.

Provides redundant means for maintaining ventilating flow.

Provides means for mounting of customer-supplied hardware, mounting of other system components, mounting to vehicle, connecting to hydraulic, pneumatic, electrical power, and instrument systems.

Provides various manual controls for operation of the system.

Provides manual means for bypassing this flow around each space suit while isolating that suit from the suit circuit assembly.

Description

The Suit Circuit Assembly, Item 190, consists of the following components and incorporates provisions for installing the following instruments:

<u>Item</u>	<u>Name</u>	<u>Qty.</u>
106	Suit Circuit Heat Exchanger	1
107	Suit Circuit Water Evaporator	1
109	Water Separator	2
110	Carbon Dioxide and Odor Removal Canister	1
111	Suit Circuit Regenerative Heat Exchanger	1
112	Suit Circuit Diverter Valve	1
113	Cabin Gas Return Check Valve	1
114	Canister Selector Valve	1
115	Water Separator Selector Valve	1
117	Suit Circuit Relief Valve	1
118	Suit Circuit Fan	2

<u>Item</u>	<u>Name</u>	<u>Qty</u>
119	Fan Backflow Check Valve	2
*122	Carbon Dioxide and Odor Removal Cartridge	1
124	Fan Differential Pressure Sensor	1
*125	Carbon Dioxide and Odor Removal Cartridge, PLSS	1
127	Carbon Dioxide and Odor Removal Canister, Small	1
138	Automatic Suit Bypass Valve	2
134	Fan Condition Signal Control	1
492	Water Check Valve	2

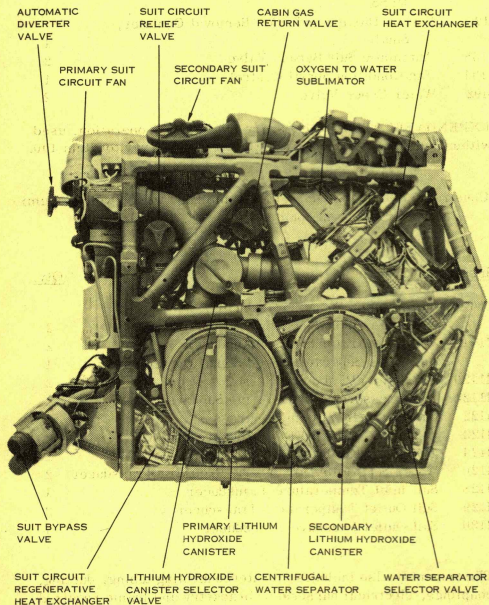
*EXPENDABLE ITEM. Necessary for Item 190 operation, used within Item 190, but not considered an integral part of Item 190.

Construction - Machined, welded aluminum frame, welded aluminum brackets and ducts.

<u>Instrument Name</u>	<u>Qty.</u>
I107 Compressor Speed Transducer	
Compressor Speed Signal Conditioner	2
I111 Water Separator Speed Transducer	2
Water Separator Speed Signal Conditioner	1
I1120 Suit Inlet VPI and Suppressor	2
I1121 Suit Pressure Relief VPI and Suppressor	2
I122 Suit Diverter VPI and Suppressor	1
I123 Cabin Gas Return VPI and Suppressor	2
I124 CO ₂ Absorber Inlet VPI and Suppressor	2
I126 Water Separator Differential Pressure Transducer	2
I128 Suit Inlet Temperature Transducer	1
I129 Suit Outlet Temperature Transducer	2
I130 Suit Outlet Pressure Transducer	1

The assembly also includes all interconnecting tubing, ducting, couplings, electrical harnesses, bracketry and frame required to mount and support the above listed components and instruments. In addition, the 190 package includes the Item 390 Control Circuitry Suppressor, the provisions required to mount the Item 390 Oxygen Control Assembly Package, and the associated equipment.

The 190 package has mounting provisions and bosses for CO₂ sensor and various temperature sensors.



LM ENVIRONMENTAL CONTROL ATMOSPHERE REVITALIZATION SECTION

Figure 4-14. LM Environmental Control Atmosphere Revitalization Section

191 CABIN AIR RECIRCULATION ASSEMBLY

Spec. no. SVHS 2477

PAT no. SVHS 3500-5

Spec. wt. - 20.31 lb

Actual wt. - 16.75 lb

Function - The cabin air recirculation assembly provides recirculation and temperature control of ambient cabin oxygen.

Description - The cabin air recirculation assembly consists basically of two motor-driven axial fans mounted in parallel on an inlet header of the cabin heat exchanger. The fan housings are an integral part of the header. The cabin assembly includes the 101 heat exchanger fan motors and fan, and ducting.

Input Voltage - 28 v.d.c.

Fan Speed - 13,000 rpm, overspeed to 17,000 rpm

Power Consumption - Not more than 30 watts at 12-15 volts d.c. (ground test ambient)

Fan Assembly Pressure Differential - 0.476 inches H₂O

203 CABIN TEMPERATURE CONTROL VALVE

Spec. no. SVHS 2339

PAT no. SVHS 3500-6

Function - The cabin temperature control valve controls the flow of coolant to the regenerative heat exchanger by sensing the coolant temperature at the outlet of the cabin heat exchanger. Controlling the flow to the regenerative heat exchanger controls the temperature to the inlet of the cabin heat exchanger, thus controlling the cabin gas temperature within specified limits.

Spec. wt. - 1.28 lb

Actual wt. - 1.09 lb

Description - The cabin temperature control valve is a spool type diverter valve with manual override provisions, and includes a thermal actuator which modulates coolant flow.

Construction - Aluminum body

Porting -

1 inlet glycol	}	all 0.375 O.D. Gamah
2 outlet glycol		
1 inlet glycol sensing port		
1 outlet glycol sensing port		

Modes of Operation -

Normal - At handle position 135° from full counterclockwise, the valve splits the flow evenly between the cabin heat exchanger and the regenerative heat exchanger at a sensed temperature of 70°F. Valve modulation is obtained by the linear motion of the thermal actuator which senses coolant temperature at the cabin heat exchanger outlet.

Manual - The manual override begins to alter the automatic operation of the valve at 80° and 180° when approached from the nominal position of 135°. 0° is maximum cooling with glycol bypassing the Item 204 regenerative heat exchanger flowing directly through the Item 101 cabin heat exchanger. 270° is maximum heating with all glycol passing through the Item 204 before flowing through the Item 101.

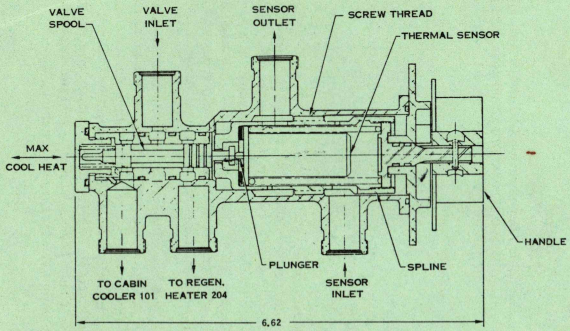


Figure 4-15. Sectional and Schematic View of Cabin Temperature Control Valve Item 203

Handle Torque - 13 in. -lb

Valve droop - The valve has a droop characteristic of 15°F to position the valve spool from full heating (all flow to Item 204) to full cooling.

Time constant - A step change of sensed coolant temperature of 15°F will displace the valve spool 63 percent of the total spool travel in 30 to 90 seconds.

Pressure drop - The pressure drop through either fully open port of the spool portion of the valve does not exceed 0.6 psi with coolant at 70°F and a flow rate of 3.7 lb/min supplied to the inlet port.

Sensor pressure drop - Not to exceed 0.4 psi through the sensor portion of the valve with coolant at 70°F and a flow rate of 3.7 lb/min supplied to the sensing inlet port.

Leakage - Internal - The spool leakage does not exceed 100 cc/hr with a coolant pressure differential of 1.2 psi and coolant temperature of 70°F. Spool leakage is defined as leakage of coolant across the closed portion of the spool. Sensor leakage does not exceed 100 cc/hr with a coolant pressure differential of 1.5 psi and coolant temperature of 70°F. Sensor leakage is defined as the leakage of coolant from the spool portion of the valve into the sensor portion of the valve.

External Leakage - Does not exceed 1×10^{-5} cc/sec of helium at STP at a pressure differential of 45 psi across the valve body.

204 HEAT EXCHANGER

Spec.no. SVHS 2403

PAT no. SVHS 3500-12

Type - Coolant regenerating

Spec. wt. - 2.83 lb

Actual wt. - 2.52 lb

Leakage - Internal - less than 0.01 cubic inches per hour between sides at 8 psid at room temperature.

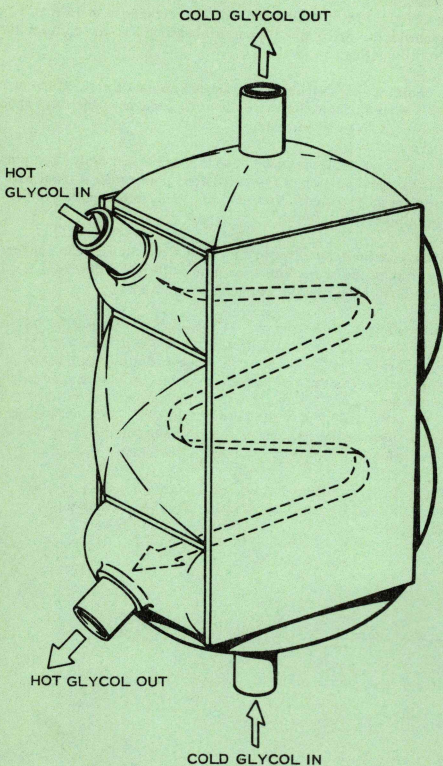


Figure 4-16. Heat Exchanger Item 204

External - Less than 1.11×10^{-5} cc/sec of helium when cold and hot side are pressurized at 45 psia at room temperature.

Construction - Fluxless brazed aluminum plate and fin.

Performance -

	<u>Hot Side</u>	<u>Cold Side</u>
Weight flow - lb/min	3.7	3.7
Temperature in - °F	68.2	45.20
Pressure in - psia	7.0 - 17.0	11.5 - 29.0

With the above inlet conditions, the following conditions exist:

Temperature out - °F	---	63.50
Pressure drop (includes headers) - psi	0.40	0.19
Percentage heating effectiveness		79.50

Heating effectiveness is defined as:

$$E_H = \frac{T_{\text{cold out}} - T_{\text{cold in}}}{T_{\text{hot in}} - T_{\text{cold in}}} \times 100$$

Ports - Inlet and outlet cold glycol }
 Inlet and outlet hot glycol } 0.375 in. O.D. Gamah

Type of Flow -

Cold glycol	Hot glycol
4-pass crosscounter flow	1 pass
11 paths	12 paths

208 SUIT VALVE TEMPERATURE CONTROL

Spec.no. SVHS 2493

PAT no. SVHS 3500-32

Type - Manual diverter valve

Spec.wt. - 0.30 lb

Actual wt. - 0.28 lb

Function - The suit valve temperature control is used for manual control of coolant flow through the 111 suit heat exchanger.

Ports - Inlet and outlet glycol }
One inlet and two outlet oxygen } 0.375 in. O.D. Gamah

Pressure Drop - The pressure drop across the valve and Item 111 Heat Exchanger combination does not exceed 0.6 psi with a coolant flow of 3.7 lb/min at 70°F with the valve in maximum heat exchanger flow position. The maximum pressure drop does not exceed 0.25 psi with a coolant flow of 3.7 lb/min at 70°F with the valve in the heat exchanger bypass.

Leakage - Internal — Internal leakage does not exceed 0.17 cc/min of coolant at a supply pressure of 0.15 psig and temperature of 70°F.

External Leakage - Leakage rate of 0.05×10^{-5} cc/sec of helium at STP is not exceeded at a pressure differential of 45 psi applied in either direction across the valve body.

Handle Position - Infinitely variable through 90° arc.

Full counterclockwise - Glycol bypasses Item 111 Heat Exchanger

Full clockwise - All glycol flow through Item 111 Heat Exchanger

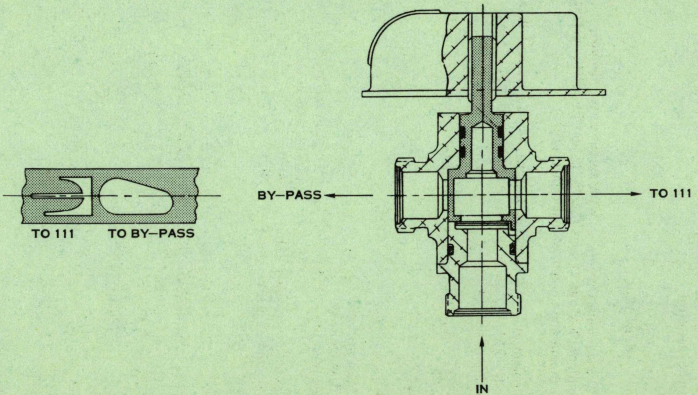


Figure 4-17. Sectional View of Temperature Control Valve (Suit)
Item 208

209 SUBLIMATOR

Spec.no. SVHS 2405

PAT no. SVHS 3500-27

Type - Glycol-to-water

Spec.wt. - 17.00 lb

Actual wt. - 15 lb, 13 oz.

Leakage - Evaporant Circuit — With steam outlet blocked, external leakage is less than 3.22 scc/hr of nitrogen at 6.5 psid and room ambient temperature.

Coolant Side - External or internal leakage is less than 1.5×10^{-5} cc/sec of helium at STP at 45 psia at room ambient temperature.

Construction - Stainless steel with sintered nickel porous plates.

Performance -

Constant Conditions

Coolant inlet pressure (psia)	5.5
Coolant flow (ppm)	3.7
Evaporant inlet temp. ($^{\circ}$ F)	81.0, 130 for Max normal heat load
Evaporant outlet pressure (μ Hg)	400.0
Evaporant inlet pressure (psia) (to flow limiter)	6.2

<u>Variable Conditions</u>	<u>Startup and Spec Point</u>	<u>Suit Integ. Heat Load</u>	<u>Low Load For Proof</u>	<u>Max. Normal Heat Load</u>
Coolant inlet temp. ($^{\circ}$ F)	86	65	38	100
Heat load (Btu/hr)	9,500	5,860	1,845	12,450
Evaporant flow (lb/min)	0.15	0.09	0.02	0.19

Output Requirements

Coolant outlet temp. ($^{\circ}$ F)	36.3 max	—	29.00 min	—
Coolant pressure drop (psid)	2.84 max	—	3.29 min	—

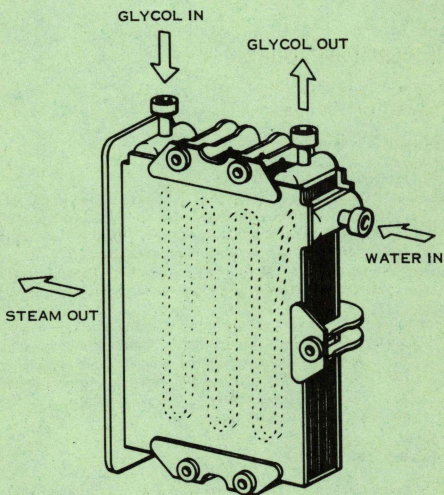


Figure 4-18. Sublimator Item 209

Ports - Inlet and outlet glycol - 0.375 in. O. D. Gamah
Inlet water - 0.275 in. O. D. Gamah
Outlet steam - 3 in. x 9 in.

Type of Flow -

<u>Glycol</u>	<u>Water</u>
6-pass crosscounter flow	one pass
6-paths	10 paths

210 GLYCOL ACCUMULATOR

Spec. no. SVHS 2494
PAT no. SVHS 3500-21

Spec. wt. - 3.85 lb
Actual wt. - 3.48 lb

Function - The coolant accumulator is used to maintain the inlet pressure to the coolant pump above a minimum value of 5.5 psia to prevent pump cavitation. The coolant accumulator also absorbs normal volumetric changes of the coolant due to temperature fluctuations. There is one in the primary glycol loop and one in the redundant glycol loop.

Description - The coolant accumulator consists of a cylindrically shaped aluminum tank. Inside the tank is a piston, spring, and diaphragm which expels the coolant under continuous pressure. The tank has one common inlet-outlet port and has an overboard vent fitting. The accumulator also has a low level indicating switch.

Functional Requirements

Accumulator Capacity - The accumulator has a minimum usable capacity of 46 cubic inches of coolant. The unusable capacity of the accumulator when the piston and diaphragm are in the extreme empty position is not greater than 4.0 cubic inches of coolant.

Low Level Instrumentation - The low level indicator is actuated by the piston at a point when 10 ± 5 percent of the usable capacity of coolant remains.

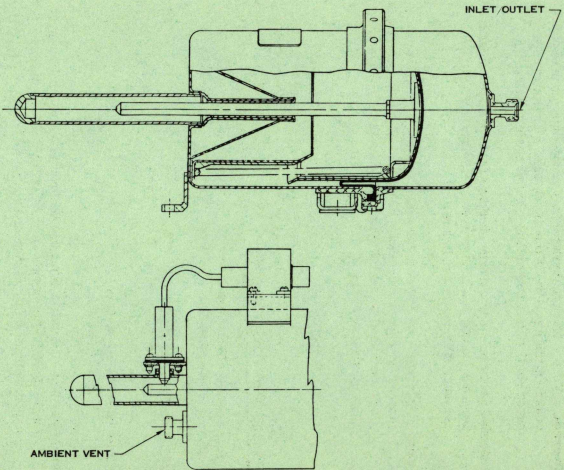


Figure 4-19. External and Sectional Views of Glycol Accumulator
Item 210

Sight Gauge - A sight gauge indicates glycol level in 10 percent increments.

Pressure Output - The pressure maintained by the accumulator on the coolant at 95 percent of usable capacity is 8.49 ± 0.42 psi. At the 5 percent of usable capacity position, the pressure is 5.66 ± 0.28 psi.

Overboard Vent - The accumulator has provisions for a vent overboard on the gas side of the diaphragm. This consists of an outer shell of the accumulator in the spring cavity.

External Leakage - The external leakage from the accumulator does not exceed 1×10^{-4} cc/sec of helium at STP with a pressure differential of 45 psi.

Internal Leakage - The internal leakage across the diaphragm is checked by a pressure decay technique. Pressure decay is not in excess of 1 psi in 30 minutes with the glycol side at 45 psig using nitrogen.

214, 223 QUICK DISCONNECTS

Spec. no. SVHS 2360, 3148

PAT no. SVHS 3500-33

Spec. wt. - 214 - 0.14 lb

223 - 0.24 lb

Actual wt. - 214 - 0.09 lb

223 - 0.18 lb

Function - The GSE quick disconnects provide supply and return connections to the ground support equipment during pre-launch operation of the heat transport section.

Construction - Aluminum body with cable-tethered cap

Operating Temperature - 20°F to 140°F

Operating Pressure - 3.5 to 45 psig

Pressure Drop - Less than 1.0 psi at 3.7 lb/min coolant flow at 70°F in either direction.

Operating fluid - Ethylene glycol and water solution.

Leakage - Coupled — The external leakage of each coupled disconnect does not exceed a helium leakage rate of 1×10^{-2} cc/hr with a pressure differential of 45 psi.

Uncoupled - With Cap On — The external leakage of each uncoupled male or female portion of each disconnect with its respective cap installed and self-sealing feature disabled does not exceed a helium leakage rate of 3×10^{-5} cc/hr at STP with helium at 45 psig.

Uncoupled - With Cap Off — The external leakage of the self-sealing device of each uncoupled male or female portion (less cap) does not exceed a helium leakage rate of 1×10^{-2} cc/hr with a pressure differential of 45 psi.

Operation - The disconnect can be coupled and uncoupled with one hand without the use of tools. Operation is possible with 45 psig static coolant pressure applied. It is possible to determine visually that the disconnect is completely coupled and locked. The disconnect has no partially coupled or unlocked positions which are stable and permit fluid flow. Coupling and uncoupling consist of a single motion with a maximum axial force of 30 lb.

218 PUMP DIFFERENTIAL PRESSURE SENSOR SWITCH

Spec.no. SVHS 2338/2757

PAT no. SVHS 3500-8

Spec.wt.- Part of 290 package total

Construction - Stainless steel housing, includes sensor, signal transmitter, and sensing ports.

Ports - Up and downstream glycol sensing ports - MS 33656-2.

Operation - When glycol pump pressure drops to 3.0 psid, the switch closes circuits to activate a cabin warning light and initiate a sequence which switches from pump one in primary loop to pump two. The contacts open where pump pressure rise exceeds 7 psid.

Leakage - External leakage with high and low pressure ports pressurized to 46 psia is less than 1×10^{-7} cc/sec helium.

224 SUBLIMATOR

Spec.no. SVHS 3299

PAT no. SVHS 3500-71

Type - Glycol-to-water

Spec.wt. - 5.36 lb

Actual wt. - 3 lb, 13 oz

Leakage - Evaporant Limit — With steam outlet sealed, external leakage is less than 3.40 scc/hr of N₂ at 6.5 psid and room ambient temperature.

Coolant Circuit - External and internal leakage from the coolant circuit does not exceed 1.5×10^{-5} cc/sec of helium at STP at 45 psia.

Construction - Stainless steel with sintered nickel porous plates.

Performance -

Constant Conditions

Coolant Inlet Pressure (psia)	4.8
Coolant Flow (ppm)	3.70
Evaporant Inlet Temperature (°F)	81
Evaporant Outlet Pressure (μ Hg)	400 max.
Evaporant Inlet Pressure (psia) (to flow limiter)	6.2

<u>Variable Conditions</u>	<u>Startup & Max. Heat Load</u>	<u>Specification Point</u>	<u>Min. Heat Load</u>
Coolant Inlet Temperature (°F)	85	60.1	40.1
Heat Load (BTU/hr) ref.	4770	2510	755
Evaporant Flow (lb/min) ref.	0.094	0.0408	0.0200

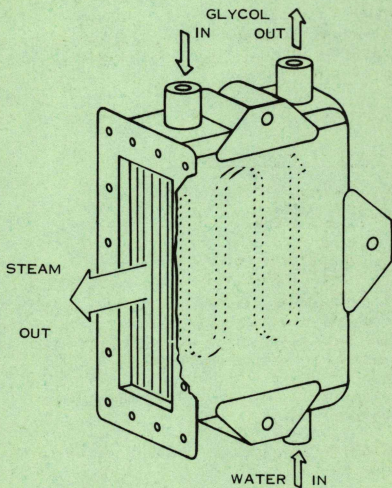


Figure 4-20. Sublimator Item 224

Output Requirements

Coolant Outlet Temperature (°F)	-----	47	-----
Coolant Pressure Drop (psid)	-----	1.26	-----

Ports - Inlet and outlet glycol - 0.375 in. O.D. Gamah
Inlet water - 0.250 in. O.D. Gamah
Steam outlet - 2 in. x 5 in.

Type of Flow -

<u>Water</u>	<u>Glycol</u>
Elbow bend, single pass	4-pass
6 paths - 4 paths	4 paths

290 COOLANT RECIRCULATION ASSEMBLY

Spec.no. SVHS 2757
PAT no. SVHS 3500-8

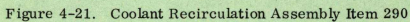
Spec.wt. - 9.09 lb
Actual wt. - 8.22 lb

Function - The function of the coolant circulation assembly is to circulate ethylene glycol solution through the heat transport section consisting of several heat exchanger controls and vehicle electronic equipment.

Construction - Hermetically sealed electronics, aluminum housing

Description - The pump package consists of the following components:

<u>Item</u>	<u>Description</u>	<u>Quantity</u>
201	Coolant Pump (incl. motor)	3
202	Relief Valve	3
212	Coolant Filter	1
213	Check Valve	3
218	Differential Pressure Switch	1
1202	Differential Pressure Transducer	1



Only one pump operator at a time and each can satisfy the pressure and flow requirements of the pump package. A coolant filter is located in the pump package at the inlet to the pump for protection from contaminated coolant. The filter contains an integral pressure relief bypass. A pump differential pressure sensor senses low pump pressure rise.

Performance -

<u>Condition</u>	<u>Min.</u>	<u>Rated</u>	<u>Max.</u>
Inlet pressure psia	5.5	5.5	23.3
Pressure rise	30.0	30.0	36.4
Coolant inlet temp.	20°F	40°F	90°F
Coolant flow (lb ³ /min)	--	3.7 (min)	--

Pressure rise is measured between the package accumulator inlet and the package outlet ports. This is the ΔP to be monitored by the ΔP switch.

Relief Valve - Located downstream of the last pump to relieve excessive pump pressure and bypass the excessive flow back to the pump inlet. Valve cracks at minimum of 35 psi pressure rise across the pump and allows full flow at a maximum of 40 psi pressure rise.

Check Valve - Located downstream of each pump. The valve cracks with a maximum of 8 inches of water applied across the valve. Maximum internal leakage is 0.33 in.³/min at 40 psig back pressure.

Coolant Filter - Located at inlet to pump. The filter includes an integral bypass relief valve to maintain coolant flow should the filter become clogged.

Pump Differential Pressure Sensor -

Voltage - 28 volts d. c.

Power Consumption - does not exceed 0.8 amps at 28 volts d. c.

Ports - Sensing ports - MS 33656-2

Inlet and outlet glycol - 0.375 in. O.D. Gamah

Leakage - With any two ports capped and the third at 45 psia helium, external leakage is no more than 1×10^{-5} cc/hr.

Mounting provision for I202 on housing

304 SHUTOFF VALVE

Spec. no. SVHS 2341
PAT no. SVHS 3500-69

Spec. wt. - 0.26 lb
Actual wt. - 0.30 lb

Function - The valve is a manually operated high pressure shutoff valve with detent provisions in both the open and closed position.

Ports - None, assembled into Item 390 manifold.

Construction - Aluminum valve body

Manual Operation - The valve travels from full open to full closed with 210° maximum rotation of the handle.

Handle Torque - 12 in.-lb.

Leakage - Internal — Leakage across the closed valve seat does not exceed 0.001 lb/hr of oxygen at a pressure differential of 950 psi at 70°F. This requirement applies with the pressure differential in either direction across the valve seat.

External - External leakage of the valve does not exceed 0.0001 lb/hr of oxygen at a pressure differential of 950 psi at 70°F. This requirement applies with the pressure differential in either direction across the valve body.

Pressure Drop - The valve is capable of passing a flow of 8 lb/min. The pressure drop does not exceed 120 psi when the valve is supplied with oxygen at 700 psia and 130°F at the filter end.

The flow is not less than 4.0 lb/min with an inlet pressure of 1000 psia and 70°F applied in the direction opposite the filter.

The flow through the valve is not less than 4.0 lb/min with a pressure drop of 100 psi and an inlet pressure of 1000 psia and 70°F applied in the direction opposite from the filter.

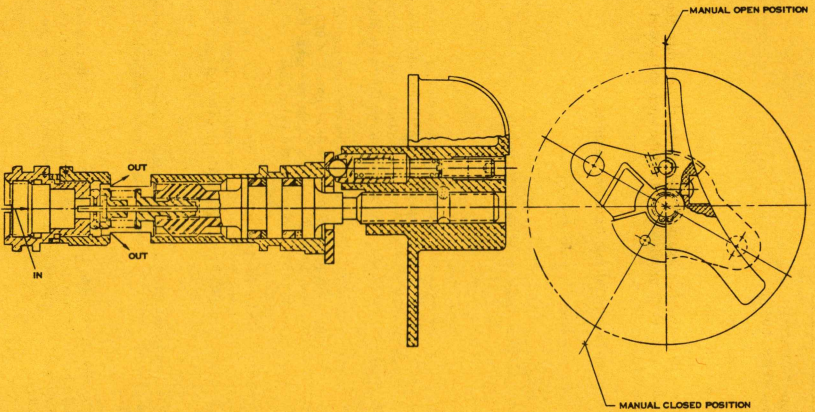


Figure 4-22. Sectional View of Manual Shutoff Valve Item 304

306 OXYGEN INFLOW REGULATOR

Spec.no. SVHS 2459/3561

PAT no. SVHS 3500-53

Spec.wt.- 2.36 lb

Actual wt.- 1.69 lb

Function - The oxygen inflow regulator automatically regulates the pressure within the atmospheric revitalization system and supplies low pressure oxygen as required to satisfy leakage and metabolic demands.

The regulator handle has four positions which control the arming of the electrical switching logic associated with Items 309, 112, and 191. Refer to figure 4-23.

Construction - Aluminum body. Each regulator has two functional switches and two VPI instrument switches.

Ports - None, regulators mount into the Item 390 manifold.

Normal flow fluid -

0°F to +160°F, 75 psia to 1100 psia

Sensed fluid

0°F to +160°F, 0 psia to 20.5 psia

Leakage - Internal — Leakage across the manually closed regulator valve seat not to exceed 0.001 lb/hr of oxygen when the normal flow inlet pressure varies from 75 psig to 950 psig at 70°F for the manual closed position.

External - External leakage of the closed regulator does not exceed 0.0001 lb/hr with 950 psig and 70°F at the normal flow inlet.

Normal Range Pressure Control - The pressure regulator is capable of controlling the pressure of a minimum volume of 2.6 ft³ as indicated in the table below.

<u>Inlet Pressure</u> <u>Range (psia)</u>	<u>Flow Range</u> <u>(lb/hr)</u>	<u>Regulator Pressure Control</u> <u>Band (psia)</u>	
		<u>Min.</u>	<u>Max.</u>
50 - 100	0.20 - 0.37 (2 reg)	4.60	5.00
100 - 400	0.10 - 0.37 (1 reg)	4.60	5.00
400 - 1100	0.10 - 0.50 (1 reg)	4.60	5.00

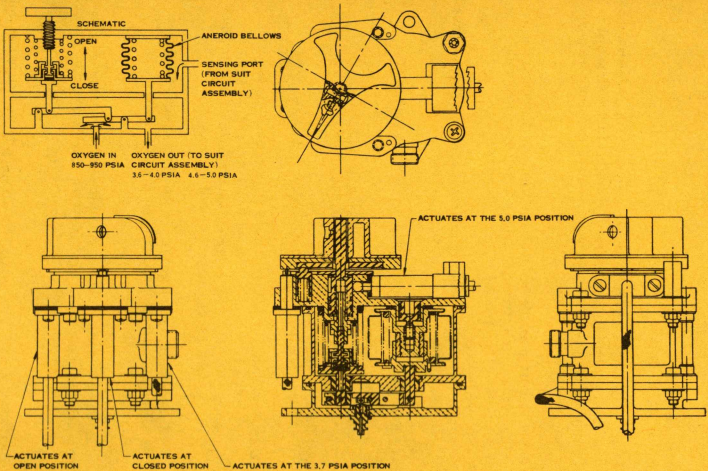


Figure 4-23. Section and Schematic Views of Oxygen Inflow Regulator Valve Item 306

Egress Range Pressure Control - The regulator egress pressure control band of the 2.6 ft³ volume shall not exceed the following limits listed below.

<u>Inlet Pressure</u> <u>Range (psia)</u>	<u>Flow Range</u> <u>lb/hr</u>	<u>Regulator Pressure Control</u> <u>Band (psia)</u>	
		<u>Min.</u>	<u>Max.</u>
50 - 100	0.10 - 0.37 (2 reg)	3.60	4.00
100 - 1100	0.05 - 0.37 (1 reg)	3.60	4.00

Manual Flow - The flow of oxygen at an inlet condition of 550 psig and 70°F is between 3.65 lb/hr and 3.91 lb/hr when the regulator is either manually open or in the egress mode with a sensed pressure of 3.5 psia.

Valve Travel - Full open to full closed is 270°

Handle Torque - 10 in. -lb.

Handle Position -

Egress - Valve fully counterclockwise - suit pressure maintained at 3.8 psia

Normal - 90° from egress position - suit pressure maintained at 4.8 psia, cabin maintained at nominal 4.8 psia.

Open - 180° from egress position.

Closed - 270° from egress

307 CABIN DUMP VALVE

Spec.no. SVHS 2460

PAT no. SVHS 3500-7

Spec.wt. - 2.27 lb

Actual wt. - 1.95 lb

Function - The cabin dump and relief valve prevents overpressurization of the cabin. In addition, the valve can be opened manually to equalize cabin and ambient pressure.

Construction - Aluminum body

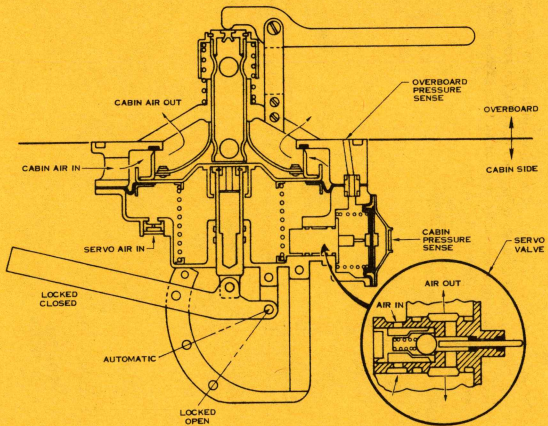


Figure 4-24. Sectional View of Cabin Dump Valve Item 307

Ports - Sensing port
 Servo dump port
 Main dump port

Fluid Temperature - From -20°F to $+160^{\circ}\text{F}$

Fluid Pressure - From 10^{-14} mm Hg to 20.5 psia

Functional Requirements -

Opening - The valve can be overridden open from the inlet side for all operating modes. Latching is provided on the inlet side only for maintaining the valve in the open position. The valve is capable of being overridden open from the discharge side provided the valve is not latched in the closed position on the inlet side.

Closing - The valve can be overridden closed from the inlet side only for all operating modes. Latching is provided for maintaining the valve in the closed position on the inlet side only.

Normal Operation - The normal operating condition (positive pressure relief function) is selectable from the inlet side. Latching in this position is provided for the inlet side. With the inlet side handle in the normal operating condition, the discharge side handle is in the normal operating position unless overridden to the open position.

Handle Positions -

Closed - Handle fully down
Normal - Handle in middle position
Open - Handle fully up

Leakage - The total leakage of the valve in the normal and manually closed modes does not exceed 0.005 pounds per hour of oxygen at any differential from 0 to 5.25 psid and 70°F inlet and 14.7 psia to 10^{-14} mm Hg abs at the outlet.

Operating Pressure Band -

Maximum Flow - The valve is capable of passing an oxygen flow of 0 to 11.1 lb/min (equivalent to 10.7 lb/min of air) to a valve discharge pressure between 0 and 3.5 psia without exceeding 5.8 psid up to 160°F .

Cracking Flow - The valve differential pressure is a minimum of 5.4 psi at a maximum flow of 1.0 lb/hr of oxygen at a fluid temperature of 70°F and ambient pressure ranging from 14.7 psia to 10⁻¹⁴ mm Hg abs.

Pressure Reversal - The valve shall remain in the closed position when the valve discharge pressure exceeds the valve inlet pressure by 0.4 psid maximum.

Handle Torque -

Positioning Feature Location	Pressure Differential (inlet - discharge)	Direction of Actuation	Maximum Torque
Inside Handle	5.8 psi	Normal to open Normal to closed	65 in.-lb.
Outside Handle	5.8 psi	Normal to open	65 in.-lb.

309 CABIN REPRESSURIZATION SOLENOID VALVE

Spec. no. SVHS 2441, 2486

PAT no. SVHS 3500-3

Spec. wt. - 1.98 lb

Actual wt. - 1.46 lb

Function - The cabin repressurization and emergency oxygen valve provides for direct delivery of oxygen to the cabin to slow decay of cabin pressure resulting from a puncture or to provide repressurization of the cabin following a normal depressurization.

Minimum Flow Rate - 8 lb/min oxygen at 800 psia supply.

Handle Torque - 13 in.-lb.

Handle Position -

Manual open - Full counterclockwise

Automatic - 90° clockwise from open

Manual closed - 180° clockwise from open

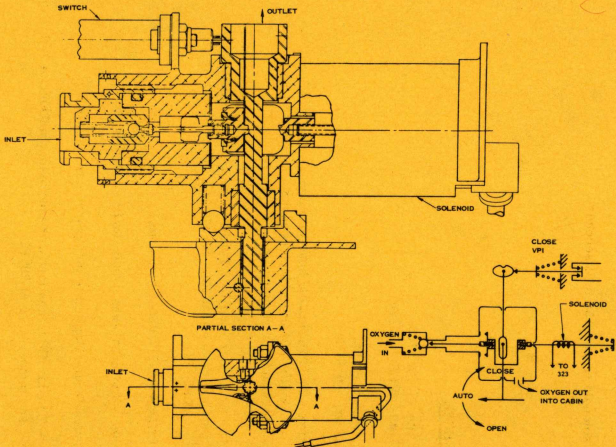


Figure 4-25. Sectional View of Manual Override Solenoid Valve
Item 309

Ports - Inlet oxygen - flange
Outlet oxygen - 1/2 in. square

Leakage - Leakage across closed valve does not exceed 0.001 lb/hr of O₂ at pressure differential of 950 psi and 75 psi at 70°F.
This requirement is for manual or solenoid closed position.

Solenoid power - 22 watts at 31.5 volts d.c. at 70°F ambient

Full solenoid travel - 50 milliseconds

316 HOSE

Spec. no. SVHS 2709
PAT no. SVHS 3500-40

Spec. wt - 0.62 lb
Actual wt. - 0.54 lb

Function - The 316 flexible hose provides oxygen flow and coupling from the 304 of the high pressure oxygen section to the backpack for recharging.

Construction - Carbon-filled Teflon inner core covered with braided stainless steel sheath. Sheath is covered with a Teflon chafing cover.

End fittings - MS 33656-4 both ends.

Leakage - Not more than 0.0001 lb/hr oxygen at 950 psig and 70°F.

Pressure Drop - Negligible (no spec requirement)

Flow - 7 lb/hr O₂ to ambient with upstream pressure at 150 psia and temperature at 20°F.

323 CABIN PRESSURE SWITCH

Spec. no. SVHS 3253/3477

PAT no. SVHS 3500-74, 81

Spec. wt. - 1.40 lb

Actual wt. - 1.37 lb

Construction - Aluminum housing, three switches interwired such that switch output reflects state of two out of three switches.

Ports - Oxygen pressure sensing port 3/4 in. diameter.

Operation - When cabin pressure drops to 4.45 - 3.70 psia, the switch closes circuit to open the 309 valve, activates a cabin warning light, and starts sequence that closes 112 valve to cabin. Switch contacts open when cabin pressure rises to 4.4 to 5.0 psia.

Current - Max. 1.5 amps

Voltage - 25 to 31.5 volts

390 OXYGEN SUPPLY MODULE

Spec. no. SVHS 2396, 3374

PAT. no. SVHS 3500-41, 77

Spec. wt. - 10.77 lb

Actual wt. - 9.53 lb

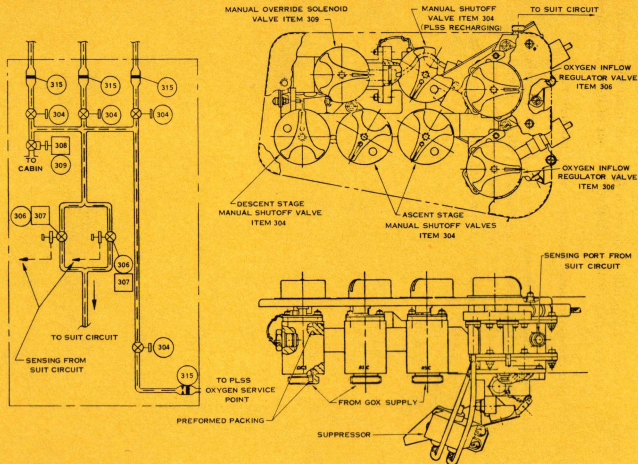
Function

Maintain ARS and cabin pressure

Provide for emergency and normal repressurization of cabin

Provide means for PLSS refill

Figure 4-26. Oxygen Supply Module Item 390



Description -

<u>Item</u>	<u>Name</u>	<u>Quantity</u>
304	Oxygen Shutoff Valve	4
306	Oxygen Flow Regulator	2
309	Cabin Repressurization and Emergency Oxygen Valve	1
315	Oxygen Filter	4
(Part)	Manifold and Inserts Module	
(Part)	Control Panel	

Ports - 304 port (4)
 309 port (1)
 306 sensing (1)
 Outlet to ARS (1)

401 & 492 CHECK VALVE

Spec. no. SVHS 2351

PAT no. - 401 - SVHS 3500-9

- 492 - SVHS 3500-72

Spec. wt. - 401 - 0.05 lb (no housing)

- 492 - 0.13 lb

Actual wt. - 401 - 0.01

- 492 - 0.11

Construction - 401 - Machined aluminum housing - rubber poppet

- 492 - Same as 401 plus machined aluminum outer housing

Operating pressures - 0 to 50 psia

Pressure Drop - Not more than 1.0 psi with water flow of 0.85 lb/min and not more than 4.0 in. of water with water flow of 0.03 lb/min. Water inlet temperature 70°F.

Cracking pressure - 3 in. H₂O

Ports - 401 - None, valve is integral with 490 module - overall diameter of 3/4 in.

492 - Inlet and outlet water 0.25 in. Gamah

Leakage -

Valve Leakage - The leakage through the valve in the reverse flow direction does not exceed 0.050 cc/hr of water with any pressure differential from 0.5 to 50 psia and a temperature of 70°F.

Assembly Leakage - Internal leakage in the reverse flow direction does not exceed 0.050 cc/hr of water with any pressure differential from 0.5 to 50.0 psi and a temperature of 70°F. External leakage shall not exceed 5×10^{-5} lb/hr O₂ at pressure differential of 10.7 psi and a temperature of 70°F.

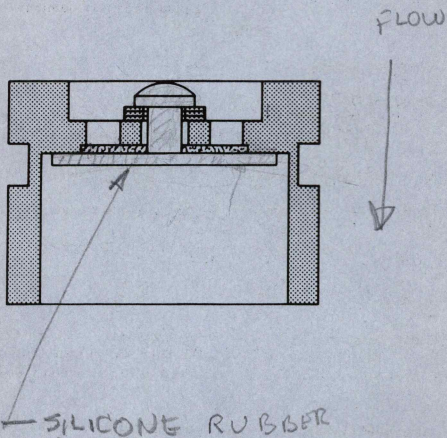


Figure 4-27. Check Valve Item 401

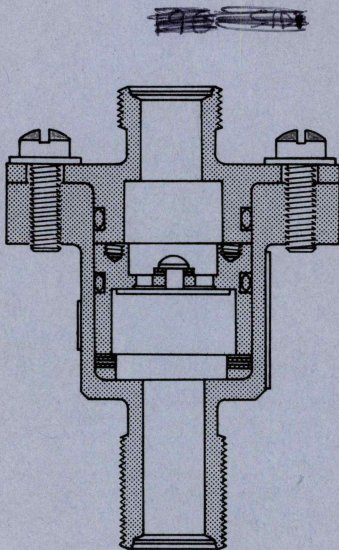


Figure 4-28. Check Valve Item 492

402 & 406 SHUTOFF VALVES

402 Spec. no. SVHS 2352

406 Spec. no. SVHS 2467

402 PAT no. SVHS 3500-43

406 PAT no. SVHS 3500-47

Spec. wt. - 402 - 0.22 lbs.

406 - 0.18 lbs.

Actual wt. - 402 - 0.16 lbs.

406 - 0.12 lbs.

Function - The 402 opens or closes water flow to the 209 sublimator.

The 406 opens or closes water flow to the 224 and 107 sublimators.

Construction - Aluminum body - titanium shaft - synthetic rubber seat

Ports - None. Valves mount into the 490 manifold.

Operating Temperature - 32° to 160°F.

Operating Pressures - 4.0 to 55 psia

Internal Leakage - Does not exceed 0.009 cc of water per hour at a pressure differential of 50 psia (inlet to outlet) at 70°F.

External Leakage - External leakage of the valve does not exceed 0.020 cc of water/hour at a pressure differential of 50 psi at 70°F.

Manual Operation - The valve handle travel from the full open to the full closed position is 270 degrees. Full clockwise is closed.

Handle Torque - 10 inch-pounds

Pressure Drop - The valve is capable of passing 0.5 pound of water per minute with a maximum pressure drop of 1.5 inches of water at room ambient conditions.

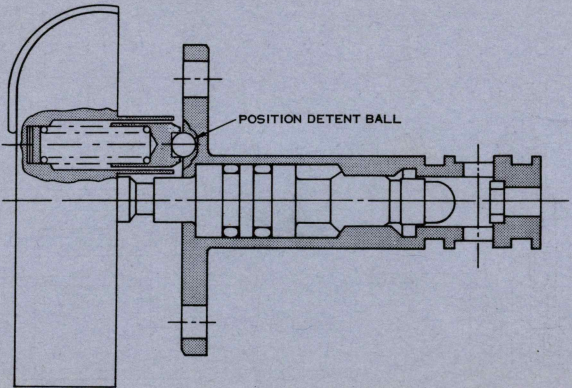


Figure 4-29. Sectional View of Shutoff Valve Item 402

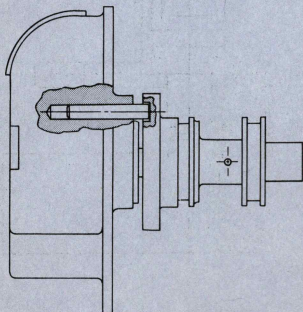
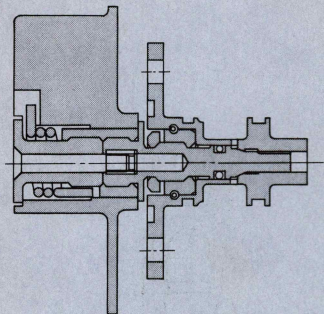


Figure 4-30. External and Sectional Views of Manual Water Control Valve Item 406

404 WATER TANK

Spec. no. SVHS 2478
PAT no. SVHS 3500-45

Spec.wt. - 23.96 lb
Actual wt. - 20.81 lb

Construction - Spun aluminum shell, silicon rubber bladder
Capacity - 332 lb of water
Pressure Range - 0-48.2 psia

Pressure Differential (Normal Use) - 15 psi outside to inside, 48.2 psi
inside to outside, 15 psi across the bladder outside to inside.

Flow Rates - 0.85 lb/min. minimum over entire range of pressure
and temperature from 48.2 psia at 160°F to 7.5 psia at 35°F.

Leakage

Gas Leakage - Across the tank bladder inside to outside is not
more than 180 scc/hr nitrogen at 5.0 psi differential.

External Nitrogen Leakage - No more than 3.6×10^{-1} scc/hr
nitrogen at 56 psid (ullage to ambient)

External Water Leakage - Not more than 1.5×10^{-2} cc/hr at
70°F

Expulsion Efficiency - 98 percent for loadings above 100 lb

409 WATER TANK

Spec. no. SVHS 2467
PAT no. SVHS 3500-47

Spec. wt. - 6.00 lb
Actual wt. - 5.31 lb

Construction - Spun aluminum shell, silicon rubber bladder

Capacity - 42.5 lb of water

Pressure range - 0-48.2 psia

Pressure Differential (Normal) - 15 psi outside to inside, 62 psi in-
side to outside, 15 psi across the bladder outside to inside

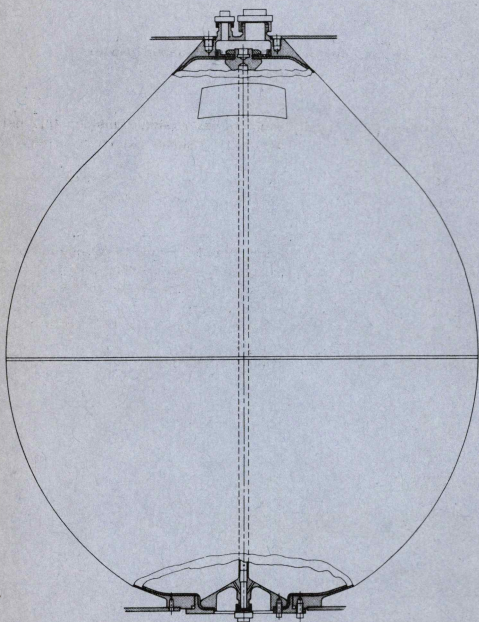


Figure 4-31. Descent Water Tank Item 404

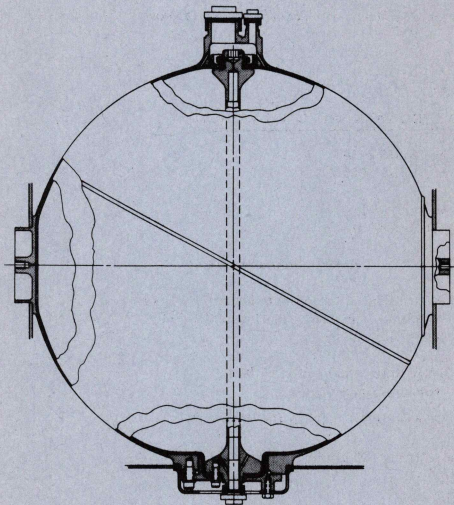


Figure 4-32. Ascent Water Tank Item 409

Flow Rates - 0.85 lb/min. over entire range of pressure and temperature from 48.2 psia at 160°F to 7.2 psi at 35°F

Leakage

Gas Leakage - Across the bladder inside to outside is not more than 85 scc/hr nitrogen at 5.0 psi differential.

External Nitrogen Leakage - Not more than 0.7×10^{-1} scc/hr at a pressure differential of 54 psi (ullage to ambient)

External Water Leakage - Not more than 1.5×10^{-2} cc/hr at 70°F

Expulsion Efficiency - 98 percent for loads above 20 lb of water

414 WATER TANK SELECTOR VALVE

Spec. no. SVHS 2718

PAT no. SVHS 3500-10

Spec. wt. - 3.66 lb

Actual wt. - 3.23 lb

Construction - Machined aluminum casting

Description - The 414 aluminum housing forms the basis for the 490 module. The valve positions and porting are discussed under Item 490.

Water Flow Rate - Max. of 0.85 lb/min. water at any pressure between 4.2 and 5.5 psia

Water Temperature - 32° to 160°F

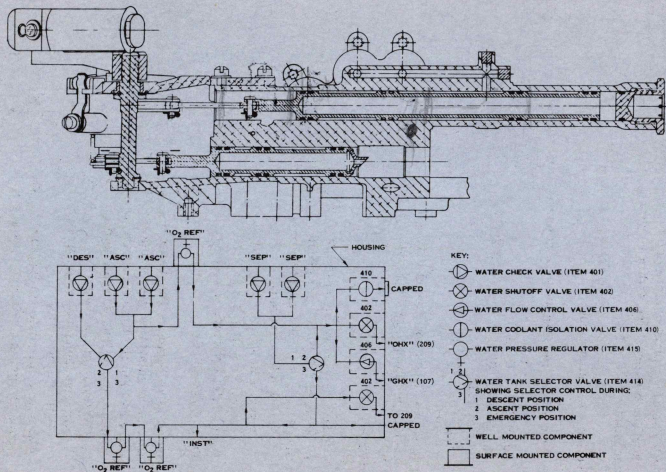
Pressure Drop - Negligible (no spec requirement)

Leakage -

Internal - Internal leakage between any of the separate valve passages with valve handle in any position is no more than 0.050 cc/hr water at 70°F and pressure differential of 50 psi max.

External - With valve handle in any position and all external ports capped, the external leakage excluding leakage from the caps is no more than 0.174 cc/hr water at 70°F and an internal pressure of 50 psig. The max. leakage through the housing body shell is 0.020 cc/hr of water.

Figure 4-33. Water Tank Selector Valve Item 414



415 WATER PRESSURE REGULATOR

Spec. no. SVHS 2717
PAT no. SVHS 3500-11

Spec. wt. - 0.72 lb
Actual wt. - 0.52 lb

Function - The water pressure regulator controls the water management section pressure within specified limits above suit loop pressure.

Construction - Aluminum body

Ports - None - 0.25 in. Gamah - O₂ reference for regulator

Normal flow fluid	
32°F to 160°F	6.5 psia to 55.0 psia
Sensed fluid	
0°F to +160°F	3.9 psia to 20.5 psia

Pressure Drop - Does not exceed 0.2 psi at a water flow rate of 0.85 pounds per minute at 70°F with regulator wide open

Regulated Pressure -

Single Regulator - The water outlet pressure from a single regulator is between 0.5 to 1.0 psi greater than the oxygen reference pressure at the conditions below.

Water Inlet Pressure	55 to 6.5 psia
Oxygen Reference Pressure	3.9 to 9.6 psia
Water Flow Rates	0.01 to 0.85 lb/min.

Water inlet pressure is at least 0.6 psi above oxygen reference pressure.

Two Regulators in Series - The water outlet pressure from the downstream regulator of two regulators in series shall be maintained within the band limits defined in figure 4-34 for the range of conditions defined below.

Water Inlet Pressure	55 to 6.5 psia
Oxygen Reference Pressure	3.9 to 9.6 psia
Water Flow Rates	0.01 to 0.85 lb/min.

Water inlet pressure to the first regulator is at least 1.2 psi above the oxygen reference pressure.

Lag Time - The regulator maintains control of downstream pressure within the limits of figure 4-34 with the reference pressure varying at any rate up to 5 psi per minute.

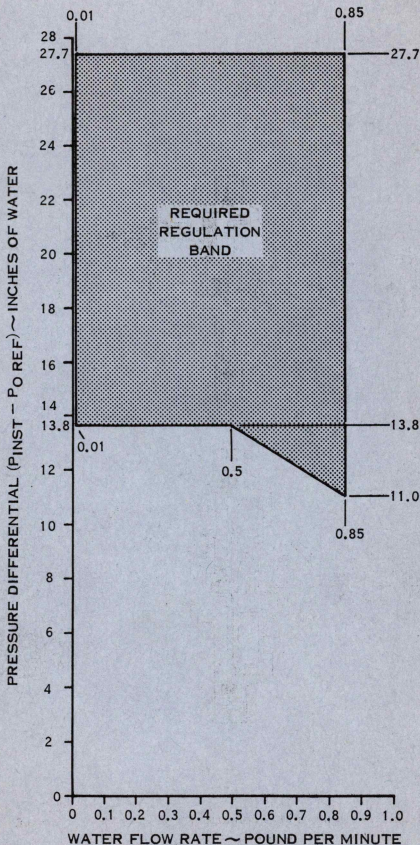
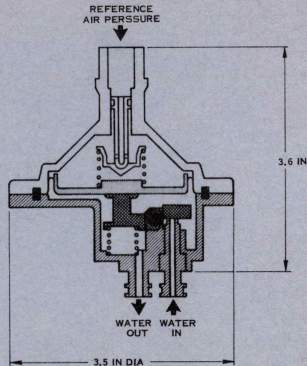
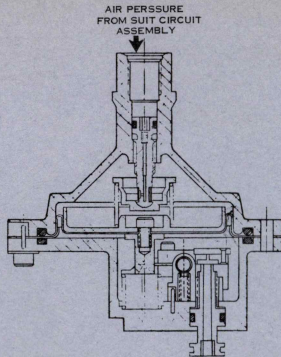


Figure 4-34. Water Pressure Series Regulation Requirements
Item 415



SCHEMATIC

Figure 4-35. Sectional and Schematic Views of Water Pressure Regulator Item 415

Leakage -

Oxygen Leakage (fill condition) - At oxygen inlet and ambient pressure of 20.5 psia and the water 0.5 mm of Hg, the oxygen leakage does not exceed 5×10^{-4} lb/hr.

Oxygen Leakage (operating condition) - At oxygen inlet pressure of 5.8 psia, ambient pressure at 10^{-14} mm of Hg A, and the water at a minimum pressure of 6.3 psia, the oxygen leakage from the oxygen side does not exceed 5×10^{-4} lb/hr.

Water Leakage (diaphragm) - With the side at 50 psia and the oxygen side at 10^{-14} mm of Hg A, the water leakage through the diaphragm does not exceed 2.3×10^{-2} cc/hr.

Water Leakage (0-seals) - With the water side at 50 psia and the ambient at 10^{-14} mm of Hg A, the water leakage to ambient does not exceed 9×10^{-3} cc/hr.

Water Leakage (internal regulator seat) - At 50 psid across the regulator seat (outlet to inlet), the leakage across the seat does not exceed 0.010 cc/hr.

416 HOSE

Spec. no. SVHS 2786

PAT no. SVHS 3500-46

Spec. wt. - 1.79 lb.

Actual wt. - 1.73 lb.

Function - The 416 flexible hose conveys water flow from the Item 490 module to the drink gun.

Construction - Carbon-filled Teflon inner core covered with braided stainless steel sheath. Sheath is covered with a heat-shrunk Teflon chafing cover.

End Fitting - MS 33656-4 both ends

Leakage - Not more than 0.018 cc/hr water at 50 psig and 70°F

Pressure Drop - Not more than 0.16 psi at 0.85 lb/min. at 70°F

Flow - 0.85 lb/min. with 0.16 psi pressure drop

418, 419 DISCONNECTS

Spec. no. SVHS 3148

PAT no. SVHS 3500

Spec. wt.

418 - 0.21 lb.

419 - 0.25 lb.

Actual wt.

418 - 0.27 lb.

419 - 0.18 lb.

Function - The disconnects provide water and nitrogen supply and return connections to the Item 404 and 409 water tanks during filling.

Construction - Aluminum body with cable-tethered cap

Operating Temp. - 35°F to 160°F

Operating Pressure - 6.5 psia to 44.5 psia

Pressure Drop - Less than 14.85 psid with a nitrogen flow of 0.02 lb/sec at room ambient temperature and 44.5 psia. Less than 1.0 psi with a water flow of 3.7 lb/min at 70°F.

Operating Fluid - Water, nitrogen

Leakage - Coupled — The external leakage of the coupled disconnect does not exceed a helium rate of 1×10^{-2} cc/hr at STP with a pressure differential of 44.5 psi.

Uncoupled - With Cap On — The external leakage of Item 419 with cap installed and self-sealing feature disabled does not exceed a helium rate of 3×10^{-5} cc/sec at STP with helium at 44.5 psig.

Uncoupled - With Cap Off — The external leakage of the self-sealing devices of each disconnect does not exceed a helium rate of 1×10^{-2} cc/hr at STP with helium of 44.5 psig.

Operation - Disconnects can be coupled and uncoupled with one hand without the use of tools. Operation is possible with static internal fluid pressures of 44.5 psig. It is possible to determine visually that the disconnects are completely coupled and locked. The disconnect has no partially coupled or unlocked positions which are stable and permit flow. Coupling and uncoupling consist of a single motion with a maximum axial force of 34 lb.

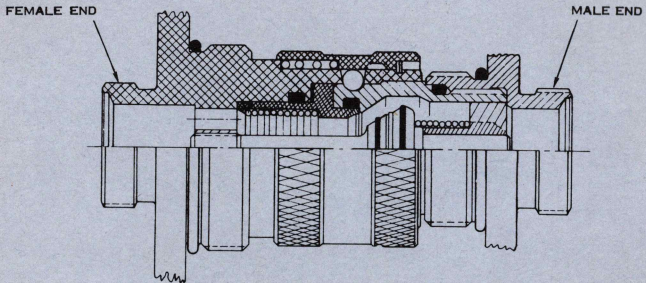


Figure 4-36. Sectional and External Views of GSE Quick Disconnect Item 214/223, 418/419

420 SHUTOFF VALVE

Spec. no. SVHS 3373

PAT no. SVHS 3500-78

Spec. wt. - 0.22 lb.

Actual wt. - 0.16 lb.

Function - The 420 opens or closes water flow to the drink line.

Construction - Machined aluminum body - titanium shaft - synthetic rubber seat

Ports - Inlet and outlet water 0.25 in. Gamah

Operating Temperature - 32° to 160°F

Operating Pressure - 0 to 55 psi

Internal Leakge - With the valve inlet at 50 psi and 70°F, leakage across the closed valve seat does not exceed 8×10^{-3} cc of water per hour.

External Leakge - External leakage of the valve does not exceed 0.028 cc of water per hour at a pressure differential of 50 psi at 70°F.

Manual Operation - The valve handle travel from the full open to the full closed position is 270 degrees. Full clockwise is closed.

Handle torque - 10 inch-pounds (max.)

Pressure Drop - The valve is capable of passing 0.5 pound of water per minute at a maximum pressure drop of 1.5 inches of water at room ambient conditions.

425 FLOW LIMITERS

Spec. no. SVHS 3827

PAT no. SVHS 3500-82

Function - The flow limiters are located just upstream of each sublimator and prevent the sudden oversupply of water to the sublimator on startup.

425-1 upstream of 209

425-3 upstream of 224

425-5 upstream of 107

Construction - Machined aluminum housing - stainless steel inner cartridge accommodating machined series orifice and protecting screens.

Fluid Temp. - 33°F to 152°F

Fluid Pressure - 4.0 to 10.6 psia

Leakage - External leakage does not exceed 0.0001 lb/hr water at 6.5 psid and room ambient

Ports - Inlet and outlet water 0.25 in. Gamah

Effective Orifice Size

425-1-3 - 0.031 in. diameter

425-3-1 - 0.018 in. diameter

425-5-2 - 0.014 in. diameter

Screen Size

0.020 in.

0.020 in.

0.010 in.

Flow Conditions -

425-1-3

Water temp

75°F

Water pressure

1.0 psid

Flow rate

80 ml/min.

425-3-1

Water temp

80°F

Water pressure

6.0 psid

Flow rate

65 ml/min.

425-5-2

Water temp

75°F

Water pressure

1.8 psid

Flow rate

22 ml/min.

490 WATER CONTROL MODULE

Description - The water control module consists of a single cast aluminum housing supporting and internally interconnecting the following items of the ECS water management section.

<u>Item No.</u>	<u>Name</u>	<u>Quantity</u>
401	Water check valve	5
402	Water shutoff valve	2
406	Water flow control valve	1
410	Water coolant isolation valve (capped)	1
414	Water tank selector valve	1
415	Water pressure regulator	3

Ports -

Inlet ascent ports (2)
Inlet descent port (1)
Inlet separator ports (2)
Outlet to 210 (1) all 0.25 in. Gamah
Outlet to 209 (2)
Outlet to 224 and 107 (1)
O₂ sensing ports for regulators (3)
Instrument port (1)

Function - The water control module provides regulation and control of the water flow in the water management section for the following functions:

Control of water flow from the water tanks and water separators in either the primary coolant loop or a secondary coolant loop and suit loop.

Regulation of the water pressure from the water tanks to a level compatible with the water separators and sublimators.

Controls the water flow from the water tanks to a quick disconnect located in the cabin.

Prevents reverse flow in the various water lines.

Shutoff of water flow as necessary.

Leakage -

Total Leakage - The total leakage from the assembled module does not exceed 0.494 cc/hr water during any normal mission phase with a water pressure of 50 psig at 70°F in all internal passages.

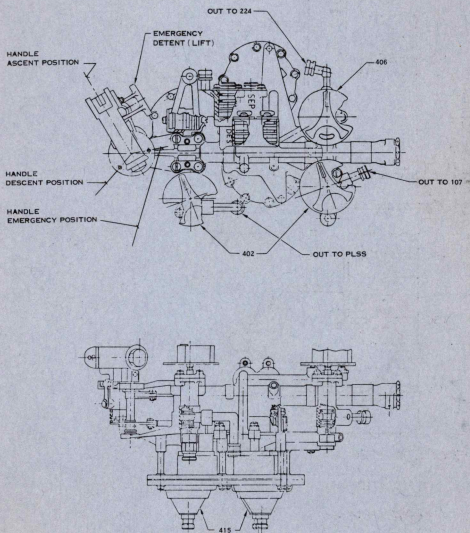


Figure 4-38. Water Control Module Item 490

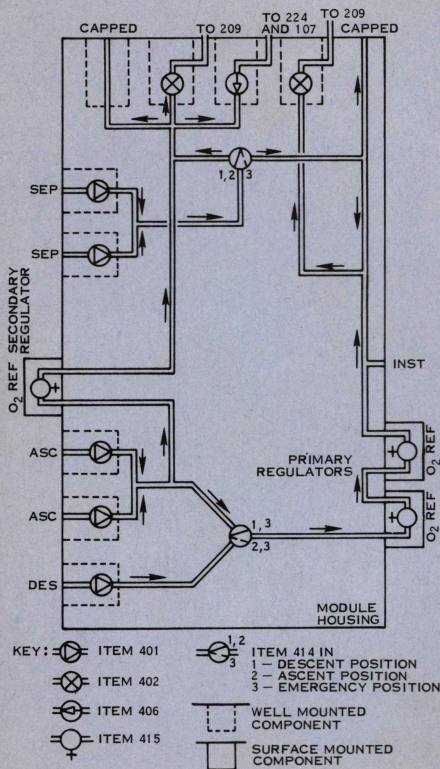


Figure 4-37. Water Control Module

Internal Leakage - The leakage through any internal passage does not exceed the maximum allowable leakage of the component with the lowest leakage requirement per the component specifications.

Operation -

Descent Mode - Water enters the module at the descent port, flows through two Item 415 primary regulators, through an Item 402 (point a) to the Item 209. Separator water enters at the separator port and flows through the same Item 402 (point a) to the Item 209. Water can also flow from the ascent port through the secondary regulator and from the separators to the remaining Item 402 (point b) prior to the Item 209.

Ascent Mode - Water enters the module at either ascent port, flows through two Item 415 primary regulators, through an Item 402 (point a) to the Item 209. Separator water enters at the separator port and flows through the same Item 402 (point a) to the Item 209. Water can also flow from the ascent port through the secondary regulator and from the separator to the remaining Item 402 (point b) prior to the item 209.

Emergency Mode - Water enters the module from either ascent port, flows through the single secondary regulator and through the Item 406 (point c) to the Items 224 and 107. Item 402 (point b) must be closed. Separator water enters at the separator port and flows through the Items 406 (point c) to the Items 224 and 107.

5.0 INSTRUMENTATION ITEM DESCRIPTION

I 111 SPEED SENSOR

Type - The 111 speed sensor is an angular velocity transducer used to develop a frequency signal proportional to the angular velocity of the 109 water separator.

Spec Wt - 1.5 ounces

Construction - Environmentally sealed electronics

Output Voltage - 2.86 millivolts/inches per second surface speed with 0.010 inch minimum gap.

Output inductance - 20 mh max

Gap width - 0.010 inches minimum

Output resistance - 200 ohms max.

I 111 SIGNAL CONDITIONER

Type - The 111 signal conditioner is a frequency-to-d.c. converter to develop a specified output voltage from a specified frequency input. The frequency input comes from the 111 speed sensor.

Spec Wt - 12.0 ounces

Construction - Environmentally sealed electronics

Response - The conditioner output has a 63-percent response to a step change in input frequency within 0.2 seconds maximum with less than 5-percent overshoot or undershoot.

Output Impedance - Less than 250 ohms from d.c. to 2000 Hz.

Power Consumption - Not more than 0.5 watt. Should the conditioner malfunction or short internally, power will not exceed one watt.

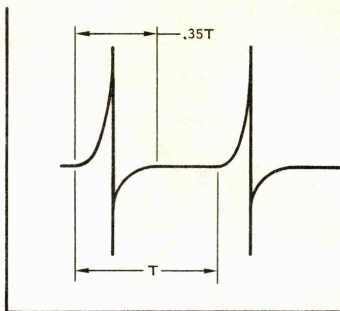
Ripple and Noise - No more than 5 millivolts peak-to-peak into a load of one megohm or greater.

I 128 TEMPERATURE SENSOR

Type - The temperature sensor consists of a platinum resistance element that penetrates the wall of a duct.

Construction - Electronic part of sensor is hermetically sealed.

Temperature Range - $+30^{\circ}$ to 110° F for - 1 version



PULSE SHAPE AND AMPLITUDE

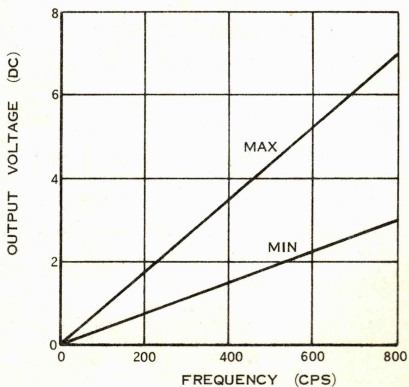


Figure 5-1. Pulse shape and amplitude

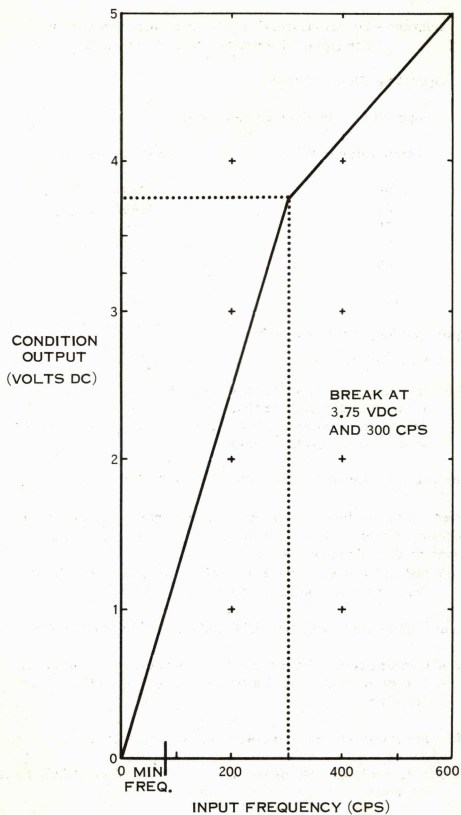


Figure 5-2. Signal conditioner - pulse and output

Current - 20 milliamperes continuous operation without damage or degradation of performance.

Operating Fluid - Oxygen

Temperature - Resistance relationship

Temperature °F	Resistance (ohms)
30	1397
32	1400
50	1459
70	1521
90	1583
110	1644
130	1705

I 130 PRESSURE TRANSDUCER

Spec. Wt. - 6 ounces

Type - The absolute pressure transducer is an integral sensor element and signal conditioner within a single case. The transducer provides a 0-5 volt d.c. analog output proportional to the absolute pressure sensed.

Construction - Hermetically sealed electrical circuitry.

Output - 0 to 5 volts d.c. directly proportional to input pressure

Operating Range - 0 to 10.0 psia

Operating Temperature - 0 - 160°F

Ripple and Noise - No more than 5 millivolts peak-to-peak into a load of 1 megohm or greater.

Output Impedance - Less than 100 ohms from d.c. to 2000 Hz.

Power Consumption - Not more than 0.28 watts at 28 volts d.c.

Not more than 0 - 42 watts with output signal leads shorted together.

Reference pressure - Vacuum chamber within sensor.

Transducer Leakage - No more than 1×10^{-8} scc/sec of helium at 41.0 psia

Switch - Plunger-actuated

Type - The position indicating and control switch assemblies are snap action switches enclosed in a metallic housing for environmental and electromagnetic interference (EMI) shielding for the switch terminals.

Leads - Shielded, twisted-pair pigtail leads.

Characteristics - See chart on next page.

Use	I204	VPI	Control	VPI	VPI	VPI	Control	Control
	Lo Level Indicator	I123	Switch	I122 I308 I124	I120 I121 I124	I307 I120	Switch	Switch (two per unit)
Type	SPST NC	SPST NC	SPST NO	SPST NC	SPST NO	SPST NC	SPST NC	NC NO
Used In	210	113	112	112 309 114	128 117 114	306 138	306 138	306
Amps at rated load	0.002	0.002	3.00	0.002	0.002	0.002	3.00	3.00/switch
Contact resistant at rated load - ohms	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2/switch
Voltage rating - vdc	20-32	20-32	20-32	20-32	20-32	20-32	20-32	20-32/switch
Actuation force - oz	24	24	24	24	24	24	24	8 lb
Release force - oz	1	1	1	1	1	1	1	2 lb
Overtravel force - lb	20	20	20	20	20	20	20	20
Pretravel - inches	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.025
Movement differential - in.	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.020
Overtravel - inches	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
Weight - ounces	3.2	2.0	3.1	3.1	3.1	3.3	3.3	4.0 per unit