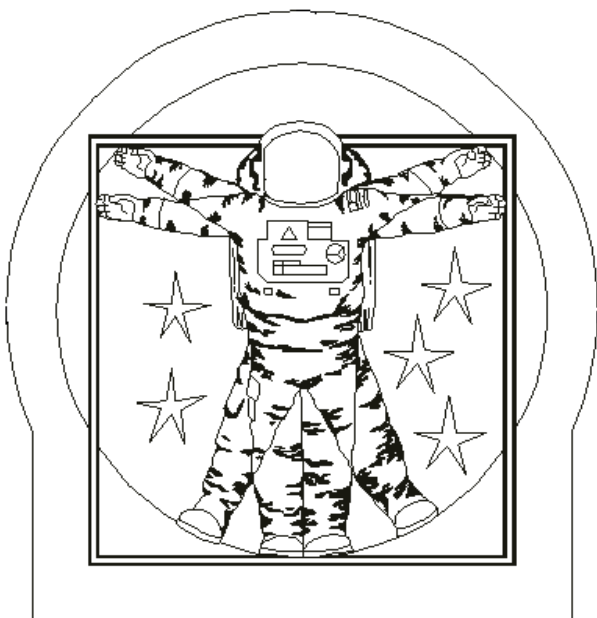


# NASA EXTRAVEHICULAR MOBILITY UNIT (EMU) LSS/SSA DATA BOOK



SEPTEMBER 2017



**UTC Aerospace Systems**

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**ACRONYMS**

A	-	AMPERES
AAH	-	AUTOMATIC ATTITUDE HOLD
AAP	-	AIRLOCK ADAPTER PLATE
ACFM	-	ACTUAL CUBIC FEET PER MINUTE
AEA	-	ASSURED EMU AVAILABILITY
AL	-	ALUMINUM
ATM	-	ADJUSTABLE THERMAL MITTENS
BCA	-	BATTERY CHARGING ASSEMBLY
BFA	-	BIOCIDE FILTER ASSEMBLY
BITE	-	BUILT-IN TEST EQUIPMENT
BLVD	-	BOOT LEG VENT DUCT
BSA	-	BATTERY STOWAGE ASSEMBLY
BSC	-	BODY SEAL CLOSURE
BSI	-	BOOT SIZING INSERT
BTA	-	BENDS TREATMENT ADAPTER
BTU	-	BRITISH THERMAL UNIT
BU	-	BACKUP
CCA	-	COMMUNICATIONS CARRIER ASSEMBLY
CCC		CONTAMINANT CONTROL CARTRIDGE OR CONTAMINANT CONTROL CANISTER
CCEM	-	CREW COMMUNICATION ELECTRONICS MODULE
CCM	-	CUBIC CENTIMETERS PER MINUTE

CCV	-	COOLING CONTROL VALVE
CEA	-	CONTROL ELECTRONICS ASSEMBLY
CEI	-	CONTRACT END ITEM
CFM	-	CUBIC FEET PER MINUTE
CIPAA	-	CURE IN PLACE ABLATOR APPLICATOR
CL	-	CREW LOCK
CLIV	-	COOLING LOOP ISOLATION VALVE
CO <sub>2</sub>	-	CARBON DIOXIDE
CPV	-	COMBINATION PURGE VALVE
CRES	-	CORROSION-RESISTANT STEEL
CWCi	-	CONTINGENCY WATER CONTAINER - IODINE
CWS	-	CAUTION AND WARNING SYSTEM
DC	-	DIRECT CURRENT
DCM	-	DISPLAY AND CONTROLS MODULE
DCU	-	DISPLAYS AND CONTROL UNIT
DIDB	-	DISPOSABLE IN-SUIT DRINK BAG
ECC	-	ELECTRONIC CUFF CHECKLIST
ECG	-	ELECTROCARDIOGRAPH
ECLSS	-	ENVIRONMENTAL CONTROL LIFE SUPPORT SYSTEM
ECWS		ENHANCED CAUTION AND WARNING SYSTEM
EDDA	-	EMU DON/DOFF ASSEMBLY
EEH	-	EMU ELECTRICAL HARNESS

EMU	-	EXTRAVEHICULAR MOBILITY UNIT
EMUPH	-	EMU POWER HARNESS
EPROM	-	ELECTRICALLY PROGRAMMABLE READ ONLY MEMORY
ERCA	-	EMU RF CAMERA ASSEMBLY
ETS	-	EMU THERMAL SLIPPER
EV	-	EXTRAVEHICULAR
EVA	-	EXTRAVEHICULAR ACTIVITY
EVC	-	EXTRAVEHICULAR COMMUNICATOR (RADIO)
EVCS	-	EXTRAVEHICULAR COMMUNICATIONS SYSTEM
EVVA	-	EXTRAVEHICULAR VISOR ASSEMBLY
F	-	FAHRENHEIT
FM	-	FREQUENCY MODULATION
FPU	-	FLUID PUMPING UNIT
FS	-	FULL SCALE
GFE	-	GOVERNMENT FURNISHED EQUIPMENT
GN <sub>2</sub>	-	GASEOUS NITROGEN
GSE	-	GROUND SERVICING EQUIPMENT
HCM	-	HAND CONTROL MODULE
HCU	-	HAND CONTROL UNIT
HL	-	HARD LINE COMMUNICATIONS
HR	-	HOURL
HTS	-	HARD TORSO SHELL

HUT	-	HARD UPPER TORSO
IC	-	INTEGRATED CIRCUIT
ICB	-	INCREASED CAPACITY BATTERY
ICOM	-	INTERCOM
IEU	-	ISS EMU UMBILICAL
IR	-	INFRARED
IRU	-	INERTIAL REFERENCE UNIT
IRU	-	IN-FLIGHT REFILL UNIT
ISS	-	INTERNATIONAL SPACE STATION
IVA	-	INTRAVEHICULAR ACTIVITY
IV/EV	-	INTRAVEHICULAR / EXTRAVEHICULAR
KBYTE	-	KILOBYTE
KHZ	-	KILOHERTZ
LB	-	POUND
LCD	-	LIQUID CRYSTAL DISPLAY
LCG	-	LIQUID COOLING GARMENT
LCVG	-	LIQUID COOLING VENT GARMENT
LED	-	LIGHT-EMITTING DIODE
Li-ion	-	LITHIUM ION
LiOH	-	LITHIUM HYDROXIDE
LLB	-	LONG LIFE BATTERY
LSS	-	LIFE SUPPORT SUBSYSTEM
LTA	-	LOWER TORSO ASSEMBLY
MAG	-	MAXIMUM ABSORPTION GARMENT

MDM	-	AIRLOCK MULTIPLEXER/DEMULTIPLEXER
METOX	-	METAL OXIDE
MHZ	-	MEGAHERTZ
MLI	-	MULTI-LAYER INSULATION
MMOD	-	MICROMETEOROID/ORBITAL DEBRIS
MMU	-	MANNED MANEUVERING UNIT
MOP	-	MAXIMUM OPERATING PRESSURE
MSPPC		MODEM / SIGNAL PROCESSOR POWER CONVERTER
MWC	-	MULTIPLE WATER CONNECTOR
MWS	-	MINI-WORKSTATION
NASA	-	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
NiMH	-	NICKEL-METAL HYDRIDE
NSI	-	NASA STANDARD INITIATOR
NVRAM	-	NON-VOLATILE RANDOM ACCESS MEMORY
O <sub>2</sub>	-	OXYGEN
OBS	-	OPERATIONAL BIOINSTRUMENTATION SYSTEM
ORU	-	ON-ORBIT REPLACEMENT UNIT
OSCA	-	ONBOARD SPACESUIT CONTROL ASSEMBLY
P	-	PRESSURE
PDA	-	PRE-DELIVERY ACCEPTANCE

PLSS	-	PRIMARY LIFE SUPPORT SUBSYSTEM
POR	-	POWER-ON RESTART
PSA	-	POWER SUPPLY ASSEMBLY
PSI	-	POUNDS PER SQUARE INCH
PSIA	-	POUNDS PER SQUARE INCH ABSOLUTE
PSID	-	POUNDS PER SQUARE INCH DIFFERENTIAL
PSIG	-	POUNDS PER SQUARE INCH GAGE
PTT	-	PUSH-TO-TALK
PWM	-	PULSE WIDTH MODULATED
RAM	-	RANDOM ACCESS MEMORY
REBA	-	RECHARGEABLE EVA BATTERY ASSEMBLY
RF	-	RADIO FREQUENCY
RPHG	-	REMOTE POWERED HEATED GLOVE
RPM	-	REVOLUTIONS PER MINUTE
RTD	-	REAL TIME DISPLAY
SAFER	-	SIMPLIFIED AID FOR EVA RESCUE
SCC	-	STANDARD CC'S
SCCM	-	STANDARD CC'S PER MINUTE
SCFM	-	STANDARD CUBIC FEET PER MINUTE
SCOF	-	SOP CHECKOUT FIXTURE
SCU	-	SERVICE AND COOLING UMBILICAL
SEMU	-	SHORT EMU

SHCMH	-	SAFER HAND CONTROLLER MODULE HARDMOUNT
SIMPLEX	-	TRANSMISSION AND RECEPTION ON THE SAME FREQUENCY
SLE	-	SEMU LAUNCH ENCLOSURE
SML	-	SATELLITE MAN LOAD
SOP	-	SECONDARY OXYGEN PACK
SOV	-	SHUTOFF VALVE
SPCE		SERVICING PERFORMANCE AND CHECKOUT EQUIPMENT
SPDT	-	SINGLE POLE DOUBLE THROW
SS	-	STAINLESS STEEL
SSA	-	SPACE SUIT ASSEMBLY
SSCS	-	SPACE TO SPACE COMMUNICATON SYSTEM
SSER	-	SPACE TO SPACE EMU RADIO
SSOR	-	SPACE TO SPACE ORBITER RADIO
SSSR	-	SPACE TO SPACE STATION RADIO
TCU	-	THERMAL COMFORT UNDERGARMENT
TDMA	-	TIME DIVISION MULTIPLE ACCESS
TMG		THERMAL MICROMETEOROID GARMENT
TRBF	-	TILE REPAIR BACKPACK FRAME
TP	-	TEST PORT
TWFM	-	TRANSPORT WATER FLOW METER
UCB	-	UMBILICAL CONNECTOR BLOCK

UCM	-	UMBILICAL CONNECTOR MANIFOLD
UIA	-	UMBILICAL INTERFACE ASSEMBLY
UTAS	-	UNITED TECHNOLOGIES CORPORATION AEROSPACE SYSTEMS
UTC	-	UNITED TECHNOLOGIES CORPORATION
V	-	VOLTS
VDA	-	VALVE DRIVER ASSEMBLY
VDC	-	VOLTS DIRECT CURRENT
VLTM	-	VENT LOOP TEST MANIFOLD
VOX	-	VOICE OPERATED TRANSMIT
WITS	-	WATER INDICATING TEST STRIPS
WL	-	WINDSOR LOCKS
XMIT	-	TRANSMIT

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## 1.1      **EXTRAVEHICULAR MOBILITY UNIT (EMU)**

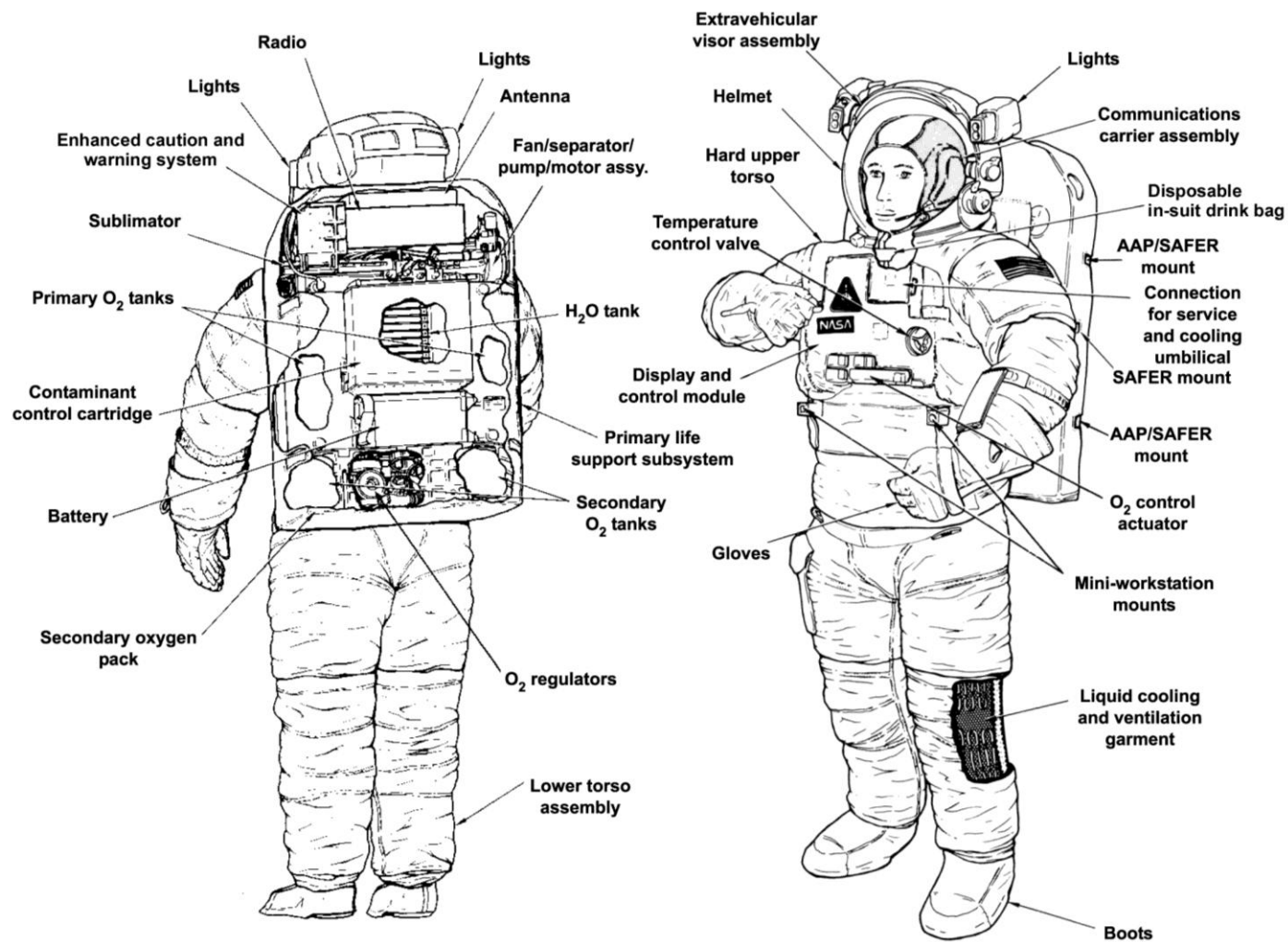
The Extravehicular Mobility Unit EMU (Figures 1.1 and 1.2) is an independent anthropomorphic system that provides environmental protection, mobility, life support and communication for Space Shuttle and ISS crewmembers to perform Extravehicular Activity (EVA) in Earth orbit. EVA is defined for EMU design considerations as activity that occurs in environmental pressure below 4.0 psia.

The EMU is designed to accommodate an EVA mission consisting of the following characteristics:

- a) Total duration of 7 hours maximum or 6 hours maximum under the worst case solar exposure.
- b) An average metabolic rate of 1000 Btu/hr for 7 hours or 850 Btu/hr for 8 hours.
- c) Peak metabolic rates of 2000 Btu/hr for 15 minutes and 1600 Btu/hr for 1 hour at anytime within the EVA.
- d) Minimum rate of 350 Btu/Hr for 30 minutes after an average work rate of 1000 Btu/Hr and followed by a rate of 700 Btu/Hr for up to 30 minutes.
- e) Prebreathe can be as short as 40 minutes with a 10.2 psia cabin pressure or as long as 4 hours with a 14.7 psia cabin pressure. Overnight Airlock Campout Protocol at 10.2 psi and Exercise Prebreathe Protocol have insuit prebreathe within this range.
- f) System will provide 2 hours Bends Treatment with a cabin pressure of 14.7 psia.

The EMU is an integrated assembly made up of two major subsystems, the Life Support Subsystem (LSS) and the Space Suit Assembly (SSA), and other associated support and ancillary equipment. Figure 1.3 shows these schematically.

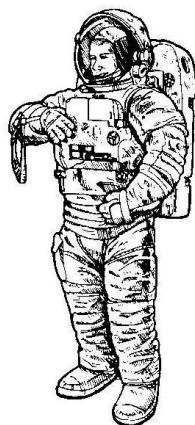
FIGURE 1.1 NASA EXTRAVEHICULAR MOBILITY UNIT



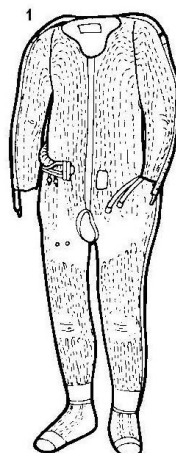
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FIGURE 1.2 EXTRAVEHICULAR MOBILITY UNIT

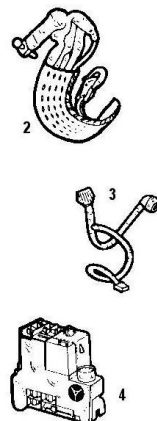
# SPACE SUIT/LIFE SUPPORT SYSTEM OR EXTRAVEHICULAR MOBILITY UNIT



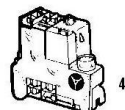
**1. LIQUID COOLING AND VENTILATION GARMENT** Worn under the pressure and gas garment. Contains liquid cooling tubes that maintain desired body temperature.



**2. SERVICE AND COOLING UMBILICAL** Contains communications lines, power, water and oxygen recharge lines and a water drain line. It has a multiple connector at one end which attaches to the EMU.



**3. EMU ELECTRICAL HARNESS** Provides bio-instrumentation and communications connections to the portable life support system.



**4. DISPLAY AND CONTROL MODULE** Chest mounted control module which contains all the external fluid and electrical interfaces, controls and displays.

**5. EXTRAVEHICULAR VISOR ASSEMBLY** Attaches externally to the helmet. Contains visors which are manually adjusted to shield the astronaut's eyes.

**6. HELMET** Consists of a clear polycarbonate bubble, neck disconnect and ventilation pad.

**7. ARM ASSEMBLY** Contains the shoulder joint and upper arm bearings that permit shoulder mobility as well as the elbow joint and wrist bearing. The arm consists of two separable elements which allows for rapid replacement along with a removable insert and cam adjusters for resizing.

**8. GLOVES** Contain the wrist disconnect, wrist joint and insulation padding for palms and fingers. Miniature heaters located in each finger are powered by a remote battery and provide for thermal comfort in cold environment. An overglove is also available to provide protection from hot or cold thermal objects.

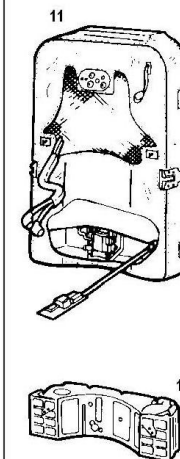
**9. LOWER TORSO ASSEMBLY** Consists of the brief/waist assembly, legs and boots. Each is separable to allow for rapid replacement along with removable insert and cam adjusters for resizing. The brief/waist also contains a bearing for mobility and a disconnect to attach to the hard upper torso. The legs and boots contain flexible sections to allow for knee and ankle joint mobility.

**10. HARD UPPER TORSO** Provides the structural mounting interface for most of the EMU-helmet, arms, lower torso, primary life support subsystem, display and control module, and electrical harness.



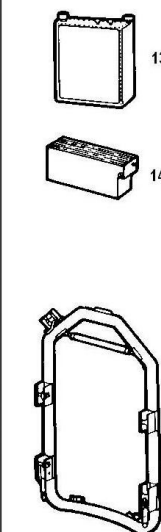
**11. PRIMARY LIFE SUPPORT SUBSYSTEM** This assembly contains the life support subsystem and expendables. Along with system telemetry and communication.

**12. SECONDARY OXYGEN PACK** Mounted to the base of the primary life support subsystem. It contains a 30-minute emergency oxygen supply and a valve and regulator assembly.



**13. CONTAMINANT CONTROL CARTRIDGE** Contains either lithium hydroxide or metal oxide, charcoal and filters which remove carbon dioxide from the air that the astronaut breathes. It can be replaced in flight.

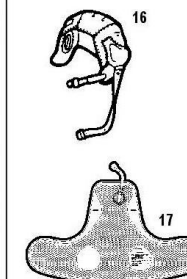
**14. BATTERY** Provides all the electrical power used by the life support system. It is filled with electrolyte and charged prior to flight. The battery is rechargeable.



**15. AIRLOCK ADAPTER PLATE** An EMU storage fixture in shuttle which is also used as a donning and doffing station.

**16. COMMUNICATIONS CARRIER ASSEMBLY** Consists of microphone and headset. Allows the astronaut to talk to the other crewmen in the vehicle or in other space suit/life support systems.

**17. DISPOSABLE IN-SUIT DRINK BAG** Stores liquid in the hard upper torso and has a tube projecting up into the helmet to permit the astronaut to drink while suited.



**18. ON ORBIT REPLACEABLE FEATURES** Are provided on most all EMU items to allow for rapid hardware change out during ground processing or flight.



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## **1.2 LIFE SUPPORT SUBSYSTEM (LSS)**

The Life Support Subsystem (LSS) consists of the following subsystems which are briefly described in the following paragraphs and discussed in depth elsewhere in this mini-data book:

- 1) Item 100, Primary Life Support Subsystem (PLSS)
- 2) Item 200, Secondary Oxygen Pack (SOP)
- 3) Item 300, Display and Controls Module (DCM)
- 4) Item 400, Service and Cooling Umbilical (SCU), in Shuttle
- 5) Item 440, EMU Electrical Harness (EEH)
- 6) Item 470, Airlock Adapter Plate (AAP), in Shuttle
- 7) Item 480, Contaminant Control Cartridge (CCC)
- 8) Item 490, Battery
- 9) Item 491, Bends Treatment Adapter (BTA)
- 10) Item 495, Secondary Oxygen Pack Checkout Fixture (SCOF)
- 11) Item 498, ISS EMU Umbilical, in Space Station

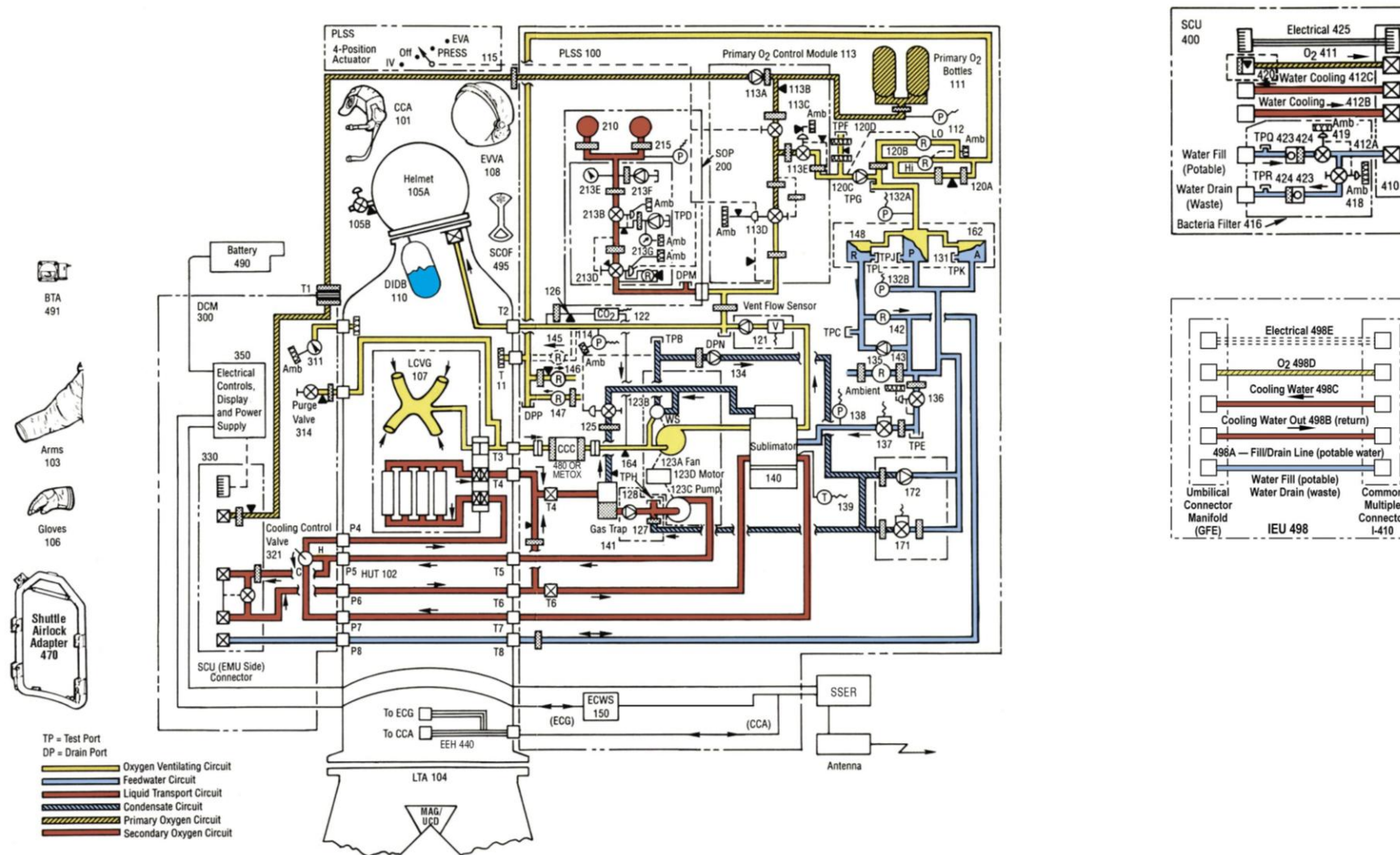
Detailed LSS component illustrations and specification summaries are located in Section 2.13 of this book.

### **1.2.1 PRIMARY LIFE SUPPORT SUBSYSTEM (PLSS)**

The PLSS (Item 100), shown schematically in Figure 1.3, is made up of four distinct circuits:

- 1) Oxygen Ventilation Circuit
- 2) Primary Oxygen Circuit
- 3) Feedwater Circuit
- 4) Liquid Transport Circuit

**FIGURE 1.3 NASA EXTRAVEHICULAR MOBILITY UNIT  
(REVISED: SEPTEMBER, 2007)**



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These circuits provide suitable breathing environment and thermal control for the crewmember inside the Space Suit enclosure. The Primary Oxygen Circuit supplies oxygen at regulated pressure to the Oxygen Ventilation Circuit for crewmember breathing, SSA pressurization, and Water Tank water expulsion. The fan portion of the Fan/Pump/Separator, located in the Oxygen Ventilation Circuit, circulates the oxygen and gas exhaled by the crewmember through connecting ducts and items. The exhaled CO<sub>2</sub> is removed from the breathing environment by a chemical contaminant control cartridge. Cooling and humidity removal occurs as the oxygen circulates through the sublimator. Additionally, primary oxygen is also directed through ducting to pressurize the water storage tanks located in the Feedwater Circuit. The water storage tanks supply expendable water at regulated pressure to the sublimator. The Feedwater Circuit in the sublimator is open to atmosphere (vacuum), and, as the expendable water is fed into the sublimator, it freezes and then sublimates to space. This sublimation removes heat from the Liquid Transport Circuit. The pump circulates cooling water through the Liquid Transport circuit which includes the Liquid Cooling and Ventilation Garment of the SSA, worn by the crewmember. The water removes heat from the crewmember and is cooled by the sublimator. These circuits and associated items are further discussed in Section 2.1.

### 1.2.2 SECONDARY OXYGEN PACK (SOP)

The SOP (Item 200), shown schematically in Figure 1.3, attaches to the bottom of the PLSS and provides 30 minutes of back-up pressure regulated oxygen in the event that:

- 1) The primary oxygen supply is exhausted
- 2) Primary pressure regulation is lost via a regulator failure or excessive oxygen demand
- 3) One of the Purge Valves is opened due to:
  - a) The PLSS fails to remove contaminants in the ventilation circuit, heat or humidity
  - b) Ventilation flow drops below acceptable levels.

The SOP is further discussed in Section 2.2.

### **1.2.3 DISPLAY AND CONTROLS MODULE (DCM)**

The DCM (Item 300) provides the electrical and mechanical controls required for one EVA crewmember to operate the EMU, and contains a Liquid Crystal Display (LCD). The LCD, in conjunction with the Caution and Warning System (Item 150), displays EMU operational information in alphanumeric format to the EVA crewmember. The Enhanced Caution and Warning System (ECWS) and the DCM are further discussed in Sections 2.1.7 and 2.3, respectively. DCM fluid circuitry is shown in Figure 1.3.

### **1.2.4 SERVICE AND COOLING UMBILICAL (SCU)**

The SCU (Item 400) connects the EMU to the Orbiter service panel and is used to replenish PLSS consumables after EVA, supply cooling and expendables during umbilical operations, and allow wastewater drainage. The CCC is the only PLSS consumable that cannot be recharged via the SCU. The SCU is discussed further in Section 2.4, and is shown schematically in Figure 1.3.

### **1.2.5 EMU ELECTRICAL HARNESS (EEH)**

The EMU Electrical Harness (Item 440) is located within the Hard Upper Torso (HUT) and connects the Communication Carrier Assembly (CCA) and the biomedical sensors to the EMU Electrical System. The EMU Electrical Harness is further discussed in Section 2.9. The EMU Electrical System is further discussed in Section 2.1.6.

### **1.2.6 AIRLOCK ADAPTER PLATE (AAP)**

The AAP (Item 470) is a mounting structure used to attach the EMU to the Orbiter airlock wall. The EMU is secured to the AAP by four mounting pins and the AAP is retained to the orbiter airlock wall by three supports. Additional AAP information is provided in Section 2.7.

### **1.2.7 CO<sub>2</sub> REMOVAL**

The CCC (Item 480) is a crewmember-replaceable item in the PLSS to remove CO<sub>2</sub>, odors, particulates and other contaminants from the Oxygen Ventilation Circuit. Additional CCC information is provided in Section 2.5.1.

Two versions of the CCC exist. LiOH CCCs support one EVA each and are then recharged on earth for reuse on subsequent flights. Metox CCCs are used aboard ISS for EVA and to support EVA prep and post activities in the Joint Airlock. After each use, Metox CCCs are regenerated on-orbit for reuse. Additional Metox information is provided in Section 2.5.2.

### **1.2.8 BATTERY**

The Battery (Item 490) supplies all power to the EMU excluding EMU lights when it is not operating on vehicle power via the SCU. A description of the battery is provided in Section 2.6.

### **1.2.9 SOP CHECKOUT FIXTURE (SCOF)**

The SCOF (Item 495) is used in place of the helmet to seal off the Oxygen Ventilation Circuit and provides over pressurization protection during pre-EVA activity (SOP checkout, fan checkout and water discharge/recharge). Additional SCOF information is provided in Section 2.10.

### **1.2.10 BENDS TREATMENT ADAPTER (BTA)**

The BTA (Item 491) is an emergency device that is used on orbit in the event that an EVA crewmember contracts decompression sickness. It permits EMU usage as a hyperbaric (7.5 – 8 psi above airlock pressure) bends treatment chamber. The BTA is further discussed in Section 2.8.

### **1.2.11 ISS EMU UMBILICAL (IEU)**

The IEU (Item 498) connects the EMU to the ISS SPCE to replenish PLSS consumables after EVA, supply cooling and consumables during IVA and allow waste water drainage. The CCC is the only PLSS consumable not recharged via the IEU. The IEU is discussed further in Section 2.4.2, and is shown schematically in Figure 1.3.

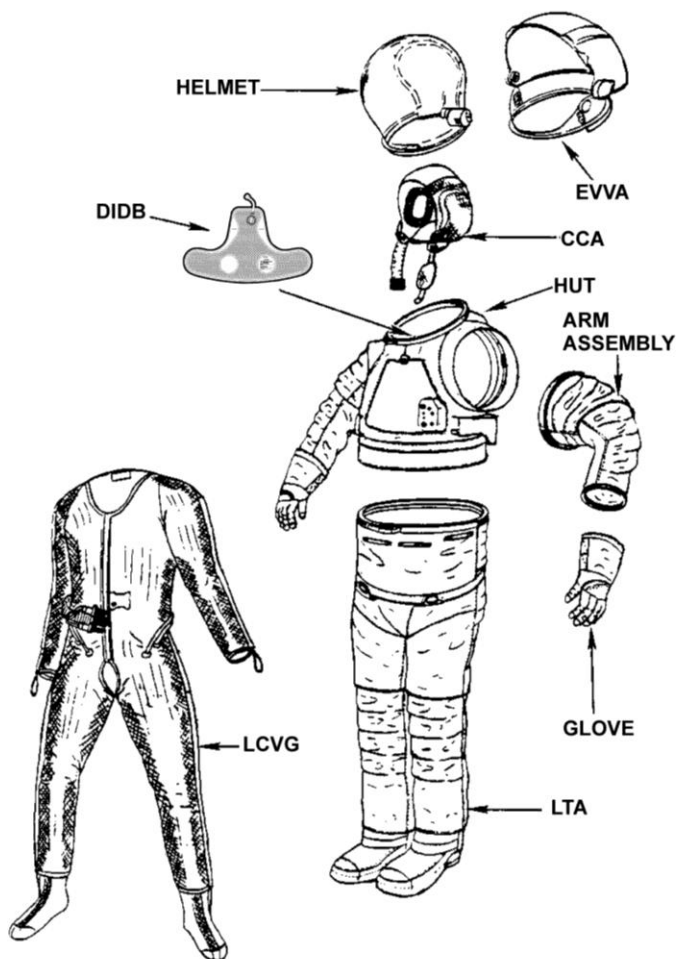
## **1.3 SPACE SUIT ASSEMBLY (SSA)**

The Space Suit Assembly (SSA) is shown in Figure 1.4 and consists of the nine subassemblies described in this book.

- 1) Item 101, Communications Carrier Assembly (CCA)
- 2) Item 102, Hard Upper Torso (HUT)
- 3) Enhanced Item 103, Arms
- 4) Enhanced Item 104, Lower Torso Assembly (LTA)
- 5) Item 105, Helmet
- 6) Item 106, Gloves
- 7) Item 107, Liquid Cooling and Ventilation Garment (LCVG)
- 8) Item 108, Extravehicular Visor Assembly (EVVA)
- 9) Item 110, Disposable In-Suit Drink Bag

The SSA interfaces with the Primary Life Support Subsystem (PLSS) and the Display and Controls Module (DCM) at the HUT. The PLSS provides mechanical, electrical, and fluid

FIGURE 1.4 SPACE SUIT ASSEMBLY



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interfaces where it joins the HUT.

The SSA components are designed to afford mobility to suit joints which closely approximate the natural anthropometric joint movements. Bending motions are accommodated in the garment construction of the enclosure. Air-tight bearings are incorporated in the components to accommodate rotation. Joints categorized as bending include the hip, knee, ankle and hand. Joints categorized as both bending and rotational include the shoulder, waist, elbow and wrist. More detailed SSA requirements are discussed in Section 3.1.

### **1.3.1 COMMUNICATIONS CARRIER ASSEMBLY (CCA)**

The CCA (Item 101) is a cloth aviator-type cap worn under the pressure suit helmet. It fits over the crewmember's head and snaps into place with a chin or neck strap. It contains microphones and headphones for communicating amongst crewmembers and receiving caution and warning tones. The CCA is further discussed in Section 3.2.

### **1.3.2 HARD UPPER TORSO (HUT)**

The HUT (Item 102) is the portion of the pressure suit that encloses the upper torso of the body. It provides the structural mounting interface for most of the EMU: Helmet, Arms, Lower Torso Assembly, Primary Life Support Subsystem, Display and Controls Module and the Electrical Harness. It is made of a fiberglass shell. Integral to the HUT are passageways for fill and drain water, vent air, and cooling water. To these passageways are attached tubing for vent air and cooling water leading to the HUT half of the Multiple Water Connector. The Multiple Water Connector interfaces to the Liquid Cooling Vent Garment (LCVG) with its cooling water and vent systems. Protection for the HUT is provided by the Thermal Micrometeoroid Garment (TMG). The HUT is further discussed in Section 3.3.

### **1.3.3 ENHANCED ARM ASSEMBLY**

The left and right Arm Assemblies (Item 103) are pressure vessels made of heat sealed, urethane-coated, nylon bladder

fabric enclosed in polyester restraint fabric. The assembly contains the shoulder joints, upper arm bearings and elbow joints that permit joint mobility. A Wrist Disconnect at the lower end of the arm assembly provides for interface of the Glove Assembly to the lower arm. Thermal protection for the arm assemblies is provided by a TMG. Arms are further discussed in Section 3.4.

### **1.3.4 ENHANCED LOWER TORSO ASSEMBLY (LTA)**

The LTA (Item 104) protects the lower torso, legs, and feet of the crewmember. It is composed of a Waist Assembly, Brief Assembly, Leg Assembly, and Boot Assembly. These fabric elements are joined through attachment to metal hardware elements. Boots are joined to the legs by the Leg Sizing Ring Assembly, Legs are joined to the Brief Assembly by the Thigh Sizing Ring Assembly, the Brief Assembly is joined to the Waist Assembly through the Waist Bearing, and the Waist Assembly is attached to the Body Seal Closure (BSC). Interface of the LTA to the HUT is accomplished via the BSC. Thermal protection for the LTA is provided by the TMGs. The TMG elements for the LTA are the Boot, the Leg, the Brief, and the Waist TMG Assemblies. The TMG components are sized to fit the corresponding Restraint Assemblies. The LTA is further discussed in Section 3.5.

### **1.3.5 HELMET**

The Helmet (Item 105) is the portion of the pressure suit providing a pressure vessel for the head. It is made of a clear polycarbonate. The Helmet contains the following subassemblies: Bubble, Neck Ring, Combination Purge Valve (CPV), and Vent Pad. The Bubble, Neck Ring and Vent Pad are permanently secured while the CPV, attached to the left side of the Bubble with three screws, is removable. The Neck Ring provides for a quick disconnect of the Helmet from the HUT. The Vent Pad, mounted in the back of the helmet, directs vent flow oxygen from the HUT inlet to the front areas of the Helmet Bubble. The Helmet provides for semi-permanent attachment of the Extravehicular visor Assembly (EVVA, Item 108) for all extravehicular operations. The Helmet is further discussed in Section 3.6.

### **1.3.6 GLOVES**

Gloves (Item 106) are the active interface between the crewmember and the work being performed. As such, they must perform a variety of functions while preserving an effective degree of tactility. Gloves also provide a protective barrier against the natural environment, as well as work place hazards. Each glove is comprised of the following basic components: Bladder, Restraint, TMG and Bearing. Gloves are further discussed in Section 3.7.

### **1.3.7 LIQUID COOLING AND VENTILATION GARMENT (LCVG)**

The LCVG (Item 107) is a conformal garment worn under the pressure suit to maintain body temperature. It has ethylene vinyl acetate tubing woven through the spandex restraint cloth. Cooling water circulates through the tubing near the skin. The LCVG also contains the ducts for returning vent air to the HUT for transfer to the PLSS, and retains the Government Furnished Equipment (GFE) dosimeter; signal conditioner, biomedical leads, and an electrical grounding lead for the crewmember. A provision is made for a crew-option Low Profile Vent Duct at the elbow, in place of the standard duct. The multiple water connector interfaces to the HUT with its cooling water and vent systems. The LCVG is further discussed in Section 3.8.

### **1.3.8 EXTRAVEHICULAR VISOR ASSEMBLY (EVVA)**

The EVVA (Item 108) fits over and attaches to the Helmet to provide the crewmember with visual, thermal, impact, and micrometeoroid protection in space. It has a polycarbonate shell, stationary polycarbonate Protective Visor, movable polysulfone Sun Visor and movable fiberglass/epoxy Center and Side Eyeshades. The Sun Visor and the Center Eyeshade are manually adjustable by rotating the supporting hubs. Each Side Eyeshade is moved by grasping a tab with the hand. A thermal Micrometeoroid Garment covering is attached to the outside of the shell. The EVVA is further discussed in Section 3.9.

### **1.3.9 DISPOSABLE IN-SUIT DRINK BAG (DIDB)**

The Disposable In-Suit Drink Bag (DIDB) is a single use, heat sealed, flexible bladder assembly mounted within a reusable Restraint Bag, which supplies a crewmember with up to 32 oz. of potable water during an EVA. Velcro patches bonded to the exterior surface of the Restraint Bag correspond to Velcro patches (adhesive bonded using an epoxy resin) on the inside front of the HUT. Adjusting the DIDB location within the range of the Velcro provides an individualized fit for the crewperson. The flexible drink tube enables unencumbered crew access to the bite valve. Biting down on the end of the valve and applying oral suction actuates the DIDB.

## **1.4 SUPPORT AND ANCILLARY EQUIPMENT**

EMU Support and ancillary equipment includes:

- EMU ORU Tool Kit Assembly – A kit containing items used to facilitate the change-out of ORU components of the SEMU.
  - ORU Tools
  - Protective Covers
  - Nitrile Gloves
- EVA Helmet Light Assembly – An incandescent lamp and battery assembly that mounts on the EVVA to provide the EVA crewmember with light, as needed.
- Mini-Work Station (MWS) – A device used in the transport and management of tools and the restraint of the EVA crewmember at a worksite.
- Tethers – Strap like devices used to tether tools and other items to the EMU and the EMU to the Orbiter.
- Adjustable Thermal Mittens (ATM) – Mittens that fit over the gloves of the EMU to provide additional thermal protection.

- Extended Service and Cooling Umbilical (ESCU) – A contingency device which interfaces to the DCM Multiple Connector to seal off the water circuits; otherwise known as a “DCM Plug”.
- Wrist Mirror – A mirror attached to the wrist of the EMU for viewing EMU controls out of the crewmember’s normal field of view.
- Cuff Checklist – A short form checklist of EVA procedures and EMU malfunction procedures attached to the wrist of the EMU for use during EVA.
- EMU Scissors – A pair of scissors tethered to the EMU for use, as needed, to cut tethers, thermal blankets, etc.
- Equipment Bag – A bag used to store items during suit donning or doffing.
- EMU Servicing Kit – A kit containing items used to prepare the EMU for EVA and for normal and contingency maintenance of the EMU.
  - Valsalva Devices
  - Antifog Wipes
  - Stericide Wipes
  - Lubricant Wipes
  - Tissue Wipes
  - Shaving Cream
  - Razors
  - Soap
  - Overtapes
  - Stoma Seals
  - Scissors
  - Needle and Lacing Cord
  - Electrode Paste
  - Metox Canister O-Rings
  - Helmet Light Recharger Fuses
  - Signal Conditioners (as required)
  - EVA Cables (as required)

- LTA Donning Handles – Devices used during suit donning to aid the crewmember in mating the lower torso to the upper torso.
- Contingency Tool (or Pry Bar) – A device used to disconnect the LTA and HUT halves of the waist ring in the event that the latching mechanism becomes jammed.
- Crew Comfort Kit – Crew preference items used to mitigate unexpected “hot spots” or pressure points.
  - Mosite
  - Moleskin
  - Pads
  - Coverlets
- EV Crew Options Kit – A kit that contains items used by the crew for comfort and hygiene purposes.
  - Sports Bra
  - Athletic Supporter
  - Socks
  - Eye Glasses
  - Glasses Retention Device
  - Hair Restraint
  - Moleskin
  - Mosite
  - Coverlets
- Fresnel Lens – A lens mounted to the lower front inside of the helmet that improves DCM visibility for crewmembers with eyeglasses.
- Wristlets – A crewmember option that provides a comfortable layer of fabric over the LCVG, at the wrist, to reduce chafing.
- Comfort Gloves – A crewmember option that adds comfort inside the Glove Assembly. Comfort Gloves also aid in donning, doffing, and wicking away perspiration.

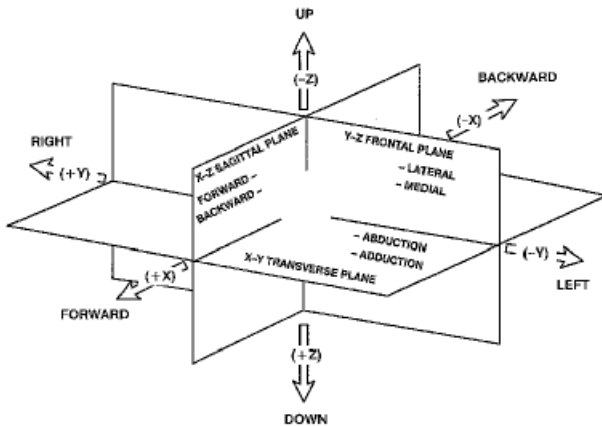
- Thermal Comfort Undergarment (TCU) – A crewmember garment worn under the LCVG used to enhance physical comfort and to allow the LCVG to remain clean for a longer period of time.
- Maximum Absorbency Garment (MAG) – A garment worn for collecting human waste.

## **1.5 EMU REQUIREMENTS**

Requirements that apply to the EMU are discussed and defined in this section.

### **1.5.1 EMU MOBILITY DEFINITIONS**

Figure 1.5 shows the EMU mobility definitions. Figure 1.6 shows the mobility definition for the glove. Figure 1.7 shows a typical SSA cross-section depicting the various layers of the suit, TMG and LCVG.

**FIGURE 1.5 EMU MOBILITY DEFINITIONS**

**ABDUCTION** - OCCURS WHEN AN ARM OR LEG IS MOVED AWAY FROM THE SAGITTAL PLANE (AWAY FROM THE X-Z PLANE INTO THE X-Y PLANE), OR WHEN THE FINGERS ARE MOVED FROM THE MEDIAN LONGITUDINAL AXIS OF THE HAND.

**ADDUCTION** - OCCURS WHEN AN ARM OR LEG IS MOVED TOWARD OR BEYOND THE SAGITTAL PLANE (TOWARD THE X-Z PLANE INTO THE X-Y PLANE), OR WHEN THE FINGERS ARE MOVED TOWARD THE MEDIAN LONGITUDINAL AXIS OF THE HAND.

**EXTENSION** - OCCURS WHEN THE ANGLE BETWEEN ADJOINING BONES IS INCREASED, AS WHEN AN ARM OR A LEG IS STRAIGHTENED.

**FLEXION** - OCCURS WHEN THE ANGLE BETWEEN ADJOINING BONES IS DECREASED AS WHEN THE FOREARM IS MOVED FORWARD AND UPWARD, THE THIGH FORWARD AND UPWARD, OR THE LOWER LEG BACKWARD AND UPWARD.

**LATERAL** - AWAY FROM X-Z PLANE IN Y-Z PLANE.

**MEDIAL** - TOWARD X-Z PLANE IN Y-Z PLANE.

**PRONATION** - FACE DOWN.

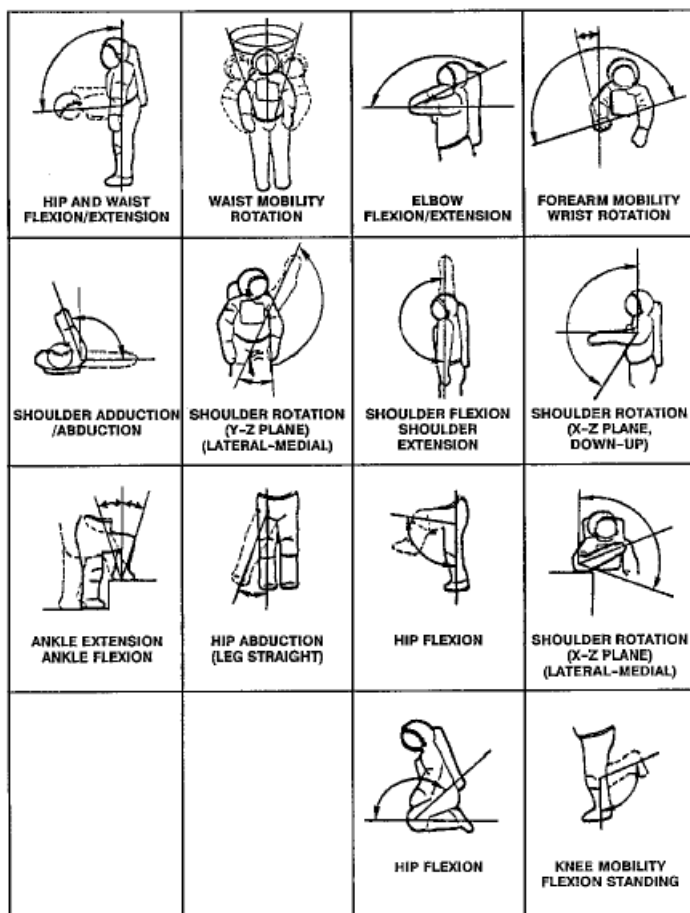
**SUPINATION** - FACE UP OR ON BACK.

**ROTATION** - REVOLVING ABOUT THE AXIS OF A BODY PART.

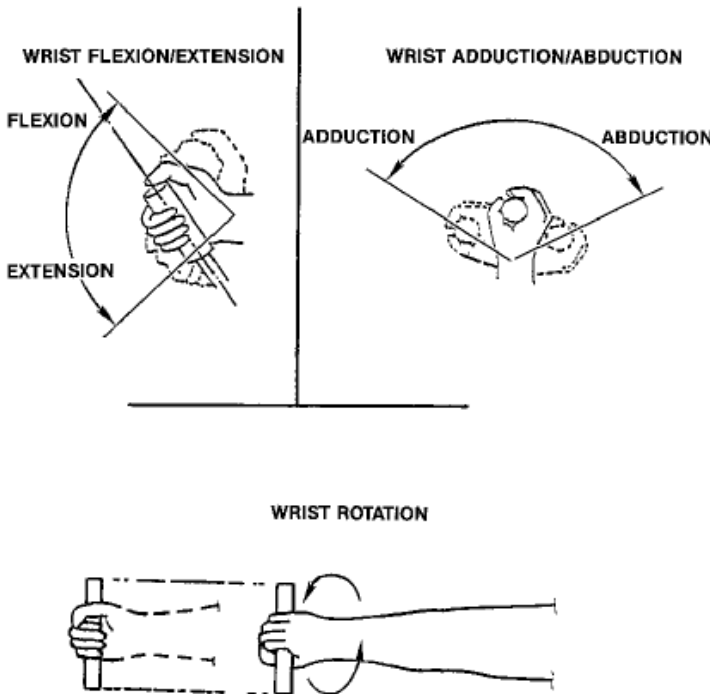
**STRETCH** - ELONGATION OF BODY PART.

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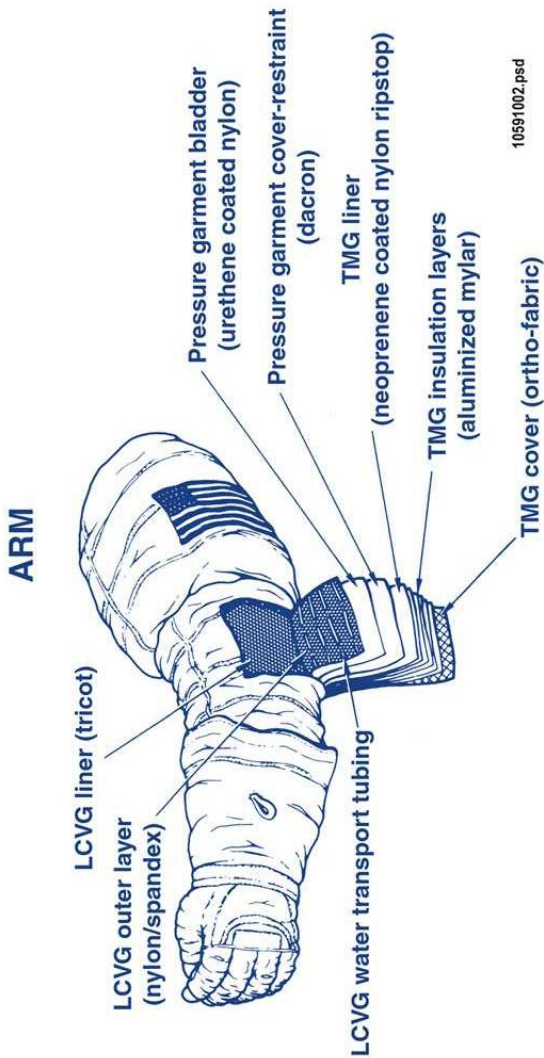
**FIGURE 1.5 EMU MOBILITY - CONTINUED**

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**FIGURE 1.6 GLOVE MOBILITY**

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FIGURE 1.7 SSA CROSS SECTION



### **1.5.2 EMU LEAKAGE SPECIFICATIONS**

Figure 1.8 summarizes the allowable gas leakage for each of the EMU CEIs. The leakage is defined for both the space and "l-g" environments.

Figure 1.9 defines detection limits for the whole EMU during ground processing and Pre-EVA and relates them to the EVA leakage limits.

### **1.5.3 EMU MASS PROPERTIES**

Figure 1.10 summarizes the EMU mass properties.

### **1.5.4 EMU DIMENSIONS**

Figures 1.11 and 1.12 show the overall dimensions of the current and ISS EMUs.

### **1.5.5 EMU FREE VOLUME**

The "free volume" within the EMU is the gas volume of the anthropometric clearance between the crewmember and the inside of the suit including the PLSS oxygen ventilating circuit. Free volume varies generally between 1.5 and 2.0 ft<sup>3</sup>.

## **1.6 ENHANCED SSA SIZING**

### **1.6.1 ENHANCED SSA LEG AND TORSO SIZING**

Figure 1.13 shows the leg and torso size variation provided by different sizes of HUT and Enhanced LTA. Section 3.5.8 discusses Enhanced LTA sizing in greater detail.

### **1.6.2 ENHANCED SSA ARM SIZING**

Figure 1.14 shows the arm sizing provided by the Enhanced Arm. Section 3.4.5 discusses Enhanced Arm Sizing in greater detail.

**FIGURE 1.8 EMU LEAKAGE SPECIFICATIONS**

	<b>ALLOWABLE LEAKAGE (Sccm)</b>	
<b>COMPONENT</b>	<b>EVA WITH O<sub>2</sub> @4.3 PSID</b>	<b>STANDARD ATMOSPHERIC /AIR @ 4.3 PSID</b>
PLANAR HUT	6.0	21.0
ARMS (EACH)	9.0	24.0
LTA	13.2	46.5
GLOVES (EACH)	3.0	8.0
HELMET	2.0	5.0
SOP	0.17	
DCM	0.33	
CCC	0.17	

**FIGURE 1.9 EMU LEAK CHECK SUMMARY**

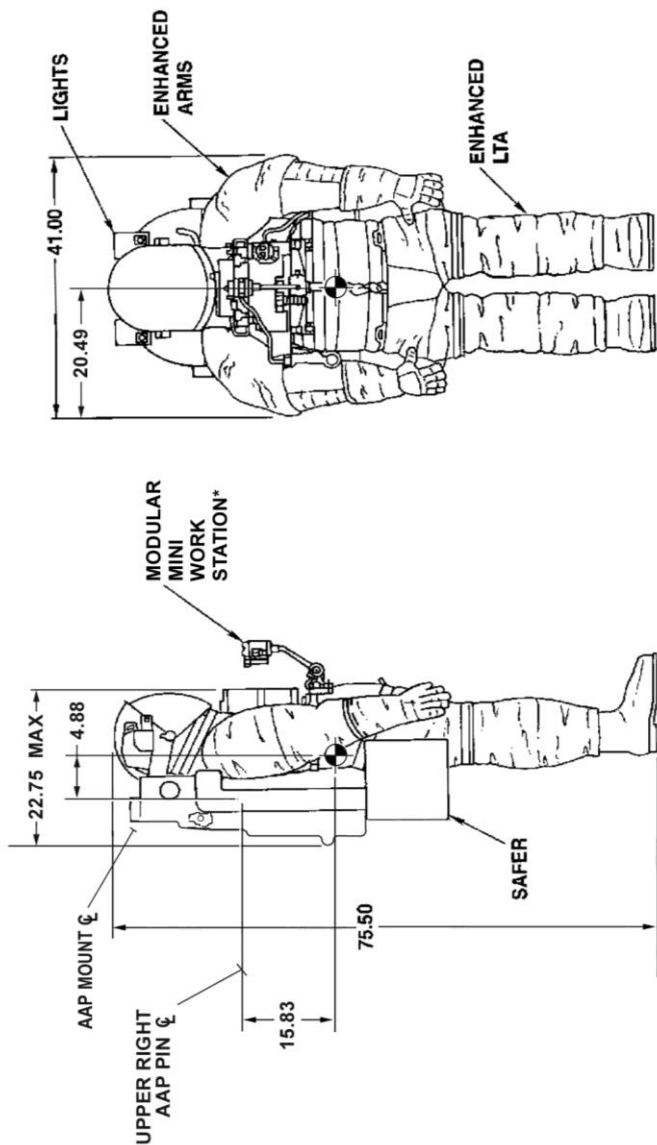
<b>Test Description</b>	<b>Ground Processing<sup>2</sup></b>	<b>EMU Checkout</b>	<b>PreEVA Leak Check</b>	<b>EVA CWS Limits</b>	<b>SOP Make-up Capability</b>
Where Performed	JSC	Vehicle	Airlock	Space Vacuum	Space Vacuum
Ambient Pressure, psia	14.7	10.2 or 14.7	5.0	0	0
Suit Pressure, psig	4.3	4.3	4.3 – 4.6	4.3	3.5
Temperature, °F	70	70	70	70	70
Pass/Fail Criteria	99.3 sccm O <sub>2</sub> , full EMU	0.3 psi suit pressure drop in 2 minutes	0.3 psi suit pressure drop in 1 minute	7 to 10.2 psi/min Primary O <sub>2</sub> Bottle pressure	No Test Performed
Equivalent Leakage Area, in <sup>2</sup>	1.85x10 <sup>-5</sup>	2.11x10 <sup>-4</sup> to 3.52x10 <sup>-4</sup>	1.39x10 <sup>-4</sup> to 2.29x10 <sup>-4</sup>	2.00x10 <sup>-3</sup> to 2.91x10 <sup>-3</sup>	0.0152
Equivalent Leakage at Ground Conditions, sccm O <sub>2</sub>	99.3	1130 to 1880	770 to 1230	10,700 to 16,200	81,500
Equivalent Leakage at Ground Conditions, sccm Air	104.1	1185 to 1980	810 to 1290	11,200 to 16,400	85,600
Equivalent Leakage at EVA Conditions, lb <sub>m</sub> /hr O <sub>2</sub>	0.006	0.069 to 0.116	0.046 to 0.075	0.656 to 0.957	5.0
Equivalent Leakage at EVA Conditions, sccm O <sub>2</sub>	35	395 to 660	260 to 430	3750 to 5460	28,500
Equivalent O <sub>2</sub> bottle decay rate, psi/min	0.064	0.739 to 1.24	0.488 to 0.804	7.01 to 10.2	53.4
Equivalent Met Rate, BTU/hr	37.2	423 to 707	279 to 460	4010 to 5850	30,550
Lost EVA time/hr @ 1000 BTU/hr	2 minutes	25 to 42 minutes	17 to 28 minutes	4.0 to 5.8 hours	30.6 hours
Lost EVA time/hr @ 800 BTU/hr	3 minutes	32 to 53 minutes	21 to 35 minutes	5.0 to 7.3 hours	38.2 hours

1. There is no leakage test performed at V1103.02
2. Ground Processing Leakage calculated for a full EMU

**FIGURE 1.10 EMU MASS PROPERTIES**

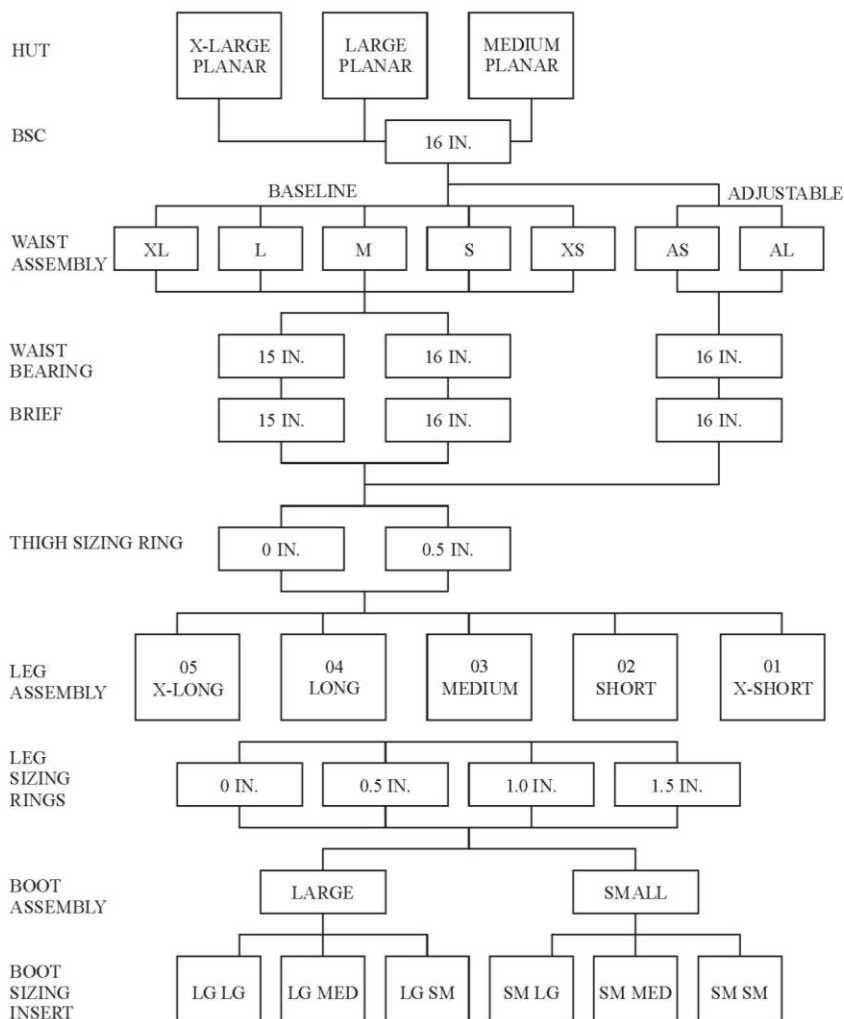
<b>COMPONENT</b>	<b>SPECIFICATION WEIGHT (LBS)</b>
<u>ENHANCED SSA</u>	
EXTRAVEHICULAR VISOR ASSEMBLY	7.20
HELMET ASSEMBLY (WITH CPV)	3.50
COMMUNICATIONS CARRIER ASSEMBLY	0.42
EMU ELECTRICAL HARNESS (EEH)	0.80
PLANAR HARD UPPER TORSO, (WET)	29.60
RPHG ARM ASSEMBLY (RIGHT AND LEFT)	22.20
ENHANCED LOWER TORSO ASSEMBLY	59.73
PHASE VI GLOVE ASSEMBLY (RIGHT AND LEFT)	7.88
SEMU ELECTRICAL HARNESS	0.60
LIQUID COOLING VENTILATION GARMENT, (WET)	8.57
IN-LINE CABLE VOLTAGE REGULATOR	0.75
DISPOSABLE IN-SUIT DRINK BAG (WET, 32 FLUID OZ)	<u>2.48</u>
SUB-TOTAL SSA w/2 ARMS AND 2 GLOVES	143.73
<u>LSS</u>	
PLSS, (WET, w/O <sub>2</sub> FOR ORU PLANAR HUT)	101.4
DCM, (WET, FOR ORU PLANAR HUT)	14.3
SOP, (CHARGED w/O <sub>2</sub> )	23.2
CCC           LiOH	6.4
METOX	32.0
BATTERY     2000 SERIES (INCREASED CAPACITY)	14.7
3000 SERIES (LLB)	15.5
SSER	9.5
ANTENNA & CABLE	<u>1.6</u>
SUB-TOTAL LSS w/METOX CCC & 2000 - SERIES BATTERY	196.7
SCU, (WET)	15.7
AAP	20.5

FIGURE 1.11 ISS EMU DIMENSIONS

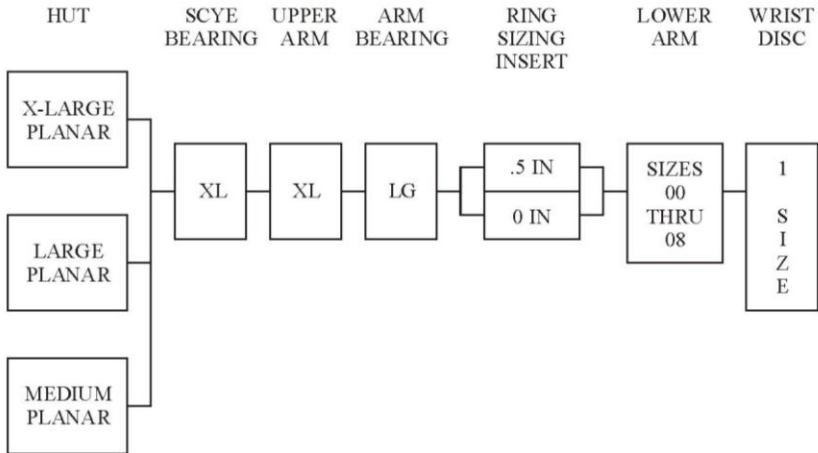


\*INCLUDES ALL HUT SIZES, THE METAL OXIDE CCC, 2000-SERIES BATTERY,  
AND THE RECHARGEABLE EMU BATTERY (REBA)

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**FIGURE 1.12 ENHANCED LEG AND TORSO SIZING**

**FIGURE 1.13 ENHANCED SSA ARM SIZING**



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# **SECTION 2.1**

## **PRIMARY LIFE SUPPORT SUBSYSTEM (PLSS)**

## 2.1 PRIMARY LIFE SUPPORT SUBSYSTEM (PLSS)

The PLSS (Item 100) performs the following functions:

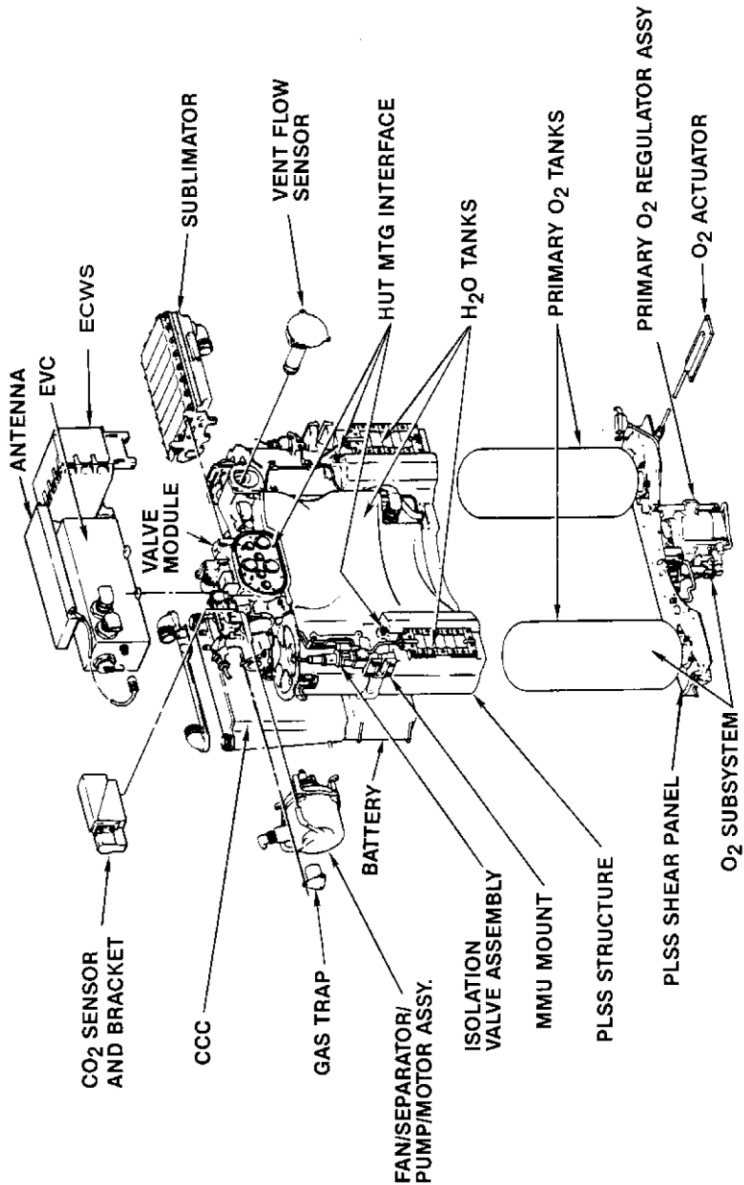
1. Provides breathing oxygen and controls the pressure of the crewmember's suit.
2. Provides thermal control by cooling and recirculating both the oxygen in the suit and the water in the Liquid Cooling Ventilation Garment (LCVG).
3. Removes humidity, odors, carbon dioxide and other contaminants from the recirculating oxygen.
4. Provides communications for the suited crewmembers.
5. Provides sensing of important system parameters.

Seven main subsystems comprise the PLSS:

- (1) the EVA radio portion of the Space to Space Communication System
- (2) the oxygen ventilating circuit
- (3) the primary oxygen circuit
- (4) the feedwater circuit
- (5) the liquid transport loop
- (6) the electrical system
- (7) the caution and warning system

The major components are arranged as shown in Figure 2.1.1.

**FIGURE 2.1.1 PLSS MAJOR COMPONENT ARRANGEMENT**



## **2.1.1 OVERVIEW OF SPACE TO SPACE EMU RADIO**

The Space to Space EMU Radio is part of an Ultra High Frequency (UHF) Time Division Multiple Access (TDMA) system. The system uses frequency modulation (FM) with a burst rate of 693 Kbps and a frequency deviation of 486.5 Khz. It supports a voice and data communications network of up to 5 Space to Space Communication System (SSCS) users. Vehicles currently using the SSCS include the Space to Space Orbiter Radio (SSOR), Space to Space EMU Radio (SSER) and the Space to Space Station (ISS) Radio (SSSR) as shown in Figure 2.1.2. The SSER transmits and receives on a frequency of 417.1 MHz or 414.2 MHz as shown in Figure 2.1.3. The four modes of the Mode Selector Switch are HL, PRI, ALT and OFF.

The SSER provides duplex voice communications between up to 3 EMUs, the SSOR and SSSR. The SSER also transmits digitized analog biomed and EMU status data from the EMUs to the SSOR and SSSR.

SSER hard-line mode is used in communications with the shuttle or station through the umbilical. There is no radio frequency reception or transmission. It is an audio only mode with no EMU or crew status input. Mode PRI is the primary radio for the SSER. Mode ALT is the redundant radio. The SSER modes PRI and ALT are two separate radios. In both SSER modes PRI and ALT, audio, digitized electrocardiogram and EMU status data are transmitted.

### **2.1.1.1 SSER MODE SELECTOR SWITCH**

#### **2.1.1.1.1 MODE HL (HARD-LINE COMMUNICATIONS)**

When operating in the HL mode, voice operation is provided using an audio input/output interface with either

**FIGURE 2.1.2 SPACE TO SPACE COMMUNICATION SYSTEM**

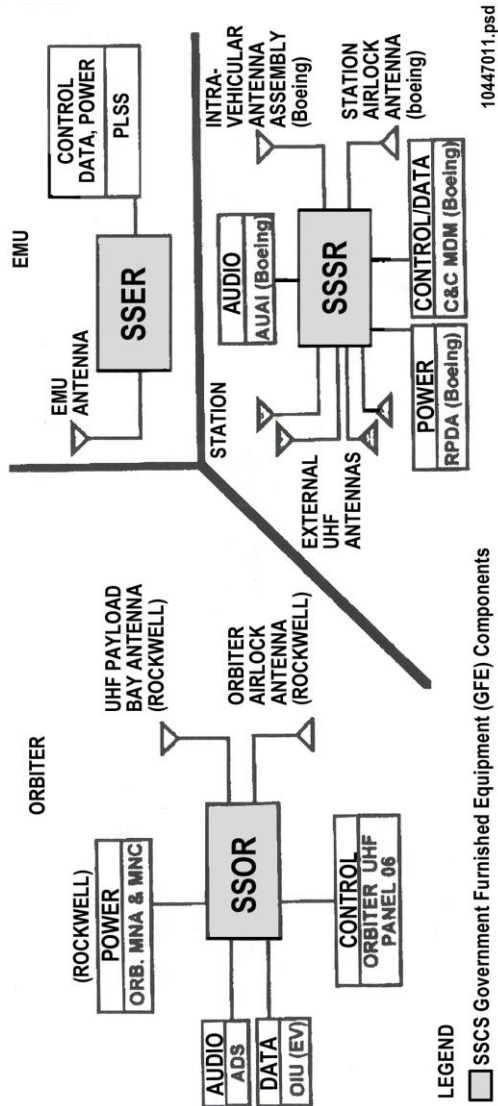
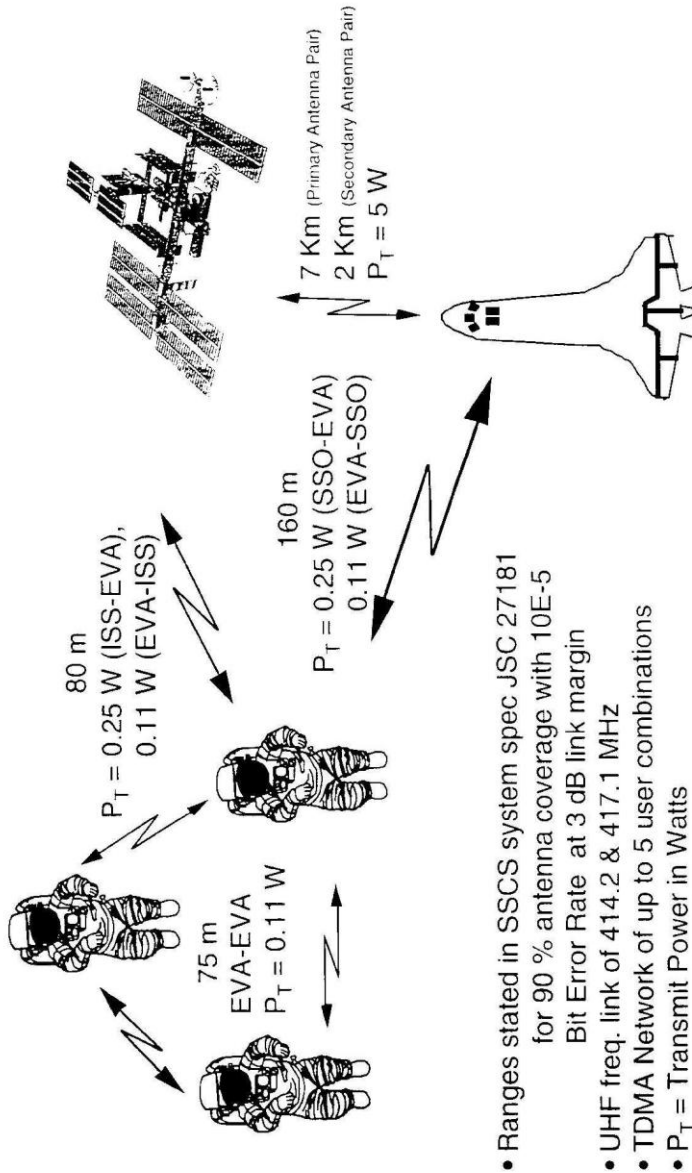


FIGURE 2.1.3 SSCS



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the Space Shuttle Orbiter or the International Space Station via an umbilical. The EMU radio can simultaneously accept microphone voice signals, transmitting them via the SCU or IEU and accept audio input signals from the SCU or IEU, driving the earphone in the EMU. No biomed data or RF transmissions are available via HL mode. Side tone is provided by the SSOR (Orbiter) or SSCS (ISS) radio. The SSER provides a Push to Talk (PTT) key signal and controls the audio volume in response to the EMU remote controls. When the SSER is opening in PRI or ALT modes, the audio and PTT interfaces to the SCU are inhibited.

#### **2.1.1.1.2        MODE PRI**

When operating in mode PRI, transmission and reception is provided on 414.2 or 417.1 MHz. At either frequency the transmitter provides continuous carrier for simultaneous transmission of the ECG/ RTD signal and voice. If the SCU is connected, Mode PRI and PTT/ LOW is selected and the ATU is powered, the crewmember will receive an audio signal via the SCU together with RF reception through the extravehicular communicator. The radio is started in Mode PRI with the PTT switch in LOW. This is the nominal position.

#### **2.1.1.1.3        MODE ALT**

Mode ALT is identical to Mode PRI. Mode ALT is the secondary radio. Transmission can be accomplished on the 414.2 or 417.1 MHz frequencies. The PTT switch HIGH, LOW or PTT/MUTE option is available on Modes PRI or ALT. In both PRI and ALT the SSER supports TDMA functions and transmits 64 Kbps  $\mu$ -Law compounded audio and 4 Kbps digitized ECG and EMU status data.

**2.1.1.1.4        MODE OFF**

Mode OFF disables the transmission and reception of the radio by removing power from the radio.

**2.1.1.2        PTT SWITCH**

The PTT switch, located on the DCM, is a three position switch.

**2.1.1.2.1       PTT/MUTE**

The PPT switch has two maintain-on positions, HIGH and LOW, and one momentary-on position, PTT/MUTE. If the crew wishes to mute their voices, they can do so by pushing the SSER PTT switch to the momentary-on PTT/MUTE position. In the SSER, the maintain-on positions HIGH and LOW select the frequency choices for the crewmember. The HIGH sets the radio transmit or receive on 417.1 MHz. LOW sets the radio transmit or receive on 414.2 MHz. There is no frequency selection in HL mode.

The PTT/MUTE momentary position allows the crewmember to manually disrupt transmission in modes PRI or ALT. The PTT/MUTE momentary position allows transmission and reception in the HL Mode.

**2.1.1.2.2       HIGH**

The HIGH maintained position allows transmission and reception at 417.1 MHz. In the PRI and ALT modes, the transmitter sends a continuous carrier. The HIGH maintained position allows reception only in the PRI or ALT Mode.

**2.1.1.2.3      LOW**

The LOW maintained position functions as the HIGH position does. It operates at 414.2 MHz. LOW is the nominal EVA position.

**2.1.1.3      VOLUME CONTROL**

The audio output in the upper volume control in relation to the SSER adjusts Mode PRI and hardline communications. Both potentiometers are 10 Kohm resistive elements consisting of independent high and low side wipers. The lower control adjusts audio output Mode ALT.

**2.1.1.4      DCM LABELING**

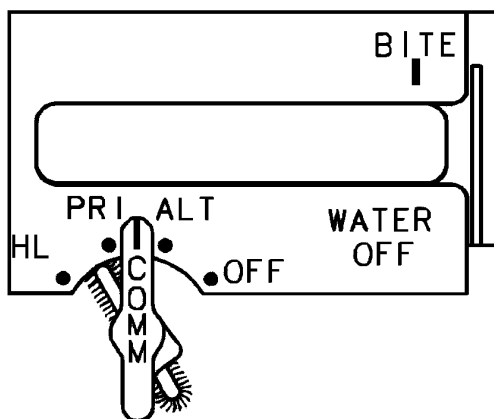
The SSER DCM TMG / Nameplate labeling is shown in Figures 2.1.4 and 2.1.5.

**2.1.1.5      DIGITAL DATA**

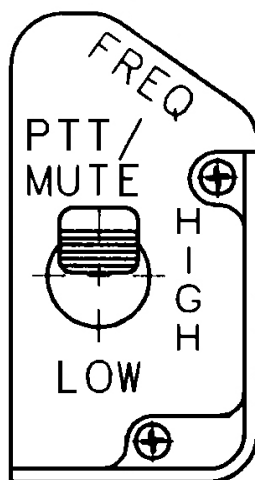
**2.1.1.5.1      EMU STATUS AND BIOMED DATA**

The SSER accepts analog data from the EMU which consists of the ECG and EMU status data time division multiplexed. The analog data is converted to digital data using an 8 bit analog to digital conversion. The analog data sampling rate is 500 samples per second giving a data rate of 4 kbps.

The simple harmonic distortion of the transmitted analog data does not exceed 10% in the frequency range from 0 to 80 Hz.



**FIGURE 2.1.4 SSER MODE SELECTOR SWITCH LABELING**



**FIGURE 2.1.5 SSER PUSH-TO-TALK (PTT) SWITCH LABELING**

### 2.1.1.5.2 ENHANCED CAUTION AND WARNING TONES

The SSER's Modem Signal Processor Power Converter (MSPPC) provides a caution tone of  $1.5\text{kHz} \pm 75\text{Hz}$  at  $0\text{dBm} \pm 3\text{dB}$  across the 600 ohm earphone output when the caution input is shorted to ground in the Hardline Mode. The MSPPC provides a warning tone of  $1.5\text{kHz} \pm 75\text{Hz}$  with  $15\text{Hz} \pm 5\text{Hz}$  pulse modulation ( $50 \pm 10\%$  duty cycle) at  $-3\text{dBm} \pm 3\text{dB}$  across the 600 ohm earphone output when the warning tone input is shorted to ground in the Hardline Mode. The warning tone takes precedence over the caution tone.

The caution and warning tone control inputs are shared with the SSER signal processors in PRI and ALT modes.

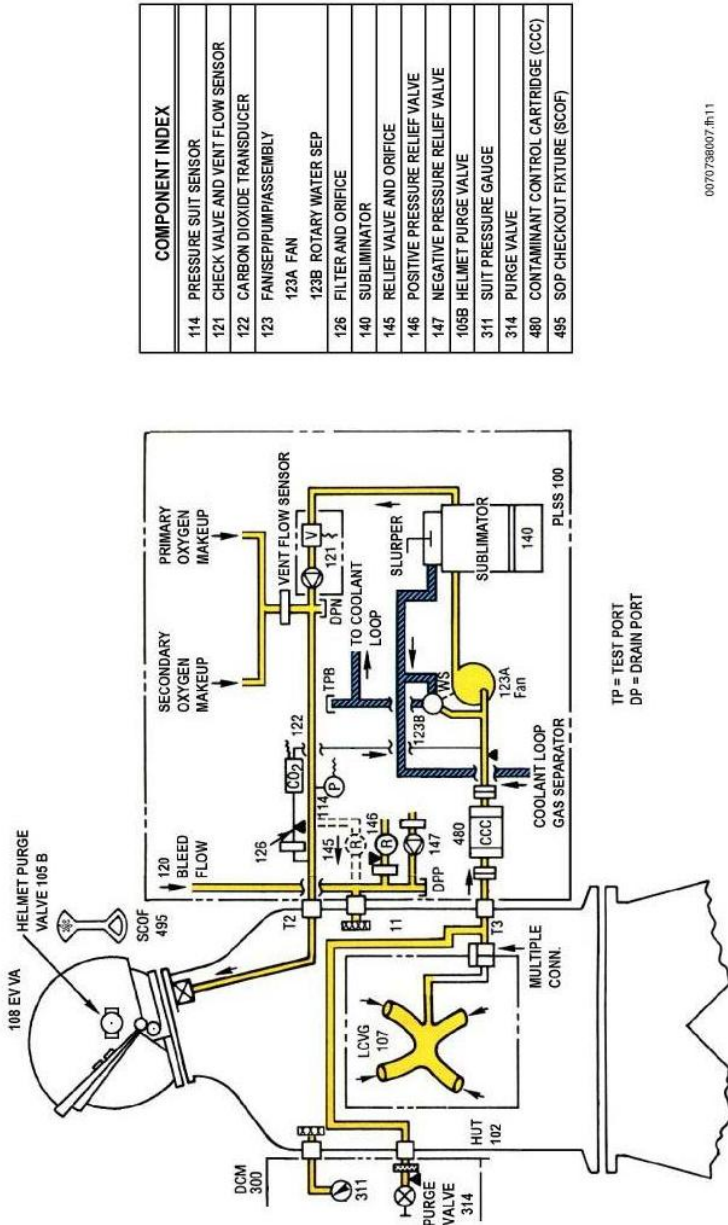
The ECWS can generate 4 different audible tones. The tones are used as follows:

1. Short (Previously known as ALERT)
2. Long (Previously known as STATUS)
3. Warble (Previously known as WARNING)
4. N/A Tone (Double Beep indicating an invalid ECWS switch actuation has taken place)

## 2.1.2 OXYGEN VENTILATING CIRCUIT

The Oxygen Ventilation Circuit (Figure 2.1.6) forms a closed loop with the pressure garment assembly. The circuit provides oxygen for breathing, suit pressurization for IVA and EVA operations, and ventilation for suit cooling and elimination of exhaled gases. The oxygen flow picks up heat, humidity,  $\text{CO}_2$ , and other contaminants from the suit. These are removed from the EMU by the ventilation circuit components. The Primary Oxygen circuit and Secondary Oxygen Pack provide a range of ventilation operating pressures that are controlled by the four-position actuator on the DCM. Normally, the oxygen ventilation circuit operates in IVA mode at  $0.9 + 0.5$  psid and in EVA mode at  $4.3 + 0.1$  psid. The table below summarizes the oxygen ventilation circuit pressure levels for various operating modes and DCM actuator positions.

FIGURE 2.1.6 OXYGEN VENTILATING CIRCUIT



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## OXYGEN VENTILATION CIRCUIT OPERATING PRESSURES

DCM Actuator Position	Operating Mode	Pressure Source	Oxygen Ventilation Circuit Pressure Level
OFF	OFF	None	N/A
IVA	Low Pressure	Primary O <sub>2</sub>	0.40 - 1.40 psid
EVA	Normal Pressure	Primary O <sub>2</sub>	4.20 - 4.40 psid
	Purge	SOP	3.33 - 3.90 psid
	Emergency Make-up	SOP/Primary O <sub>2</sub>	3.4 - 3.9 / 4.2 - 4.4 psid
PRESS	Pressurized	Primary O <sub>2</sub>	4.2 - 4.4 psid

The inlet to the ventilation circuit from the primary and secondary oxygen circuit is downstream of the check valve/vent flow sensor (Item 121). Before entering the pressure garment assembly, the ventilation flow passes a pressure transducer (Item 114) and the inlet to the CO<sub>2</sub> sensor (Item 122). The pressure transducer and the CO<sub>2</sub> sensor outputs are fed into the ECWS (Caution and Warning System) and the measurements are available to the crewmember. The transducer provides a continuous signal to the ECWS of vent loop pressure relative to ambient. As a redundant pressure measurement, a mechanical pneumatic gage (Item 311) is mounted on the DCM and senses directly into the suit. The flow through the CO<sub>2</sub> sensor is limited by a flow restrictor to less than one percent of the total flow through the ventilation passages. The remainder of the oxygen goes to the suit via the helmet vent pad. Within the helmet, the flow then passes downward over the visor to prevent fogging, to cool the head, and to direct CO<sub>2</sub> away from the oral/nasal area. The flow then continues on to the pressure garment. Ventilation flow is picked up at the body extremities and returned to the upper torso (Item 102) via a vent duct manifold that is part of the cooling garment (Item 107). During donning, the cooling garment is connected to the upper torso by a multiple connector. From the upper torso, the gas is routed back into the PLSS (Item 100) and the CCC (Item 480).

The CCC is sized to absorb 1.48 lb of CO<sub>2</sub> (average of 1000 Btu/Hr for seven hours). For metabolic rates of

1600 Btu/Hr or less, the CO<sub>2</sub> partial pressure should not exceed 7.6 mmHg. For metabolic rates between 1600 and 2000 Btu/Hr, the CO<sub>2</sub> partial pressure is maintained below 15 mmHg. The cartridge also contains a filter to trap and limit particulates in the ventilation flow stream and charcoal to absorb trace contaminants. The cartridge is replaceable on-orbit by an unassisted crewmember without the use of tools. It can be changed out while a crewmember is inside the suit by another IV crewmember provided that the EMU is at the same pressure as the environment.

Two CCC versions are available: a single EVA LiOH contaminant control cartridge which can be recharged on the ground, and a reusable metal oxide (METOX) contaminant control canister which can be regenerated on-orbit in the ISS.

The centrifugal fan (Item 123A), located downstream of the CCC and running at 19,300 rpm, produces a 3.5 in H<sub>2</sub>O pressure rise and delivers a minimum of 6.0 cfm ventilation flow to the pressure garment at the helmet inlet.

The vent flow continues from the fan through the sublimator (Item 140) where it is cooled from 103F to 57F. Ventilation gas enters the sublimator with a dewpoint of up to 92.3F and leaves at a dewpoint of 54.5F maximum. Condensate is formed when humidity in the ventilation gas condenses in the sublimator. A hydrophilic coating promotes wetting of the walls in the gas-side passages of the sublimator, and condensate is wicked along the walls by capillary action. Wicking the water along the surface prevents water from puddling in the passages and reduces the pressure loss in the vent circuit by approximately 0.5 in. H<sub>2</sub>O. At the exit end of the gas side passage, holes placed between each fin space lead to a transverse passage called a slurper header. A slight suction provided by the fan draws the condensate through the holes into the slurper header, thus removing the condensate from the ventilation circuit. Approximately 1 to 10 percent of the ventilation gas flow

accompanies the condensate into the slurper. The slurper gas and condensate are drawn by the fan into a motor-driven rotary water separator (Item 123B) that returns the slurper gas to the ventilation circuit and delivers condensate at a maximum pressure of 19 psid above inlet pressure into the feedwater circuit, becoming available as expendable water.

A check valve/vent flow sensor (Item 121) is located downstream of the sublimator. The check valve assures that all purge flow is directed into the helmet when the fan is unpowered. Purge flow is used to denitrogenate the suit during EMU donning activities and is also used as an emergency EVA mode should the fan malfunction. The position of the check valve also indicates sufficiency of vent flow. Inadequate flow is indicated when flow falls to 3.7 acfm minimum at 3.35 psia and adequate flow is indicated when flow returns to 5.7 acfm maximum at 3.35 psia or 5.4 acfm maximum at 4.3 psia. The sensor is pressure compensated to retain these set and reset points over the full range of ventilation circuit pressures. The pressure transducer (Item 114) is located downstream of the vent flow sensor.

A set of valves mounted in the PLSS is used to accomplish purge, checkout, and pressure relief for various conditions of ventilation loop operation. A purge valve (Item 314), located on the DCM, is manually activated and passes a minimum of 4.74 lb/hr of oxygen from the vent circuit at 3.45 psia. The helmet purge valve (Item 105B), a backup to the DCM purge valve, is also manually activated and passes a minimum of 2.5+ 0.4 lb/hr of oxygen from the vent circuit at 3.35 psia.

Overpressure protection against failed open SOP or primary oxygen subsystem regulators is accomplished by a positive pressure relief valve (Item 146) located in the vent circuit adjacent to the upper torso (Item 102). The relief valve is sized to pass 7.79 lb/hr of dry oxygen at 5.5 psig loop pressure. A negative pressure relief valve (Item 147), is located adjacent to the positive pressure relief valve, allows suit pressure to track the airlock emergency

repressurization rate within 0.8 psid to prevent the suit from collapsing.

The ventilation circuit and SCOF are used to check out the SOP before EMU donning.

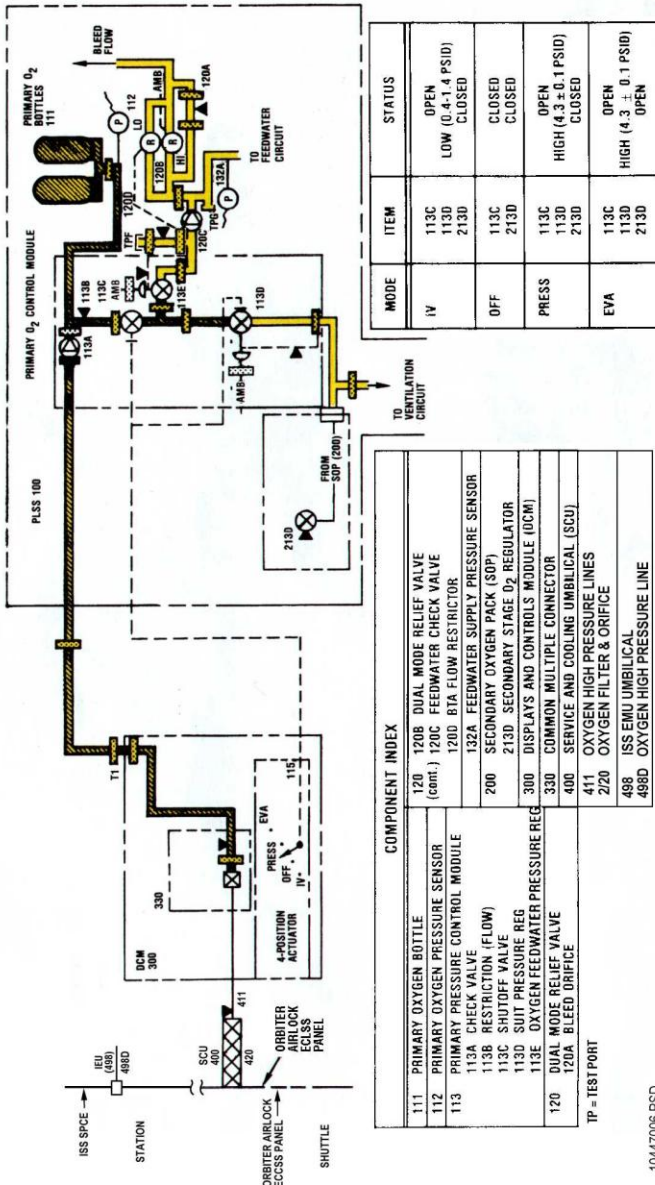
The SCOF is mounted to the HUT neck ring, sealing the vent outlet duct. The SCOF incorporates a relief valve which is sized to pass 7.49 lb/hr of oxygen at 5.5 psid and 10.2 psia downstream ambient pressure. The SCOF provides SOP, PLSS and HUT protection in the event of an Item 113 regulator or SOP regulator failure during SOP checkout.

### **2.1.3 PRIMARY OXYGEN CIRCUIT**

The Primary Oxygen Circuit (Figure 2.1.7) provides breathing oxygen, water tank and suit pressurization, and gaseous oxygen storage.

Charging oxygen at  $900 \pm 50$  psig from the Shuttle ECLSS via the SCU fills the circuit through a common multiple connector (Item 330) on the DCM. Similarly, the ISS SPCE provides charging oxygen at  $900 \pm 50$  psig to the EMU via the IEU. A check valve, downstream of the charging fitting, prevents backflow if the supply pressure falls below the PLSS bottle pressure, and is redundant with the fill fitting in preventing over-board leakage through the fill line. Two oxygen bottles (Item 111) store a total of 1.217 lb minimum of usable oxygen. The storage bottles are isolated from the vent loop by a manual shut-off valve (Item 113C) controlled by the actuator mounted on the bottom of the DCM. A pressure transducer (Item 112) between the manual shut-off valve and the oxygen bottles measures the primary oxygen bottle pressure. This pressure measurement is monitored by the ECWS and is displayed to the crewmember via the DCM.

### FIGURE 2.1.7 PRIMARY OXYGEN CIRCUIT



The suit pressure regulator provides two regulation pressures from the primary source of oxygen. The suit pressure regulator pressurizes the ventilation circuit to  $0.9 \pm 0.5$  psid for the IV position on the O<sub>2</sub> (oxygen) actuator or  $4.3 \pm 0.1$  psid for the PRESS or EVA positions on the O<sub>2</sub> actuator. The OFF position of the O<sub>2</sub> actuator closes the oxygen shut-off valve (Item 113C) upstream of the regulators to stop oxygen flow into the suit.

The water pressure regulator (Item 113 E) provides the gas side of the water tanks with 14.6 - 15.7 psid to pressurize the feedwater circuit. The oxygen flows through the Dual Mode Relief Valve (Item 120). Item 120 contains a check valve (Item 120C) that prevents the moisture-laden gas from the water tanks from backflowing through the water pressure regulator. This moisture-laden gas could cause regulator corrosion.

The check valve, along with the BTA Flow Restrictor (Item 120D), also provides for the cyclic opening of the Low Mode Relief Valve (Item 120B) during BTA operation. The high pressure relief mode of the Item 120 B allows excess pressure to be dumped into the ventilation circuit so that a failed open oxygen feedwater pressure regulator (Item 113E) will not cause a catastrophic failure of the water tanks. The low pressure relief mode of this valve allows a rapid water recharge by releasing trapped oxygen on the backside of the water tank. This occurs when the O<sub>2</sub> actuator is placed on the OFF position for water tank filling. An orifice (Item 120A), sized for one half the minimum metabolic rate, keeps the water pressure regulator dynamic.

There is a downstream sense line on both the feedwater tank pressure regulator and the suit pressure regulator. The sense line ports the downstream pressure to the sense chamber. The sense chamber contains a bellows which is sensitive to differential pressure (outlet pressure to ambient pressure). As the downstream pressure increases above the regulator set point, the sense element will close the regulator poppet valve. As downstream pressure

decreases below the regulator set point, the sense element will open the regulator poppet valve. To minimize regulator set point shift, due to inlet pressure variation caused by bottle pressure decay as oxygen is consumed, the suit pressure regulator contains an upstream pressure compensator.

Safeguards are included in the water pressure loop to protect the hardware from contamination and to protect the crewmember and the hardware from failure. Filters are located throughout the circuit to protect the system from debris. If either regulator fails open, the flow restrictor (Item 113B), upstream of the shut-off valve, limits flow from the primary oxygen bottles to 7.1 lb/hr at 950 psia supply pressure.

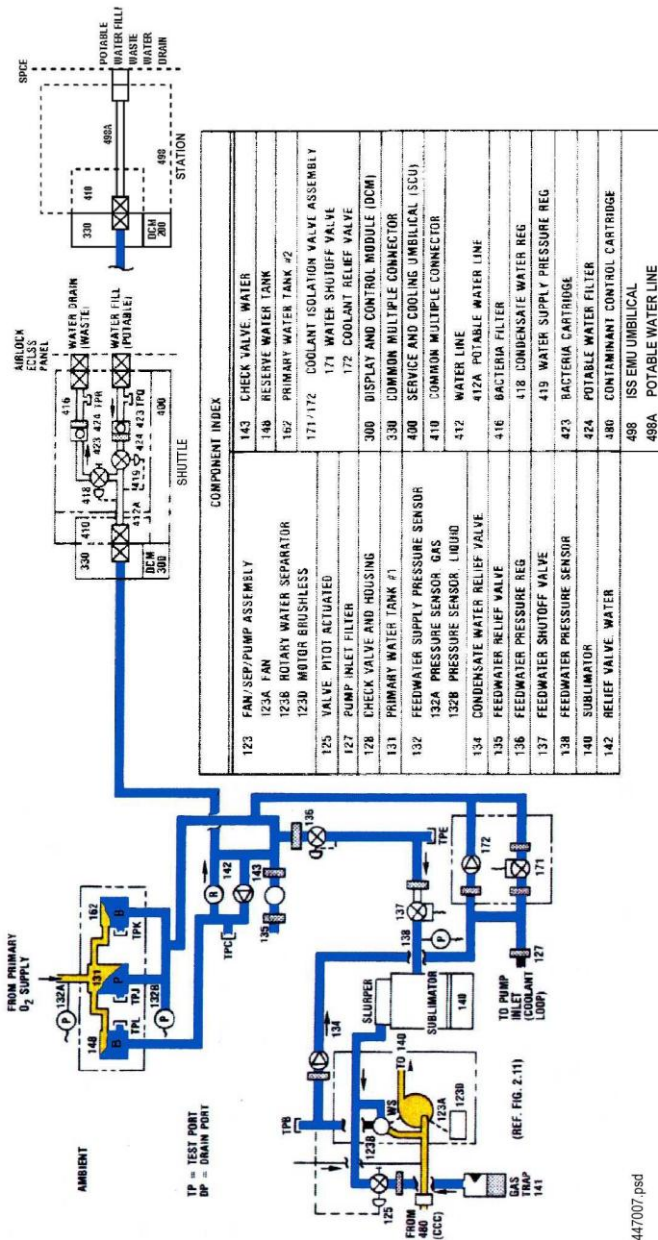
#### **2.1.4 FEEDWATER CIRCUIT**

The Feedwater Circuit shown in Figure 2.1.8 contains the equipment and water to reject heat loads imposed on the system by the crewmember, the PLSS, the DCM, and the environment. The equipment removes moisture from the ventilation circuit, gas from the transport circuit, separates the water and gas, and puts each back into their respective loops.

The primary feedwater reservoirs (Items 131 and 162) and reserve (Item 148) store a combined total of approximately 10 lbs of feedwater. Potable water from the Orbiter ECLSS, via the SCU at 8 to 15 psig, is used to fill or recharge the reservoirs. The water reservoirs are pressurized to 15 psig by the primary oxygen circuit for feedwater circuit operation. Similarly, the ISS SPCE provides potable water at a maximum pressure of 17.0 psig via the IEU. Thus, any gas dissolved in the water charged from the vehicle remains in solution in the reservoirs.

In the event that primary feedwater is depleted, the reserve feedwater reservoir provides 30 minutes of water for EMU

FIGURE 2.1.8 FEEDWATER CIRCUIT



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cooling at a 1000 BTU metabolic rate. Fill or recharge water enters the reserve feedwater reservoir through a check valve (Item 143) located in parallel with a relief valve (Item 142) downstream of the reserve reservoir. When the primary tanks empty and the water supply pressure drops 4 – 5 psi below the O<sub>2</sub> pressure, the relief valve opens controlling the feedwater pressure to 10 psig. The pressure difference is detected by pressure transducers located upstream and downstream (Items 132A and 132B, respectively) of the primary tanks. The system is monitored by the ECWS, which alerts the crewmember when 30 minutes of feedwater remains.

The feedwater then passes through a pressure regulator (Item 136) that reduces the pressure to 2.55 to 4.15 psid above ambient pressure to supply the sublimator during sublimator operation. The crewmember uses a DCM switch to control a shutoff valve (Item 137). The switch will remain in the last selected position should power be removed from the EMU. Feedwater passes into the sublimator, freezes in the stainless steel porous plate, and the ice sublimates into space. This sublimation cools the cooling water that flows through the sublimator adjacent to the cooled plate.

A pressure transducer (Item 138) provides monitoring of feedwater pressure by the ECWS. When the sublimator is not in operation, the transducer is used to monitor ambient pressure. It is open to the ambient through the porous plate.

During IVA, the Orbiter ECLSS cools the EMU Cooling Loop via the SCU, and condensate generated during this period is not consumed. It is removed by the water separator and transferred to the water tanks. Originally, the condensate pressure regulator (Item 418) was designed to relieve condensate from full water tanks at  $16.5 \pm 0.5$  psid to the Orbiter Waste System. However, it is not desirable to run the Orbiter Waste System during prebreathe. Therefore approximately one pound of water is off-loaded from the EMU water tanks prior to prebreathe to provide room for the condensate.

Similarly, prior to ISS IVA prebreathe, approximately 0.2 lb of water is offloaded. The remaining humidity generated by the crewmember is absorbed by the Metox CCC during hydration, which is required for CO<sub>2</sub> absorption.

During startup, several minutes are required for sufficient condensate to accumulate and submerge the pitot in the water separator. During this time, the pitot tube may be dry, developing no head. In this situation, pressurized feedwater is prevented from flowing back through the separator and flooding the ventilation loop by means of a check/relief valve (Item 134) located in the pitot discharge line. When sufficient condensate has built up in the pitot tube so that 2.5 to 2.9 psid above water reservoir pressure is generated across the check/relief valve, the relief valve opens, allowing condensate to leave the separator. When the pressure increases to 5 psig, the Pitot Actuated Valve (Item 125) opens permitting degassing of the transport water circuit. If the Isolation Valve (Item 171) fails to open, a relief valve (Item 172) allows condensate to flow to the feedwater system. If the PLSS is stored after feedwater recharging, thermal expansion may cause the water reservoir pressure to exceed  $19 \pm 1$  psid. A relief valve (Item 135) will bleed the excess water to ambient.

## **2.1.5 LIQUID TRANSPORT CIRCUIT**

To provide the PLSS thermal control function, the Liquid Transport Circuit (Figure 2.1.9) normally circulates water at a minimum rate of 240 lb/hr through the cooling garment by means of a centrifugal pump (Item 123C). The cooling garment pressure level is regulated by the feedwater circuit to 14.6 to 15.7 psig at the pump inlet. During IVA operation, the pump circulates water through the EMU and the SCU to the LCVG heat exchanger in the Orbiter. Similarly, during ISS IVA, the pump circulates cooling water through the EMU and IEU to the SPCE heat exchanger.

TP-TEST PORT

HUT 102 PLSS 100

LCVG 107

TO FEEDWATER LOOP

TPH

128

127

123C

141

LCVG BYPASS PLATE

139

SUBLIMATOR

140

FROM FEEDWATER LOOP

DCM 300

COOLING CONTROL VALVE

321

SCU (EMU SIDE) CONNECTOR

330

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A cooling control valve (Item 321), located on the DCM, provides temperature control by permitting the crewmember to bypass a variable amount of water around the sublimator during EVA (or vehicle LCVG heat exchanger when EMU is attached to the umbilical) and back to the cooling garment. This includes the ability to bypass the LCVG also. Details of the bypass are presented at the end of this section.

Liquid transport loop gas purging is accomplished by a gas trap (Item 141) located just upstream of the pump. The liquid transport flow brings bubbles to the gas trap, which consists of a screen that passes water but blocks bubbles. The bubbles are bled off through orifices to the water separator, along with approximately 4 percent of the pump water flow.

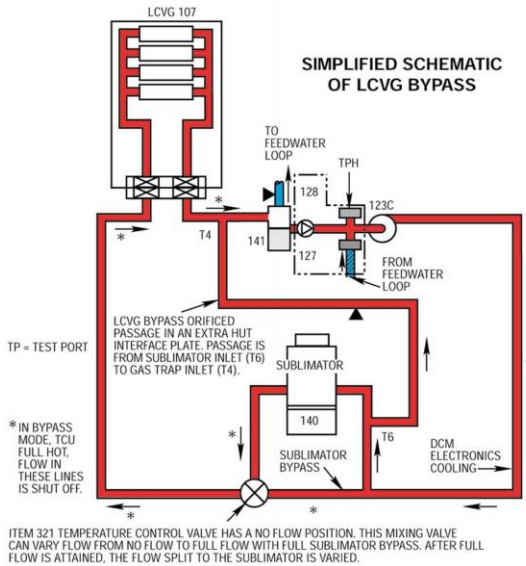
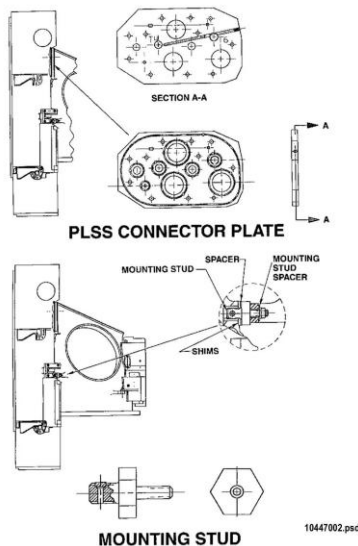
If the pump and the water separator are energized in a dry condition, they will produce no head. For this case, the Pitot-actuated valve (Item 125) has a manual override button accessible from the rear of the PLSS. Pushing the button allows the gas to escape from the transport loop and primes the water pump. In normal operation, the transport loop is wet and the Pitot-actuated valve will not open until the water separator produces greater than 5 psid at the water separator outlet. The valve will close when this pressure is less than 2 psid. This prevents the transport loop water from flooding the ventilation loop during water separator startup. The Water Shutoff Valve (Item 171) provides redundant isolation of the Vent Loop from the coolant loop, backing up Items 125 and 134, when the Fan/ Separator / Pump (Item 123) is not running.

The pump develops a 5 psid head and is capable of flowing water at 240 lb/hr. The water flows to the cooling control valve located on the DCM which provides manual adjustment of water flow for crewmember cooling requirements. Mirror image markings indicating cooling control valve positions are located on the DCM thermal cover. Part of the warm water bypasses the valve and flows through the multiple connector (Item 330) to the

sublimator (or Orbiter heat exchanger) and the rest continues through the cooling control valve. The valve controls the cooled water flow rate from 240 lb/hr for maximum cooling to 2.0 lb/hr maximum for minimum cooling. From the sublimator, the cooled water is returned to the cooling control valve where it is mixed with the warm water. The mixture then enters the cooling garment through the multiple water connector. A temperature sensor (Item 139) at the sublimator outlet monitors the temperature of the cooling water leaving the sublimator and provides an analog signal input to the ECWS.

The EMU includes an LCVG Bypass to the EMU to enhance thermal comfort in cold environments. Figure 2.1.10 shows this schematically. The LCVG Bypass function consists of the following hardware items depicted in Figures 2.1.10 and 2.1.11: a 0.310 inch thick stainless steel LCVG bypass PLSS Interface Plate between the HUT and PLSS that contains an orifice passage between the Sublimator (Item 140) inlet at T6 and the Gas Trap (Item 141) inlet at T4, a modified Cooling Control Valve (Item 321) that provides no flow to the LCVG at FULL HOT, and a longer mounting stud, nut and washer at the lower PLSS to HUT attachment point to accommodate the LCVG bypass plate. The new mounting stud has a modified hex head to accommodate the new assembly. Additionally, the PLSS side stud and mounting hardware are 0.250 in. diameter to accommodate the increased launch and landing loads associated with a Shuttle external airlock.

Figures 2.1.9 and 2.1.10 show the operation of the LCVG Bypass function. For normal EVA and IV operation, flow through the plate reduces the transport water flow to the LCVG by 15 lb/hr for cooling control valve positions 2 through FULL COLD. When FULL HOT is selected during EVA, the flow to the LCVG is shut off. At this position the pump head increases to 8 psid with 15 lb/hr flowing from the pump to the gas trap inlet via the T6-to-T4 bypass. When FULL HOT is selected during IV operation, the water flows from the pump outlet through

**FIGURE 2.1.10 LIQUID TRANSPORT CIRCUIT****FIGURE 2.1.11 LIQUID TRANSPORT CIRCUIT**

the LCVG Heat Exchanger in the vehicle and then through the passage from T6 to T4. As the Cooling Control Valve is adjusted from FULL HOT to position 2, the flow in the LCVG tubes increases progressively to the nominal level. Between 2 and FULL COLD the modified Cooling Control Valve mimics the unmodified CCV operation by just adjusting the flow rate to the sublimator.

## **2.1.6 EMU ELECTRICAL SYSTEM**

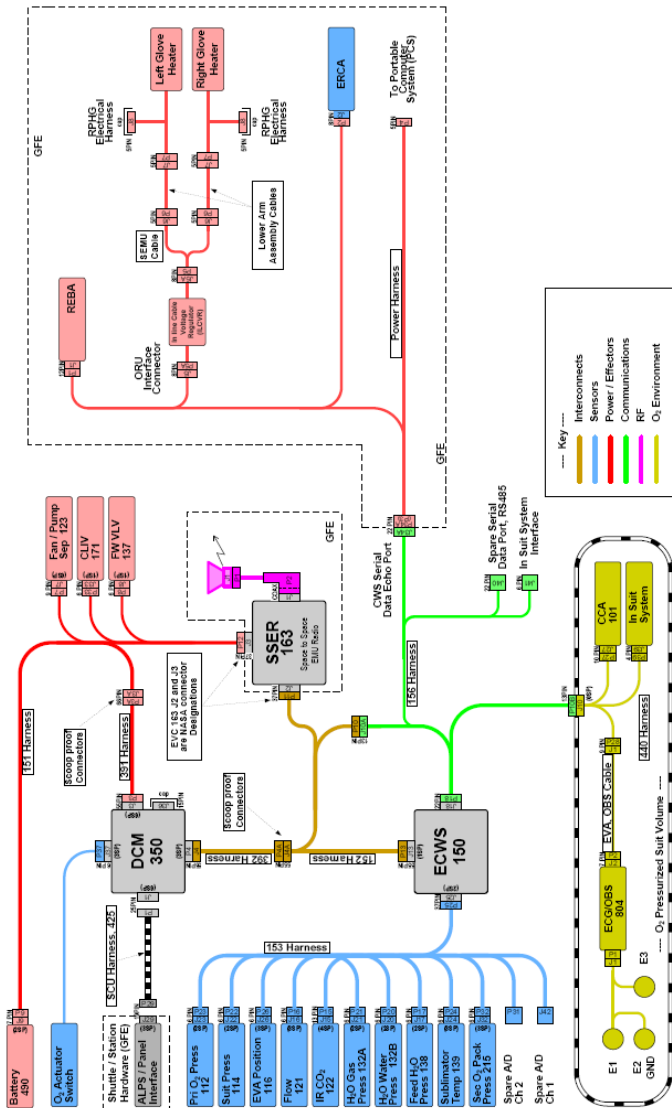
The EMU Electrical System consists of a battery, the DCM, the ECWS, the EVC, the feedwater and coolant-isolation solenoid valves, the fan/pump/ separator motor, various sensors, harnesses and instrumentation. Block diagrams illustrating the electrical subsystem for non-ORU and ORU versions of the EMU are in Figures 2.1.12 and 2.1.15, respectively.

Power for EVA operation of all electrical and electronic subsystem components is supplied by a battery (Item 490), which is mounted in the PLSS. The battery is sized for a minimum of 26.6 A-h, based on a maximum EMU current draw of 3.8 Amps for a 7-hour EVA. The battery may be removed from the PLSS without the use of tools. The EMU can use two types of batteries: the 2000 Series Ag-Zn Increased Capacity Battery (ICB) or the 3000 Series Li-ion Long Life Battery (LLB).

The ICB operates at a nominal 16.8 V and consists of 11 sealed silver zinc cells connected in series. This assembly provides a sealed system with a single stage relief valve per cell to serve as a safety mechanism in the event of excessive pressure buildup. Absorbent material in the cavity behind each relief valve keeps the electrolyte from leaking out of the battery when the relief valves are open.

The ICB is stored dry before use and is activated on the ground prior to launch by filling with pre-measured electrolyte. In flight, the battery can be either replaced or recharged via the umbilical while the battery is in the PLSS.

FIGURE 2.1.12 EMU ELECTRICAL SCHEMATIC



The ICB can be fully recharged within 20 hours to support a 7-hour EVA. Once formed with electrolyte, the ICB life is limited to 300 days and 12 charge/discharge cycles.

The LLB operates nominally between 17.5 and 20.6 V and consists of 80 commercial 18650 Li-ion cells arranged in 5 banks of 16 cells. It is a sealed assembly that can be recharged while either installed or removed from the PLSS. It must be recharged using a dedicated, portable charger either on the ground or in flight. Recharge on the ground at 120 V takes ~50 hr, while recharge in flight at 28 V takes ~62 hr. LLB life is a minimum of 50 charge/discharge cycles during 5 years with 600 days charged.

The instrumentation in the electrical system consists of sensors and transducers that monitor critical performance parameters and provide signal inputs to the Enhanced Caution and Warning System (ECWS), located within the PLSS. The functions of these instrumentation items are discussed in Sections 2.1.2 through 2.1.5 and in Sections 2.1.7 and 2.2.

The output signals from the PLSS instrumentation go to the ECWS which then displays status information to the crewmember via the Liquid Crystal Display on the DCM. The DCM displays anomaly and status messages and also monitors and displays consumables status. An audible warning tone is provided via the SSER to alert the crewmember of system malfunction. Operation of the ECWS is discussed in detail in Section 2.1.7.

An Electrical Harness (Item 440), located within the Hard Upper Torso (HUT) connects the microphone and earphone circuits of the Communications Carrier Assembly (Item 101) and biomed sensors to the SSER.

## 2.1.7 ENHANCED CAUTION AND WARNING SYSTEM

The ECWS is a microprocessor-based system that displays the status of the EMU, detects and displays EMU system faults, monitors consumables during the mission and performs a suit leak check. It uses radiation tolerant electronics that eliminate most of the radiation sensitive components that contributed to the limited life of the former Caution and Warning System (CWS) and Real Time Data System (RTDS). The electronics use a 16-bit processor with enhanced status and message capability and downloadable memory, an electronically erasable programmable read-only memory, EEPROM. ECWS also integrates the former functions of the CWS discrete logic components into a field-programmable gate array (FPGA). A 50-baud universal asynchronous receiver transmitter (UART), signal isolation and electro cardiogram (EKG) relay perform the former RTDS functions.

The Enhanced Caution and Warning System (ECWS) replaced the PLSS's original CWS as those units approached the end of their design life. By using current electronics technology, the ECWS saved enough volume within the existing CWS envelope to accommodate the RTDS function within the ECWS and to provide additional room for future capability growth. Deleting the RTDS required redesigning the I-156 RTDS Harness. However, ECWS leaves the sensors, discrete inputs and physical envelope of the original CWS unchanged. Therefore, after removing the RTDS and replacing the I-156 harness, the ECWS became a "drop-in" replacement for the CWS.

The ECWS software monitors the EMU, taking measurements of 14 analog parameters and 10 discrete signals. This data is analyzed for problems with the EMU and how it is operating. The crewmember interacts with the ECWS through the Display and Control Module (DCM) and by tones heard in the CCA when significant events occur.

The ECWS provides output of both the raw IRCO<sub>2</sub> output as well as the pressure compensated value. The software checks to determine if pressure sensor data is reliable and performs sensor compensation if possible. The value on the DCM display is the compensated value unless compensation is not possible.

The ECWS also assists the crewmember in performing leak checks, which verify the EMU's pressure integrity.

The mission profile is tracked, which allows the software to identify whether the pressure sensor in the sublimator is reading ambient air pressure or sublimator pressure and customizes the anomaly messages. There are also state variables associated with performing a leak check, and Bends Treatment Adapter (BTA) usage.

The ECWS monitors consumables during the mission. It will report when critical limits are reached to allow the crewmember sufficient time to return. The consumables include:

- Primary oxygen – via pressure and usage rate
- Secondary oxygen – via pressure and usage rate
- Water (used for cooling) – a countdown if the reserve tanks are used
- Battery – by amp-hr consumption

There are serial data ports for sending the data being monitored to test equipment and to the EMU radio, which in turn relays it to the ground. The data sent to the ground is usually alternated with biomedical data.

### 2.1.7.1 DATA INPUTS

The ECWS monitors the following discrete inputs:

Discrete Inputs	Source	Open	Closed	Logic Level Seen at ECWS (Active-Closed)	Type
CWS Switch In	DCM	Normal	CWS IN	Low	Switch
CWS Switch OUT	DCM	Normal	CWS OUT	Low	Switch
PWR MODE BATT	DCM	SCU	BATT	Low	Opto
Vehicle PWR	DCM	Off	On	Low	Opto
Vent Flow Switch	PLSS	No Flow	Flow	Low	Switch
Fan Pump Switch	DCM	Off	On	Low	Opto
O2 Actuator Off/Press	DCM	True	False	High	Switch
O2 Actuator IV/Press	DCM	True	False	High	Switch
O2 Actuator EVA	PLSS	False	True	Low	Switch
BOOT	Test	Off	On	Low	Logic Level
TEST	Test	Off	On	Low	Logic Level
Feedwater Disc 1	DCM	Off	On	Low	Switch
Feedwater Disc 2	DCM	Off	On	Low	Switch

The ECWS monitors analog inputs and produces an output as listed below:

<b>Parameter</b>	<b>Source</b>	<b>Range</b>	<b>Accuracy</b>
H2O Gas Pressure	PLSS	0-40 psia	+/-1.0 psi
H2O Water Pressure	PLSS	0-40 psia	+/-1.0 psi
Primary O2 Pressure	PLSS	0-1100 psia	+/-27.5 psi
Suit Pressure	PLSS	0-6 psig	+/-0.15 psi
Sublimator Pressure / Ambient Pressure	PLSS	0-16 psia	+/-0.4 psi
Sublimator Temperature	PLSS	32- 126 °F	+/-1.5 °F
CO2 Level	PLSS	0.0 - 30.0 mmHg (at nominal pressure)	At 8psi cal. point: +/-1 for 0-10 mmHg +/-2 for 20-30 mmHg
Pressure Compensated CO2 Level	ECWS	0.0 – 30.0 mmHg	@EVA (4.3 psia): ~ ± 1.5 @ 8mmHg ~ ± 2.4 @ 12 mmHg
Secondary O2 Pressure	SOP	0-7400 psia	+/-259 psi
Battery Voltage	DCM	0-25 V	+/-0.6 V
Battery Current	DCM	0-10 amps	+/-0.3 amps
Spare 1	N/C		
Spare 2	N/C		
Ref 95%	ECWS	4.77 V	+/-0.1 V
Ref 5%	ECWS	0.227 V	+/-0.1 V
Positive V	ECWS	+14 V	+/-2 V
Negative V	ECWS	-14 V	+/-2 V

### 2.1.7.2 CREW INTERFACES

**The CWS Status/Proceed Switch-** The CWS switch is a three-position, momentary switch on the DCM. When not being activated by the crewmember the CWS switch returns to the central, inactive position. The crewmember can activate the switch to the CWS OUT position (also called “PRO”) and to the CWS IN position (also called “STATUS”).

The ECWS recognizes both long (longer than four seconds) and short (shorter than four seconds) activations of the CWS switch in both the IN and OUT positions.

A Short CWS OUT (“PRO”):

- Acknowledges a warble tone.
- Moves in the reverse direction through the status list and sub-lists.

A Short CWS IN (“STATUS”)

- Moves in the forward direction through the status list and sub-lists.

A LONG CWS OUT (“YES”)

- Answers YES to a question:  
“LEAK CHECK?”
- Acknowledges seeing a message.  
“NO VENT FLOW”
- Answers YES to enter a sub-list:  
“DATA? COMBO”  
“DATA? 26.6AH”  
“BTA? DISABLED”
- Answers YES to select an entry from a sub-list.
- Locks the currently displayed status list parameter.
- If the display is currently at the default display, a LONG CWS OUT will start the display of all active faults.

## A LONG CWS NO (“NO”)

- Answers NO to a question: “LEAK CHECK?” (returns to default message)
- Returns to the default display if displaying a status list parameter.
- Aborts a leak check when it is in progress. (Think of “NO, I don’t want to stay in the leak check.”)
- Aborts selecting from a sub-list and returns to the entry point for the sub-list. (Think of “NO, I don’t want to make a new selection.”)

LONG CWS IN and LONG CWS OUT switch activations are followed by a “key beep” when they are accepted to confirm them.

Activations of the CWS switch which are ignored are acknowledged by a “NAK tone” to inform the crewmember that the switch activation was noticed, but will not be acted on. Examples of this include: LONG CWS IN when at default message. Anything except a LONG CWS OUT to a message that must be acknowledged.

**Warble Tone-** The warble tone indicates a problem. The warble tone will continue until acknowledged with a SHORT CWS OUT switch activation or five minutes has elapsed, whichever comes first.

Warble tones are issued when there is a power restart and during the tones test of a cold start. These do not indicate a problem nor do they need to be acknowledged.

If there is BITE light issued by the watchdog indicating a software failure, the warble tone will terminate after four seconds and cannot be acknowledged.

**Continuous Tone Discrete-** The ECWS manages the continuous tone discrete to make several distinct sounds. They do not sound simultaneously, but may be sounded sequentially.

**Long Tone (status tone)-**The long tone, of approximately 5 seconds, indicates a leak check failure or that there is only 6 minutes of oxygen left, when on SOP.

**Short Tone (alert tone) -** The short tone, of approximately 0.2-second duration, indicates that attention or some action from the crewmember is required.

This includes:

- Various times during the leak check when the O2 Actuator must be moved, or when the leak check has been terminated early.
- When the default message changes (except when going to EVA state and display blanks).
- When the airlock pressure passes 6 PSI falling or 4 PSI rising.

**Key Beep Tone-** The key beep tone, of approximately 0.05-second duration, provides audible confirmation that a LONG CWS switch activation has been accepted.

**NAK Tone-** The NAK tone pattern (beep-beep) indicates a CWS switch activation that is not valid.

### 2.1.7.3 DATA OUTPUTS

**4800-Baud RS-232-** The 4800-baud RS-232 output from the ECWS is used primarily in tests to display and store data rapidly. At 4800-baud the serial data pipeline is kept full, and data is transmitted continuously. A record can be transmitted in 0.144 seconds (63 bytes of 11 bits each at 4800 bits / second) equal to about 7 records per second.

**RS-232 50-Baud-** The RS-232 50-baud channel is shared between serial data and EKG data. The ECWS has a relay that selects which will be transmitted. In normal operation there is a two-minute cycle. One serial data record is transmitted (which requires approximately 20 seconds including 6 seconds of synchronization time), and then the remainder of the cycle is used to transmit EKG data. The crewmember may select from the status menu to transmit normally (“COMBO”), all serial data (“EMU”) or all EKG data (“BIO”).

**RS-485 Port-** The RS-485 port is used for test and maintenance.

An instrument, such as a temperature sensor, may also be connected to the ECWS RS-485 port. The ECWS will request data from the instrument periodically, and this data will be transmitted in the normal serial data stream, and from one to three lines will be displayed on the DCM when at the correct position in the Status List.

#### 2.1.7.4 DISPLAY MESSAGES

**DCM Display-** The DCM display is a 12 character LCD with a backlight. It displays the messages generated by the ECWS as listed in the tables below.

The BITE light is a 13<sup>th</sup> character at the far right of the display that has all of its segments lit when it is active. Activation of the BITE light (other than during power restart) indicates that there is a significant problem with the ECWS, and correct reporting of system anomalies cannot be assured. Once the BITE light has been activated, it will not be turned off until the next power restart.

The BITE light is turned on during power restart as a self-test. During normal operations the BITE light may be turned on by the watchdog electronics if the software fails to service it correctly. The software may turn the BITE light on if it detects a problem.

**POWER-RESTART AND TESTS**

<b><u>Message #</u></b>	<b><u>Display</u></b>
001	PWR RESTART VERS **. * --OR-- PWR RESTART VERS **. * B
002	Same (for warm restart only)
	BOOT V **. *
004	PWR RESTART VERS **. * T
010	CONT TONE
011	WARBL TONE
012	DISP TEST
013	Display test patterns
na	@ABDHP?

**DEFAULT MESSAGES**

If no other message is active, a default message will be displayed.

<b><u>Message #</u></b>	<b><u>Display</u></b>
099	Same
101	BTA ENABLED
102	SOP O2 ON TIME LF##'## SUIT P *. *
103	O2 LF ###% TIME LF##'##
104	PWR LF ###% TIME LF##'##
105	RESRV H2O ON TIME LF##'##
106	Same
107	Same
108	BATT DECAY BAT VDC **. *

When the default message changes a **SHORT TONE** is sounded to notify the crewmember that something has changed.

## **ANOMALY MESSAGES**

When the ECWS detects an anomaly condition, it activates the warble tone and displays the associated warning message. The crewmember must acknowledge the message with a **SHORT CWS OUT** switch activation. If there is another active anomaly message it will then be displayed with another warble tone. The final acknowledged anomaly message remains on the display for 20 seconds before returning to the default display.

From the default message, a crewmember may display a list of all the active faults via the fault roll-call. The first display will be the number of faults that are currently active, or "**NO FAULTS**". If there are no faults, the display will immediately return to the default display. Each active fault will display for 4 seconds times the number of lines in the message, and will then advance to the next fault in the list. When all active faults have been displayed, the message "**END FAULTS**" will be displayed. The fault roll call may be interrupted with a **LONG CWS IN** switch activation.

## ANOMALY MESSAGES

<u>Display ID</u>	<u>Message</u>	<u>Conditions</u>	<u>EMU State</u>
178	5V REF FAIL	The 5% and/or 95% reference is outside acceptable limits. 95% limits = 4.77 V +/- 0.10 Volts (4.67 to 4.87 Volts) 5% limits – 0.227V +/- 0.01 Volts (0.217 to 0.237 Volts) BITE Light is activated and remains activated	All
140	** FAULTS	Number of faults, NO for zero. The 'S' is not present if 1 fault present. Automatically cycle into Fault List if faults are present. Switch actuations have no effect.	All
141	END FAULTS	Displayed after all faults are roll called.	All
150 to 32	BATT AMPS HI BAT AMPS *.*	Battery Current is > 5.0 [4.8] amps for > 5 seconds	All
151 to 31	BATT VDC LOW BAT VDC *.*	Battery voltage is < 16.5 ± 0.2 * <b>And either</b> Current is < 5.0 [4.8] <b>or</b> Current is > 5.0 [4.8] amps for ≤ 5 Seconds *Value as of 9/2007	All
152 to 26	SUIT P LOW SUIT P *.*	Suit pressure is < 4.05 [4.10] psid <b>and</b> Suit pressure is > 3.20 [3.10] psid <b>and</b> Oxygen actuator position is EVA <b>and</b> SOP pressure decreasing < 24 [36] psid/min	All
153 to 26	SUIT P LOW SET O2 EVA SUIT P *.*	Absolute suit pressure is < 4.05 [4.10] psia <b>and</b> Oxygen actuator position is not EVA	1,2,4,6,7,8
154 to 26	SUIT P EMERG CLOSE PURG V SUIT P *.*	Suit pressure is ≤ 3.10 [3.20] psid <b>and</b> Oxygen actuator position is EVA	5,6,7,8

# REV M

<u>Display ID</u>	<u>Message</u>	<u>Conditions</u>	<u>EMU State</u>
102	SOP O2 ON TIME LRF'***' SUIT P *.*	Oxygen actuator position is EVA <b>And</b> (Suit Pressure < 4.05 [4.10] psid and SOP pressure is decreasing > 36 [24] psid/min) <b>Or</b> (Suit Pressure < 3.10 [3.20] psid <b>and</b> in XSTATES 1,2 or 4) See 6.8.8 Limiting Consumable for explanation	As specified in Shall Criteria
155 to 26	SUIT P LOW REPRES AIRLK SUIT P *.*	Suit pressure < 4.05 [4.10] psid <b>and</b> Oxygen actuator position is not EVA	5
156 to 27	RLF V FAIL STOP DEPRESS SUIT P *.*	Suit pressure is > 5.7 psid <b>or</b> Suit pressure was >5.7 psid since cold start	1,2,4,5,6,7,8
157 to 26	SUIT P HIGH O2 RATE *.* SOP RATE ****	[Suit pressure is > 5.10 [5.05] psid <b>and</b> EMU State has been 7 (<10 minutes)] <b>Or</b> Suit pressure is > 4.55 [4.50] psid <b>and</b> (EMU state has been 7 for > 10 minutes <b>or</b> EMU state has been 1/2 for > 30 seconds <b>or</b> EMU State is 8)	1,2,7,8 and text
158 to 27	O2 USE HIGH O2 RATE *.*	Vehicle power is not available (SCU disconnected) <b>and</b> Primary oxygen use rate > 10.2 [7.0] psig/ min <b>or</b> <b>Both</b> Primary oxygen tank pressure is < 150 [160] psig <b>and</b> Time EVA < 5 hours	1,2,3,4,5,6,7
159 to 29	SOP P LOW SOP P **** SOP RATE ****	Message 102 is not the default message <b>And</b> SOP is off <b>And</b> SOP pressure has dropped > 600 [500] psid since start of the mission <b>Or</b> SOP pressure < 4500 [4700] psid	All

# REV M

<u>Display ID</u>	<u>Message</u>	<u>Conditions</u>	<u>EMU State</u>
108 to 31	BATT V DECAY BAT VDC **.*	Batt V < 17.5 ± 0.2 * <b>And</b> Power Mode Switch position is BATTERY *Value as of 9/2007	All
160	SW/FAN FAIL	Fan/ pump switch position has been ON for > 7 seconds <b>and</b> Fan/pump RPM is < 11,000 RPM <b>Or</b> Fan/ pump switch position has been OFF for > 7 seconds <b>and</b> Fan/pump RPM is > 11,000 RPM	All
161 to 33	NO VENT FLOW SET O2 EVA	<b><u>No Vent Flow Detected:</u></b> SOP is off <b>and</b> Primary oxygen use rate is < 24.0 psid/ min <b>and</b> Fan/pump switch position is ON <b>and</b> Vent flow switch indicates NO FLOW <b>and</b> More than 7 seconds have elapsed since the fan or vent switch last changed  <b><u>Should prompt for O2 EVA:</u></b> EMU State is 6 7 <b>and</b> Oxygen actuator position is not EVA	See Text
162 to 33	NO VENT FLOW	<b>“No Vent Flow Detected”</b> condition from message 161 <b>and</b> <b>NOT “Should prompt for O2 EVA”</b> condition from message 161	See Text
163	FAN SW OFF	SOP is off <b>and</b> Primary oxygen use rate is < 24.0 psid/ min <b>and</b> Fan/ pump switch position is OFF <b>And</b> Suit pressure is > 0.25 psig <b>and</b> More than 7 seconds have elapsed since the fan or vent switch last changed. <b>And</b> EMU State is 2 3 4 5 6 7 8	See Text

<u>Display ID</u>	<u>Message</u>	<u>Conditions</u>	<u>EMU State</u>
164 to 33	VENT SW FAIL	SOP is off <b>and</b> Primary oxygen use rate is < 24.0 psid/ min <b>and</b> Fan/ pump switch position is OFF <b>and</b> Vent Flow switch indicates flow <b>and</b> more than 7 seconds have elapsed since the fan or vent switch last changed <b>and</b> message 160 not active	All
165 to 34	CO2 SNSR BAD	Sensor voltage below 0.3V after it has warmed up for 30 seconds <b>or</b> Uncompensated CO2 partial pressure is > 25 mmHg <b>and</b> Uncompensated CO2 partial pressure has increased from 5 to 25 mmHg in less than two minutes as measured at the output of the filter, this indicates an actual sensor head increase within a second (failed sensor). Messages 166, 167 and 176 will be disabled.	All
166 to 34	CO2 HIGH SET O2 EVA	O2 Actuator is NOT EVA <b>and</b> CO2 Sensor OK <b>and</b> CO2 > 12.4 [11.9] mm Hg if compensation possible <b>or</b> CO2 > 8.0 [7.5] mm Hg if compensation not possible	6, 7
167 to 34	CO2 HIGH OPEN PURGE V	Same CO2 levels as message 166 <b>and</b> CO2 Sensor OK <b>and</b> O2 Actuator IS EVA <b>and</b> EMU State 6/7	See Text
168	SET O2 EVA	Oxygen actuator position is not EVA <b>and</b> message 153 is not active	5,6,7
169	SET O2 PRESS AIRLK REPRES	SOP is off <b>and</b> <b>Either</b> Oxygen actuator position is EVA <b>or</b> <b>Both</b> Oxygen actuator position is not PRESS <b>and</b> Airlock pressure is < 4.0 [4.2] psia	8
170	O2 ACT FAULT	If the O2 actuator discrete inputs are all high <b>or</b> all low together for > 30 seconds	All

<u>Display ID</u>	<u>Message</u>	<u>Conditions</u>	<u>EMU State</u>
171 to 21	SUBLM P *.* SET H2O OFF	Sublimator feedwater switch is ON <b>and</b> <b>Either</b> Sublimator pressure > 5.3 [5.1] psia <b>or</b> Sublimator pressure < 1.5 [1.7] psia <b>and</b> Conditions exist for > 15 seconds	7
172 to 36	H2O GP LOW	Oxygen actuator position is not OFF <b>and</b> Relative reservoir gas pressure < 13.5 [14.0] psid <b>and</b> Conditions exist for > 25 seconds	2,3,4,5,6,7
173	H2O IS OFF	Sublimator feedwater switch is OFF <b>and</b> Vehicle power is not available (SCU disconnected)	7
174 to 21	SET H2O OFF	Sublimator feedwater switch is ON <b>and</b> EMU State is not 7 <b>and</b> airlock pressure > 0.3 psia <b>or</b> EMU State has been 7 for more than 2 minutes <b>and</b> Vehicle power has been available for more than 10 minutes	All
175 to 37	H2O WP HIGH H2O WP *.* *	Water Pressure is greater than 17.0 psi relative to airlock pressure. Indicating a spike during water charge or that the sensor has failed high. The airlock pressure must be known, so the sublimator feedwater switch must be OFF except in EMU State 7.	1, 7
176 to 34	MONITOR CO2 CO2 *.* * MM	CO2 Between 8.0 [7.5] mm Hg and Limit of message 166 if compsn possible <b>or</b> CO2 between 3.0 [2.7] mm Hg and Limit of message 166 if compsn not possible <b>and</b> CO2 Sensor OK	All
177	14V SUP FAIL	The +/- 14 Volt Supply is outside acceptable limits. + 14 volt limits = + 12 to +16 - 14 volt limits = -12 to -16 Bite Light is activated and remains activated.	All
179	SCU PWR AVAL	Vehicle power has been available for last minute <b>and</b> Power mode switch position is BATTERY	All

<u>Display ID</u>	<u>Message</u>	<u>Conditions</u>	<u>EMU State</u>
103	O2 LF ***% TIME LF ***'	Oxygen is the limiting consumable <b>and</b> time left on Oxygen is $\leq 30$ [33] minutes <b>and</b> vehicle power is not available.	All
104	PWR LF ***% TIME LF ***'	Power Mode Switch Position is BATTERY <b>and</b> battery is the limiting consumable <b>and</b> vehicle power is not available <b>and</b> time left on battery is $\leq 30$ [33] minutes.	All
105	RESRV H2O ON TIME LF ***'	Water is the limiting consumable <b>and</b> Gas pressure is $> 2.1$ psid above water pressure <b>and</b> vehicle power is not available.	All
180	DRAM FAIL	Dynamic RAM test has failed BITE Light is activated and remains activated	All
181	EE CSUM FAIL	EE CheckSum has failed BITE Light is activated and remains activated.	All
182	BUS CK FAIL	Bus Check has failed BITE Light is activated and remains activated.	All
183	BOO CSUM BAD	BOOT page checksum has failed BITE Light is NOT activated (since does not affect flight mode)	All
184	WAT DOG FAIL	WATCH DOG not ready in required time. BITE Light is activated and remains activated	All
185	FW ANOMOLY	Feedwater discretes are in disagreement for longer than 5 seconds.	All
240	O2 IS OFF	O2 Actuator position is OFF for $\geq 5$ seconds <b>and</b> <b>Either</b> EMU State is 2 <b>or</b> EMU State is 4 <b>or</b> <b>All of the following:</b> EMU State is 8 <b>and</b> message 169 is not active <b>and</b> airlock pressure is $> 4.0$ [3.8] psia <b>and</b> Airlock pressure is $< 7.3$ [7.5] psia	See Text

1. Absolute suit pressure is the gauge suit pressure during EVA and is the sum of gauge suit pressure and the ambient pressure otherwise.
2. Relative gas pressure is equal to the absolute gas pressure during EVA and equal to the absolute gas pressure minus the absolute ambient pressure otherwise.

### **2.1.7.5 EMU MISSION PROFILE**

The ECWS determines the current state of the EMU. These states correspond to the stages or phases of an EMU mission. As an EVA progresses, the EMU transitions from one state to another. These states determine the fault detection logic to be executed and the limits to be used. For example, the ECWS customizes some anomaly messages by reading sublimator pressure and its rate of change, and ECWS software uses that information to distinguish between ambient air pressure in the airlock and vacuum. States associated with performing leakage checks and Bends Treatment Adapter (BTA) operations also exist.

The state transition diagram in the EMU State Transition Logic table below shows the conditions required to change from one EMU state to another. The rows of the table represent the current state. The columns represent the new state. Each row contains a set of letters in one or more columns indicating the state transition conditions. These letters refer to the conditions listed in EMU State Transition Conditions table. If any condition is satisfied, the ECWS transitions to the new state as indicated by the column containing the letter.

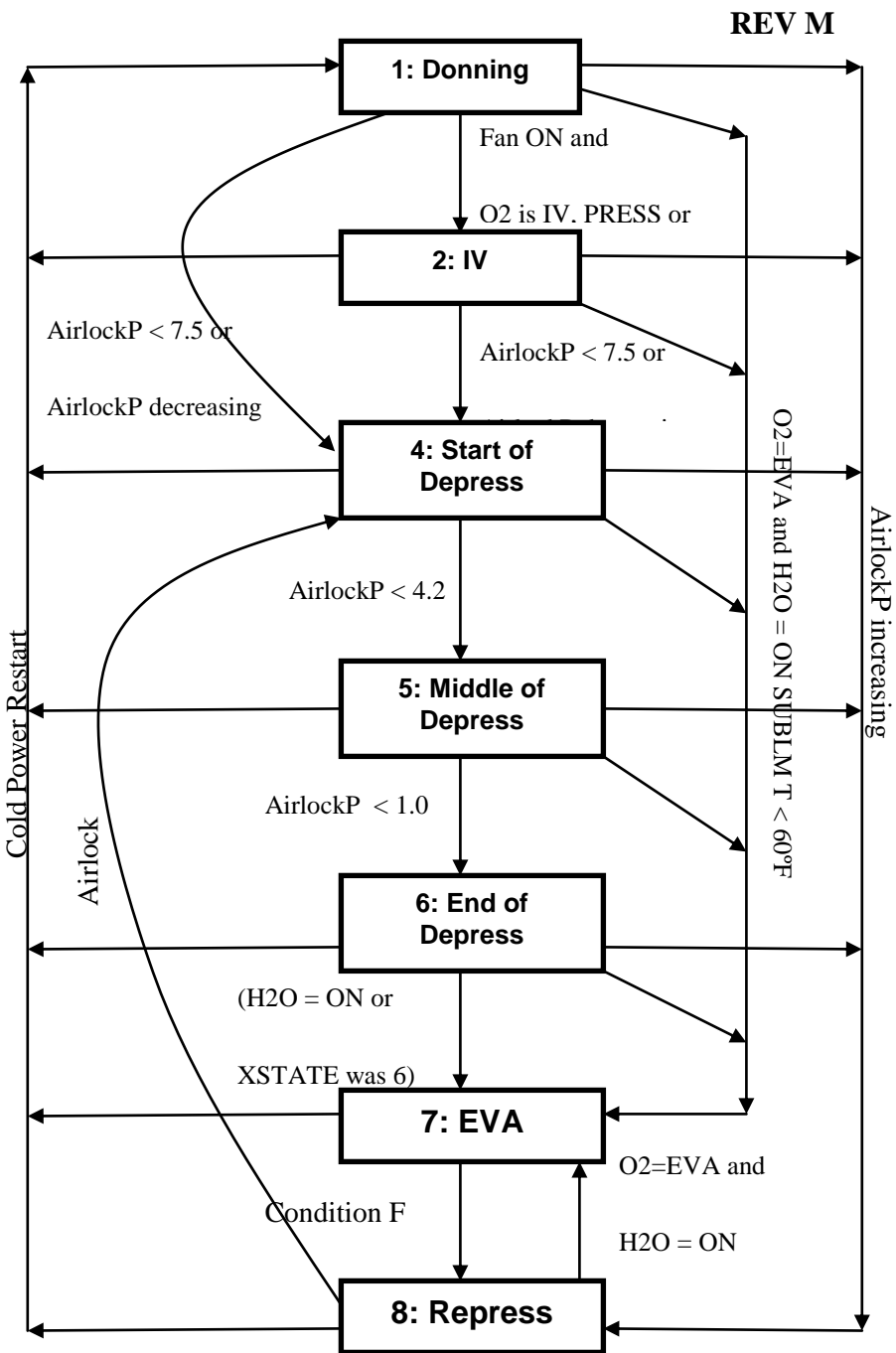
For multiple letters in a column, the required logical operations are performed and satisfied for a state transition. The state transitions continue to occur until no transition conditions for the current state are satisfied. The transitions to State 1 (Donning), are all based on transition Z, a COLD START.

## EMU STATE TRANSITION LOGIC

Current State	New State							
	1 Donning	2 IV	3 BTA	4 Begin	5 Mid	6 End	7 EVA	8 Repress
1 Donning	*	A	J	B G			H	I
2 IV	Z	*	J	B G			H	I
3 BTA	Z K	K	*	B G				K
4 Begin	Z			*	C		H	I
5 Mid	Z				*	D	H	I
6 End	Z					*	E H	I
7 EVA	Z						*	F
8 Repress	Z		J	G			H	*

## EMU STATE TRANSITION CONDITIONS

<u>Condition *:</u>	Default condition if no other conditions apply
<u>Condition A:</u>	Fan/pump switch position is ON and oxygen actuator position is IV, PRESS, or EVA
<u>Condition B:</u>	Airlock pressure < 7.5 psia
<u>Condition C:</u>	Airlock pressure < 4.2 psia
<u>Condition D:</u>	Airlock pressure < 1.0 psia
<u>Condition E:</u>	Sublimator feedwater switch is ON <b>or</b> EMU state is 6 for four minutes.
<u>Condition F:</u>	Sublimator feedwater switch position is OFF <b>and</b> <b>Either</b> Oxygen actuator position is not EVA <b>or</b> Airlock pressure > 1.45 psia after being below 1.0 psia in EMU State 7 with the sublimator feedwater switch off.
<u>Condition G:</u>	Airlock pressure is decreasing, which is defined as either of the following conditions: <ol style="list-style-type: none"> <li>1. A slow but significant decrease in pressure. [Where the pressure has decreased more than 0.5 PSI since pressure was considered ("STABLE").]</li> <li>2. A rapid decrease in pressure. (Where the rate of pressure is greater than 0.12 PSI per 10 seconds.)</li> </ol>
<u>Condition H:</u>	Oxygen actuator position is EVA <b>and</b> Sublimator feedwater switch position is ON and Temperature is less than 60 degrees F.
<u>Condition I:</u>	Airlock pressure is increasing, which is defined as either of the following conditions: <ol style="list-style-type: none"> <li>1. A slow but significant increase in pressure. [Where the pressure has decreased more than 0.5 PSI since pressure was considered ("STABLE").]</li> <li>2. A rapid increase in pressure. (Where the rate of pressure is greater than 0.12 PSI per 10 seconds.)</li> </ol>
<u>Condition J:</u>	BTA MODE is selected in status list
<u>Condition K:</u>	BTA MODE is de-selected in status list <b>or</b> Oxygen actuator position is EVA Exiting BTA returns to the same XSTATE from which BTA was entered.
<u>Condition Z:</u>	The ECWS shall be initialized when a Cold Start takes place. The following conditions define a Cold Start scenario:  A Power Restart (transition from SCU to BATT or BATT to SCU except if in test mode) has occurred <b>and</b> any of the following conditions is satisfied. <ol style="list-style-type: none"> <li>1. The previous X-State is 1</li> <li>2. The fan is off and the O<sub>2</sub> actuator is off.</li> <li>3. The RAM saved information is corrupt.</li> </ol>



**FIGURE 2.1.14**

**XSTATE TRANSITION DIAGRAM  
(Except BTA State)**

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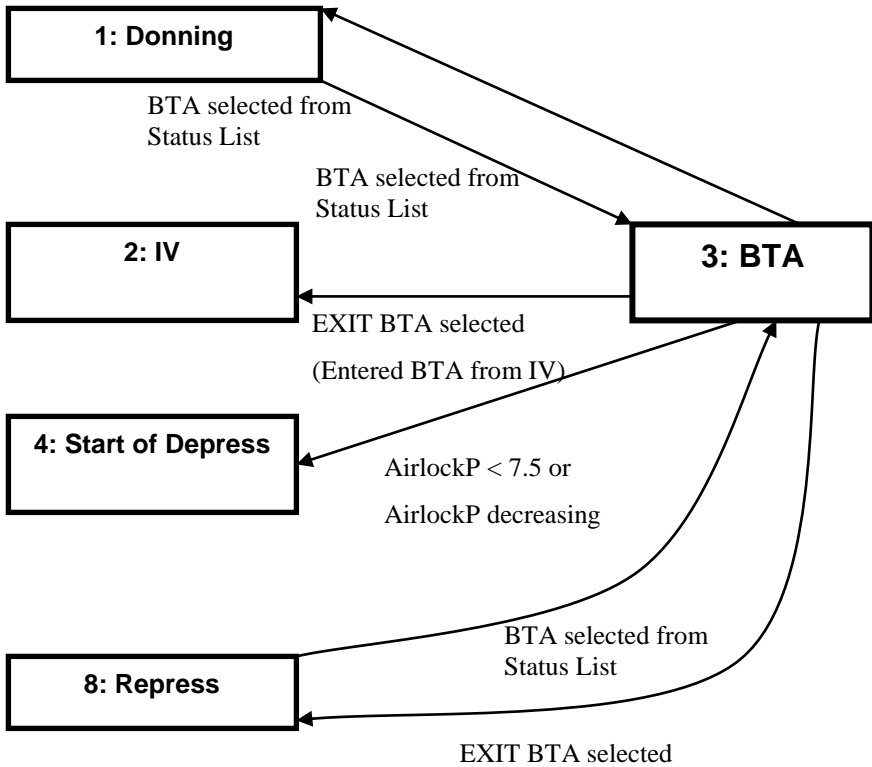


FIGURE 2.1.15

X-STATE TRANSITION DIAGRAM  
(Only BTA Transitions)

### 2.1.7.6 CALCULATED PARAMETERS

The ECWS calculates the following parameters and determines which of the four consumables will be exhausted first, thus limiting the length of the EVA:

- Primary Oxygen Use Rate
- Secondary Oxygen Use Rate
- \*Time Left on Primary Oxygen
- \*Time Left on SOP
- \*Time Left on Battery
- \*Time Left on Water

\* Limiting consumable resources:

### 2.1.7.7 LEAK CHECK

A leak check ensures the pressure integrity of the EMU. During a leak check, the suit is pressurized, and then the pressure supply is turned off. If the suit maintains its pressure, then the leak check passes. The leak check may be exited before it is complete by moving the O2 actuator out of its required position, or by a LONG CWS IN ("NO").

**Leak Check Question-** Moving to the display "LEAK CHECK?" on the DCM, and then doing a LONG CWS OUT, starts a leak check. A leak check may only be run while there is adequate pressure in the airlock to support life. If the pressure is too low, then "LEAK CHECK?" will not appear.

**Pressurizing-** If the suit pressure is less than 4.1 PSIG, the crewmember is prompted "SET O2 PRESS" with a SHORT TONE. The display changes to "SUIT P #.# / PRESSURIZING" until the required pressure is exceeded. If the pressure is not achieved within 30 seconds, the leak check exits with the message "PRESS FAIL".

**Set O2 IV-** When there is adequate pressure, the message changes to “SET O2 IV” with a SHORT TONE. In this position no further pressure will be added to the suit, and the wait has begun. The length of the wait is 2.5 minutes for an unmanned leak check (XSTATE=1, DONNING AND STOWAGE) and 1.5 minutes for a manned leak check.

**Leak Check Wait-** The display changes to “LEAK CK-WAIT / MIN LF '##' ## / SUIT P #.#”. For the first 30 seconds of the wait, the pressure is allowed to stabilize. Then the base pressure reading is taken. The wait continues until either the time completes or an unacceptable pressure drop ( $>0.3$  PSI) is detected.

**Leak Check Completion-** Leak check completes with one of the following possible messages:

PRESS FAIL / SUIT P #.#

(could not get adequate pressure in the suit to begin test)

LEAKAGE HI / SUIT P #.#

(too much pressure was lost)

LEAK CK COMP / O2 POS IV

(test passed, and there is  $> 7$  PSI in the airlock)

LEAK CK COMP / SET O2 EVA

(test passed, and there is  $\leq 7$  PSI in the airlock.)

The display returns to the “LEAK CHECK?” question when a leak check is completed or aborted (by moving the O2 actuator to an unexpected position or holding the CWS switch in the IN position).

# **SECTION 2.2**

## **SECONDARY OXYGEN PACK (SOP)**

## 2.2 SECONDARY OXYGEN PACK (SOP)

The Secondary Oxygen Pack (Item 200), shown in Figure 2.2.1, provides suit ventilation loop backup pressure regulation and emergency open loop purge for 30 minutes. The SOP delivers oxygen at 3.33 to 3.9 psid, and the flow rate is sufficient to limit maximum inspired CO<sub>2</sub> pressure to 7.6 mmHg at a metabolic work rate of 1000 Btu/hr.

The SOP contains two oxygen bottles (Item 210), which contain a minimum of 2.631 lbs of oxygen. A tube brazed to the internal wall of each bottle causes the gas to circulate around the interior of the bottle prior to exiting thus heating the usable gas and preventing condensation during expansions in the regulator manifold assembly.

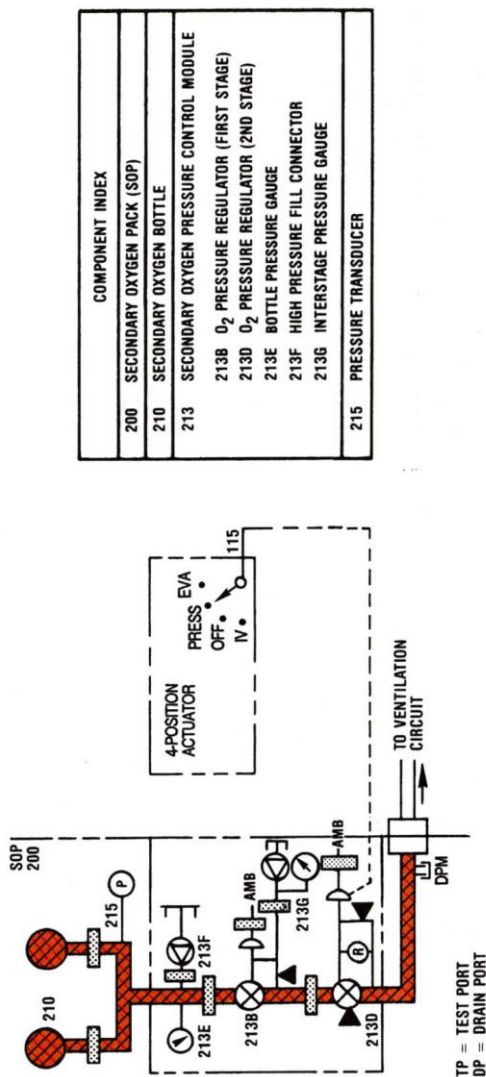
The SOP Regulator manifold assembly contains a two-stage regulator, two dial-type pressure gages (Item 213E and Item 213G), a pressure transducer (Item 215), and an oxygen fill connector (Item 213F) for servicing the SOP through Ground Servicing Equipment (GSE) only and an interstage test port.

Both the Item 213E pressure gage and the Item 215 pressure transducer indicate SOP bottle pressure.

The Interstage Pressure Gage (Item 213G) detects a failed open or excessive leading First Stage Regulator (Item 213B) during Pre-EVA SOP checkout.

The First-Stage Regulator (Item 213B) reduces a nominal supply pressure of  $6000 \pm 200$  psig to an interstage pressure of 160 to 280 psig. The Second-Stage Regulator (Item 213D) further reduces the interstage pressure to maintain the ventilation loop at 3.33 to 3.62 psid over a flow range of 4.51 to 5.26 lb/hr, 3.33 to 3.9 psid over 1.01 to 4.5 lb/hr, and 3.4 to 3.9 psid over 0.06 to 1.00 lb/hr.

# FIGURE 2.2.1 SECONDARY OXYGEN PACK



The Second-Stage Regulator (Item 213D) also acts as the shut-off valve for this system. The second-stage regulator is disengaged when the PLSS O<sub>2</sub> actuator is in the OFF, IV and PRESS positions. When the O<sub>2</sub> actuator is placed in the EVA position, the second-stage regulator is engaged and oxygen is allowed to flow as demanded. The second-stage regulator also has a manual override that provides for crewmember checkout of the SOP before donning the EMU.

If the second-stage regulator fails open, the outlet of the regulator acts as a flow-limiting orifice, limiting flow to 7.49 lb/hr, allowing the Suit Relief Valve (Item 146) to maintain suit pressure. The second-stage regulator is designed to regulate suit pressure from 3.33 to 3.9 psid with an upstream pressure equal to full tank pressure, protecting against a failed open or excessively leaking first-stage regulator. A GSE test port is located between the two regulators for checkout of regulator operation.

When the PLSS O<sub>2</sub> actuator is in the EVA position, the SOP makeup mode of operation is automatically initiated to maintain suit loop pressure above 3.33 psid if the primary oxygen circuit fails. Initiation of the makeup mode requires no action by the crewmember. The DCM purge mode is used when the PLSS fails to remove CO<sub>2</sub>, heat, or humidity from the system and is initiated by the crewmember manually opening the DCM Purge Valve (Item 314). In this mode, suit pressure is controlled to 3.33-to-3.62 psid, and a maximum oxygen flow of 5.01 lb/hr is delivered from the SOP through the Helmet (Item 105A), over the body, and then overboard via the purge valve to remove CO<sub>2</sub>, heat and humidity for a minimum of 30 minutes. A backflow check valve (Item 121) in the PLSS ventilation duct helps direct all flow to the helmet.

A second purge mode can be initiated by the crewmember opening the Helmet Purge Valve (Item 105B) on the helmet. The two purge modes are to be used independently and not at the same time. Suit

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pressure is controlled from 3.33 to 3.9 psid and a flow of 2.5 lb/hr is delivered through the helmet. Flow in this mode is into the helmet through the vent pad, over and around the crewmember's head, and then out through the helmet purge valve; no body cooling is provided. At no time should both purge valves be allowed to dump oxygen overboard because the suit pressure would decay, due to the limited oxygen flow rate, and the oxygen would be exhausted in much less than the required 30 minutes.

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# **SECTION 2.3**

## **DISPLAY AND CONTROLS MODULE (DCM)**

## **2.3 DISPLAY AND CONTROLS MODULE (DCM)**

The DCM (Item 300) provides the operating controls and vehicle interfaces with the EMU. The DCM is mounted to the front of the HUT via a flange mount. The DCM consists of two separable components, the O<sub>2</sub>/H<sub>2</sub>O Manifold Assembly (Item 385) and an Electronics Assembly (Item 350).

### **2.3.1 O<sub>2</sub>/H<sub>2</sub>O MANIFOLD ASSEMBLY**

The O<sub>2</sub>/H<sub>2</sub>O Manifold Assembly is a brazed assembly of water and oxygen carrying tubes. The manifold houses the EMU pressure gauge, purge valve, cooling control valve, and DCM multiple connector. The pressure gauge allows continual visual indication of suit pressure. The normal operating range is 4.1 to 4.5 psid. The emergency range is 3.3 to 3.6 psid. The purge valve provides open loop ventilation of the space suit when vent flow or cooling capacity fails. The cooling control valve is a manually adjusted valve used by the crewmembers to achieve thermal comfort by controlling the temperature of the water entering the LCVG. The amount of chilled water returning from the sublimator and the amount of warm water bypassed from the sublimator can be varied to achieve the desired LCVG inlet temperature.

The multiple connector provides a vehicle interface for electrical power, oxygen and water lines via the SCU. The multiple connector contains self-sealing oxygen and water valves, as well as an electrical connector. The three water lines consist of a single line for water tank fill and drain, and two lines for cooling to the vehicle heat exchanger. The oxygen line is a high pressure fill line for the primary oxygen tanks. The electrical connector provides vehicle power to the EMU and battery recharge capability.

### 2.3.2 ELECTRONICS ASSEMBLY

The electronics assembly contains DC/DC converter circuitry, a 12 character alphanumeric display (LCD), an ECWS malfunction indicator (BITE), current limiting circuitry, and battery voltage and current sensing circuitry. Manual controls in the electronics assembly include the power mode switch, EVC mode selection switch, push-to-talk switch, CWS proceed/status switch, fan/CLIV switch, feedwater switch, radio volume controls, and alphanumeric display intensity control.

The DCM DC/DC converter operates on battery or vehicle power. Steady-state battery power is  $16.8 \pm 0.8$  VDC. Steady-state vehicle power is rated at  $18.5 \pm 0.5$  VDC. The DC/DC converter provides the following output voltages and currents to the EMU electronic components.

Secondary Voltage	Power
$5.6 \pm 0.1$ VDC at 100 mA	ECWS, DCM Logic Board
$+14.2 \pm 1.0$ VDC at 50 mA	ECWS, DCM Logic Board, I-122: IRCO2, I-215: SOP Transducer
$-14.2 \pm 1.0$ VDC at 25 mA	ECWS, DCM Logic Board, I-122: IRCO2, I-215: SOP Transducer
$3.8 \pm 0.5$ VDC at 200 mA	DCM Display Backlight

The converter provides an additional 18.0 VDC line which is not used. The electronics assembly is covered by a contoured, multi-layered thermal and micrometeoroid protection garment which covers all exterior areas except those containing controls or the display. The O<sub>2</sub> actuator/switch assembly is mounted on the bottom of the electronics assembly and connected by a short cable to the Shear Plate Assembly (Item 115).

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# **SECTION 2.4**

# **UMBILICALS**

### 2.4.1 ISS EMU UMBILICAL (IEU)

The ISS EMU Umbilical (Item 498) is an interface between the ISS Umbilical Interface Assembly (UIA) and the Extravehicular Mobility Unit (EMU). It provides electrical power and communication, water fill/drain, and water cooling capability from the International Space Station (ISS) for the EMU. The IEU consists of the following items: three water lines of which two are used for water cooling of the LCVG and one for feedwater charging and condensate draining of the PLSS, one oxygen line, one electrical harness assembly for power and communication, a tether restraint and the TMG. The Common Multiple Connector, Item 410, provides a single interface point for connecting and disconnecting the IEU from the DCM. An Umbilical Connector Manifold (UCM), which is government furnished equipment (GFE), provides a single IEU attachment point to the ISS UIA. The IEU provides recharge capability for the PLSS oxygen tank, water reservoir, and battery. In the event a decontamination EVA is needed, the umbilical is designed to withstand environments external to the Airlock.

The EMU umbilical terminates at each end with a ganged multiple connector that requires only a single operation to connect or disconnect the umbilical.

The outer layer of the IEU is a multi-layer Thermal Micrometeoroid Garment (TMG) to provide thermal insulation and protection from micrometeoroid impacts. The IEU includes a protective pouch that will provide thermal and impact protection for the IEU common multiple connector while disconnected from the EMU.

The Umbilical contains a strain relief strap which, during IV operations, attaches via a GFE tether hook to one of the Lower Torso Assembly (LTA) D-rings at the EMU end and to a separate tether ring on the Crew Lock (CL) wall. For EV operations, the hook is disengaged from the UIA panel ring and is secured to a D-ring near the UIA panel. In the event that an EVA decontamination bake out of the

EMU is required, this tethering scenario will serve to ensure that UIA design loads are not exceeded.

While not in service (i.e., when completely disconnected from the UIA and EMU), the umbilical is stowed in the equipment lock. While attached to the UIA, the umbilical is restrained against the CL wall by GFE provided restraint straps.

The useful life (combination of the operational life and shelf life) of the Umbilical is 15 years from the date of PDA. The dry weight of the Umbilical does not exceed 30 lbm. This weight includes all GFE provided hardware (2 tether hooks and the UCM).

#### **2.4.2 SERVICE AND COOLING UMBILICAL (SCU)**

The Service and Cooling Umbilical (Item 400) is an 11-ft umbilical consisting of three water hoses, a high-pressure oxygen hose, electrical harness, bacteria filter assembly, and a strain relief tether. The SCU supplies the PLSS with electrical power, communications, oxygen, waste water drainage and water cooling from the Orbiter during pre- and post-EVA operations. It also supplies the EMU with recharge of the oxygen tanks, water tanks, and battery.

The end of the SCU that connects into the airlock panel, otherwise known as the vehicle end of the SCU, consists of the four fluid ECLSS connections in addition to one electrical connector that attaches the SCU to the Orbiter airlock service panel AW82. The connections remain intact between flights and do not require crewmember operation. The vehicle waste water drain and potable water fill lines are connected to the bacteria filter housing located on the airlock wall. On both the drain side and the potable water fill side, a bacteria filter of iodine-impregnated epoxy resin spheres is incorporated, along with a particulate filter made of sintered stainless steel. These filters are used to prevent contamination from passing between the Orbiter ECLSS and the EMU. During normal IVA operations, the Orbiter Waste System is off

and there is no ability to dump excess condensate. Approximately one pound of water is drained from the EMU water tanks after filling to allow room for condensate while IVA.

The common connector on the EMU end of the SCU combines the four fluid connections and one electrical circuit connector into a single unit operated by the crewmember. Disengagement of the connector is accomplished by pulling out on the SCU connector cam T-handle to retract a locking pin and then rotating the cam handle from the "locked" position approximately 180° to a detent, which is the "open" position. This rotation of the SCU connector cam disengages two pins on the mating connector. Engagement of the connector is accomplished by rotating the SCU connector cam T-handle to the "open" position, engaging the two pins on the mating connector with the cam, and then rotating the cam handle from the "open" position approximately 180° to the "locked" position, where a cam locking pin is engaged.

The SCU is stowed on the airlock wall when it is not being used. The common connector (SCU side) is attached to a mating stowage connector on the EMU mount (AAP). The SCU is unstowed and connected to the DCM during EMU donning to provide vehicle consumables for the suited EVA preparation activities in the airlock until life support from the EMU is initiated. Nominally, the SCU is disconnected at an airlock pressure of zero psia during airlock depressurization prior to an EVA and reconnected at an airlock pressure of zero psia during airlock re-pressurization after an EVA. The life support from the SCU is maintained during the suited post-EVA activities until the start of EMU doffing. The SCU is also connected to the EMU to supply Orbiter consumables for recharge of the EMU oxygen, the water tanks, and the battery.

**SECTION 2.5**

**CONTAMINANT  
CONTROL  
CARTRIDGES  
(CCC)**

### **2.5.1 LiOH CONTAMINANT CONTROL CARTRIDGE (CCC)**

The CCC (Item 480) contains an activated charcoal bed for trace contaminant removal, a lithium hydroxide (LiOH) bed for CO<sub>2</sub> chemisorption and a particulate filter to trap solid particles and prevent migration of LiOH dust.

Ventilation flow enters the CCC through the inlet duct, passes through the activated charcoal bed, the LiOH bed, particulate filters, and then passes through the outlet duct. The CO<sub>2</sub> removal chemical reaction is exothermic and produces water vapor. The water vapor is condensed in the sublimator and removed from the vent loop by the slurper.

The CCC can be replaced in the EMU by an unassisted crewman without the use of tools in less than five minutes.

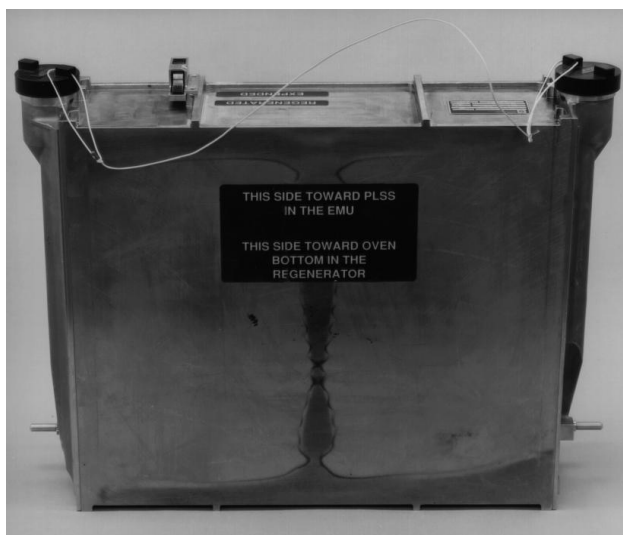
The LiOH CCC supports one EVA. After it is used, it is returned to earth and repacked with fresh LiOH and charcoal, and can then be returned to service.

### **2.5.2 METOX REGENERABLE CO<sub>2</sub> REMOVAL SYSTEM**

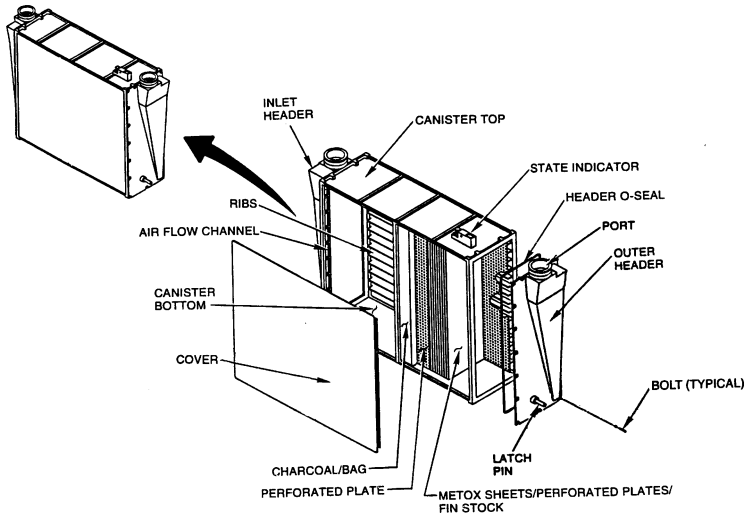
Metox is an on-orbit regenerable CO<sub>2</sub> removal system for use primarily with the EMU and for ISS Joint Airlock CO<sub>2</sub> removal. The nickname "Metox" reflects use of metal-oxide as the CO<sub>2</sub> sorbent material.

The Metox flight system consists of two assemblies, a metal oxide sorbent canister (Figures 2.5.2.1 and 2.5.2.2) and a regeneration assembly (Figure A.1). The regenerator assembly regenerates the canister by removing the absorbed CO<sub>2</sub> and trace contaminants. The regenerator is discussed in more detail in Appendix A.

## FIGURE 2.5.2.1 METOX CANISTER ASSEMBLY



G:\EMU MINIBOOK\METOX\SAE FIGURE 2

**FIGURE 2.5.2.2 METOX CANISTER ASSEMBLY  
EXPLODED VIEW**

G:\EMU MINIBOOK\METOX\SAE FIGURE 5

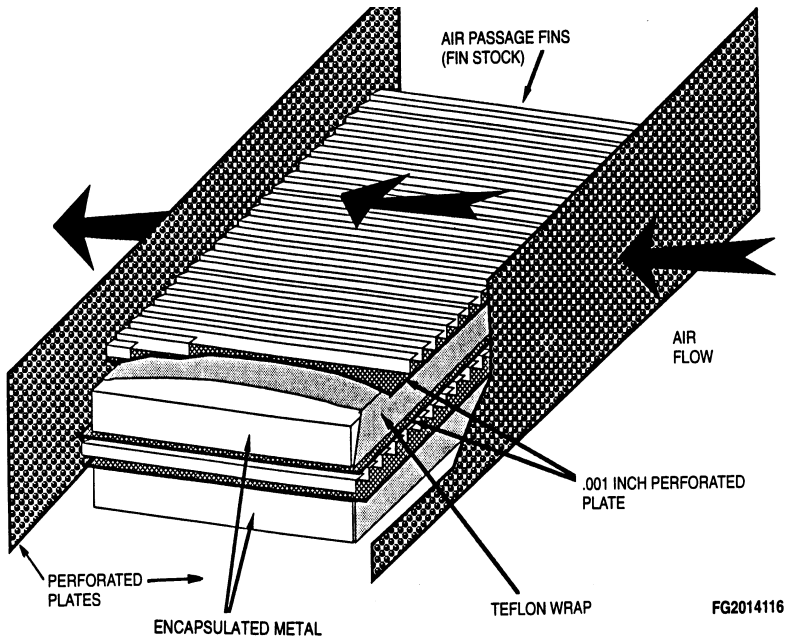
The canister removes metabolically produced CO<sub>2</sub> in the EMU during EVA and in the ISS Joint Airlock during pre-breathe activities. It also contains charcoal to remove trace contaminants from the EMU vent loop. After the EVA, the canister is removed from the EMU and placed in the Metox Regenerator. Regeneration is accomplished by flowing heated cabin air through the canister. The canister can then be reused in either the EMU or in the ISS Joint Airlock CO<sub>2</sub> removal subsystem for EVA prep and post activities. The canister can be installed in the EMU and the regenerator by a single crewmember in less than 3 minutes without the use of tools. The state indicator and labels prevent the canister from being installed into the EMU or regenerator in the incorrect orientation. The Metox canister is interchangeable with the LiOH Contaminant Control Cartridge (CCC).

### **2.5.2.1 CANISTER DESCRIPTION**

The metal oxide canister consists of metal oxide sheet assemblies, a charcoal bag containing activated charcoal and a container and cover panel with cast headers that are fastened to the container. The metal oxide sheet assembly is shown in Figure 2.5.2.3 and consists of an encapsulated metal oxide sorbent sheet, perforated plates, and air passage fins.

There are approximately 45 metal oxide sheets loaded into each side of the canister. After this is completed, a perforated plate is installed to separate the metal oxide from the charcoal. A charcoal bag is placed in the remaining volume in the canister and charcoal is loaded into the bag. Although dimensionally different, the charcoal and bag construction are the same as that used in the LiOH CCC. A wave spring is placed between the loaded charcoal bag and the headers. Similarly, a silicone compression pad is placed between the metal oxide and the header and is fastened to the container housing.

FIGURE 2.5.2.3 METOX SHEET ASSEMBLY



G:\EMU MINIBOOK\METOX\SAE Figures 1 & 2 Can Pictures

The container and cover panel are machined from 304L stainless steel. Ribs, which are machined into both the container and the cover panel, provide flow distribution on the inlet and outlet sides of the canister. Perforated plates are brazed to the ribs on the container and cover panel to separate the metal oxide sorbent sheets and activated charcoal from the flow distribution volume. A center support welded between the container and cover panel is added for rigidity. The metal oxide sorbent sheets and activated charcoal are loaded from both the inlet and outlet sides of the canister. The inlet and outlet sides of the container have machined-in flow paths and tapped holes for mounting the cast headers. The container also has a face seal o-ring groove for header-to-canister environmental sealing, and radial port seals for sealing in the EMU or regenerator.

The inlet and outlet headers are machined from a common cast mold. A slight difference in the header bolt pattern between the two prevents the headers from being installed incorrectly. A cast-in elongated boss is machined as necessary to provide the proper mounting pin location for installation into the EMU. A radial o-ring is provided at the inlet and outlet ports for sealing with the EMU or the regenerator. A 150-mesh filter is welded into the outlet header and serves as a particulate filter.

A state indicator is attached to the housing to indicate whether the canister has been regenerated or is expended. The state indicator consists of an indicator, a flat spring, a ball bearing, a spacer, pins and housing, and is located on the top of the canister. When the canister is installed in the EMU, the rocker is pushed against a support on the EMU and moves from one position (regenerated) to the other (expended). The location of the state indicator prevents the canister from being installed backwards in the EMU by contacting the unused LiOH water ports before the mounting pins can be installed in their latches. In the regenerator, a solenoid switches the rocker back to the regenerated position once the regeneration cycle is complete. An interference bracket is built into the oven

and contacts the state indicator to prevent the canister from being installed backwards in the oven.

The overall dimensions of the canister are 10 inches high, 13.46 inches wide, and 3.431 inches deep. The maximum weight in the regenerated state is 32 pounds. The canister external leakage shall not exceed 10 scc/hr when pressurized to 9.0 psig.

### **2.5.2.2 CANISTER OPERATION**

To remove CO<sub>2</sub>, between 6 and 7 cfm of moist, CO<sub>2</sub> laden O<sub>2</sub> or air is passed through the canister. The gas enters the left header and is distributed across the back cover plate. It first passes through the charcoal bed, where metabolically produced trace contaminants are removed. It then passes through the metal oxide bed, where CO<sub>2</sub> and some water vapor are removed. The CO<sub>2</sub>-free O<sub>2</sub> is then collected along the front wall and directed to the right header where it passes through the 150-micron particulate filter before exiting the canister.

The canister flow direction during the heating mode of the regeneration cycle is opposite the usage flow direction. (i.e., the flow enters the right header, is distributed across the front wall, passes through the metal oxide and charcoal beds, is collected on the back wall and exits through the left header). During the cooling mode of the regeneration cycle, all internal flow is stopped and cool air is directed over the outside surface of the canister. This is done to prevent cabin CO<sub>2</sub> from being re-absorbed by the canister during cooldown.

### **2.5.2.3 PERFORMANCE REQUIREMENTS**

During pre-EVA camp-out operation, the canister is required to remove 0.1 pph CO<sub>2</sub> for 12 hours (1.2 pounds total). The total required CO<sub>2</sub> removal capacity for EMU operation is 1.48 pounds. As part of that capacity, the

canister is required to support an eight-hour EVA at an average metabolic rate of 850 Btu/hr (equivalent to CO<sub>2</sub> generation rate of 0.17 pph). This represents a slight change from the LiOH CCC requirement of seven hours at 1000 Btu/hr. The change in EVA requirements is the result of Shuttle EVA experience.

For IVA, the canister is required to maintain the Joint Airlock CO<sub>2</sub> partial pressure at less than 7.6 mmHg. For EVA, the requirement is for a crewmember's inspired CO<sub>2</sub> partial pressure to be less than 7.6 mmHg for metabolic rates up to 1600 Btu/hr and below 15 mmHg for metabolic rates between 1600 and 2000 Btu/hr.

The beginning-of-life (BOL) and end-of-life (EOL) pressure drop requirements are 0.67 and 0.9 inches of water, respectively, at 7.2 CFM of O<sub>2</sub>, 4.1 psia and 72F (EVA conditions).

The canister operates for a minimum of 55 absorption/regeneration cycles.

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# **SECTION 2.6**

# **BATTERIES**

## 2.6 BATTERIES

The EMU Battery (Item 490) is the EVA electrical power source for the EMU. Each EMU uses one battery, which is mounted behind the main water tank and under the Contaminant Control Cartridge (CCC) in the PLSS. The battery can be replaced in the PLSS by an unassisted crewmember without the use of tools in less than five minutes. There are two versions of the battery: the 2000 Series Increased Capacity Battery (ICB) and the 3000 Series Long Life Battery (LLB).

The 2000 Series Battery is rechargeable for a minimum of 12 charge/discharge cycles over a wet life of 300 days. It consists of eleven, series connected, silver-zinc, high current density cells and provides a minimum of 26.6 ampere-hours over a seven-hour EVA mission at a nominal voltage of 16.8 volts.

The 3000 Series Battery is rechargeable for a minimum of 50 charge/discharge cycles over a certified life of 1825 days (5 years) at ambient temperature and <50% State of Charge with a minimum of 600 days at full charge. It consists of five series banks of sixteen parallel lithium ion electrochemical cells and provides a minimum of 26.6 ampere-hours over a seven-hour EVA mission over a voltage range of 20.6 to 17.5 volts. The 3000 Series Battery contains an external fuse holder should the fuse within require replacement and a dedicated service connector for use with the associated portable charger.

# **SECTION 2.7**

## **AIRLOCK ADAPTER PLATE (AAP)**

## 2.7 AIRLOCK ADAPTER PLATE (AAP)

The AAP (Item 470) is an aluminum structure consisting of tubing and mounting pads. It provides storage, stowage during launch and landing, and a mechanical interface with the EMU to the Shuttle airlock wall.

The AAP interfaces with the EMU by four pins that lock into fittings in the PLSS. Two pins are stationary at the top of the AAP and the two lower pins can be retracted or extended and locked by handles near the bottom of the AAP. The AAP also acts as a donning and doffing station for the crewmembers. When crewmembers return to the airlock after an EVA, they locate the AAP for doffing by backing into “ramps” at the bottom of the AAP and then by backing into the pinning position.

For storage of the EMU, a stowage bag is attached at the bottom of the AAP. The bag encompasses the EMU and attaches to the “D” rings near the top of the AAP.

# **SECTION 2.8**

## **BENDS TREATMENT ADAPTER (BTA)**

## 2.8 BENDS TREATMENT ADAPTER (BTA)

The BTA (Item 491) is an emergency device used while in orbit should an EVA crewmember contract decompression sickness. It permits the EMU to be used as a hyperbaric chamber (7.5 - 8.0 psi above I-146 relief pressure) for bends treatment.

In order to configure the EMU for bends treatment operation, a plug must be removed from the Item 120D allowing restricted flow to ambient, which results in the cyclic opening of the Item 120 Low Mode Relief Valve during BTA use. The Item 146 Relief Valve must be disabled by fixturing the valve poppet open using the Poppet Keeper Screw. The Poppet Keeper Screw is stored on the BTA housing. The BTA, containing a pressure gauge and an 8 psi relief valve, is then mounted over the Item 146.

The in-suit bends treatment procedure allows suit pressure to be maintained at 4.3 psid during configuration of the suit for bends treatment. Decompression sickness treatment is significantly improved by not depressurizing the suit and crewmember. However, the poppet keeper screw is not installed into the Item 146. Suit pressure can now be increased to and maintained at an elevated pressure by repeatedly dumping the 15 psig gas volume from behind the water tank bladders through the Item 120 Low Pressure Relief Valve into the suit. This is done by cycling the EMU O<sub>2</sub> actuator from "OFF" to "PRESS" to "OFF", etc.

During bends treatment operation, make-up oxygen, make-up water and electrical power are provided by the umbilical. When suit pressure exceeds maximum SUIT P sensor capability (6 psi), suit pressure can be monitored via the H<sub>2</sub>O GP sensor when the O<sub>2</sub> actuator is OFF. Ventilation flow for CO<sub>2</sub> washout from the oral-nasal area and water flow for cooling are provided by the PLSS fan/pump/separator operation. CO<sub>2</sub> removal is provided by the CCC.

## **SECTION 2.9**

# **EMU ELECTRICAL HARNESSES (EEH)**

## **2.9 EMU ELECTRICAL HARNESSSES (EEH)**

The EEH (Item 440) provides interconnecting wiring between the Communications Carrier Assembly (CCA), the Operational Bioinstrumentation System (OBS), and the PLSS via a pass-through connector on the HUT. The OBS wiring is also referred to as ECG wiring.

The EEH is secured to the HUT interior so as not to interfere with donning and doffing operations.

The EEH has four branches. The added branch, called the expansion leg, is a scar to provide EMU power to future in-suit electrical instrumentation. This branch and the CCA and OBS branches are equipped with LEMO electrical connectors.

# **SECTION 2.10**

## **SECONDARY OXYGEN PACK CHECKOUT FIXTURE (SCOF)**

## **2.10 SECONDARY OXYGEN PACK CHECKOUT FIXTURE (SCOF)**

The SCOF (Item 495) is locker-stowed flight support equipment. It is used during SOP checkout, fan checkout and water recharge. It is opened on orbit using the BTA Keeper. The Item 495 has functionally replaced the Item 145 relief valve.

It is mounted to the hard upper torso neck ring and provides PLSS and HUT overpressure protection in the event of a SOP Item 213D failure or a primary O<sub>2</sub> circuit Item 113D failure during checkout.

The SCOF consists of a relief valve/fixture assembly that mounts into the neck ring disconnect (in place of the helmet) on the HUT and seals over the vent outlet duct.

**SECTION 2.11**

**EMU SYSTEM LEVEL  
ON-ORBIT  
REPLACEABLE UNITS  
(ORU)**

## **2.11 EMU SYSTEM LEVEL ON-ORBIT REPLACEABLE UNITS (ORU)**

The EMU can be separated into four major On-Orbit Replaceable Unit (ORU) systems. The ORU systems include the Primary Life Support Subsystem (PLSS), Secondary Oxygen Pack (SOP), Display and Controls Module (DCM), and the Hard Upper Torso (HUT). Separation of these components can be accomplished by an unassisted crewmember while on-orbit without the use of special tools. The EMU ORU capability applies exclusively to International Space Station (ISS) usage.

The ORU components are 100% interchangeable. In the event of a failure, the failed ORU will be replaced with a functional ORU from a spare EMU, and the failed ORU will be identified and reassembled to the spare EMU for stowage. EMU ORU maintenance shall be performed with the battery removed and primary O<sub>2</sub> bottles unpressurized (SOP remains pressurized).

All interfaces utilize captive fasteners, one-way installation, provide self-alignment features and visual feedback of proper installation. These ORU interface features do not require on-orbit maintenance.

### **2.11.1 PRIMARY LIFE SUPPORT SUBSYSTEM ORU**

The PLSS is separable from the EMU and changeout can be performed by an unassisted crewmember without the use of special tools on-orbit (Figure 2.11.1).

The ORU PLSS configuration includes:

- A break point is included in the Item 151/152 harness, and a harness bracket fastens the harnesses to the PLSS water tank structure (Figure 2.11.2). The Item 151/152 design incorporates a metal backshell and halar overbraid (Figure 2.11.3).

FIGURE 2.11.1 ORU PLSS COMPONENTS

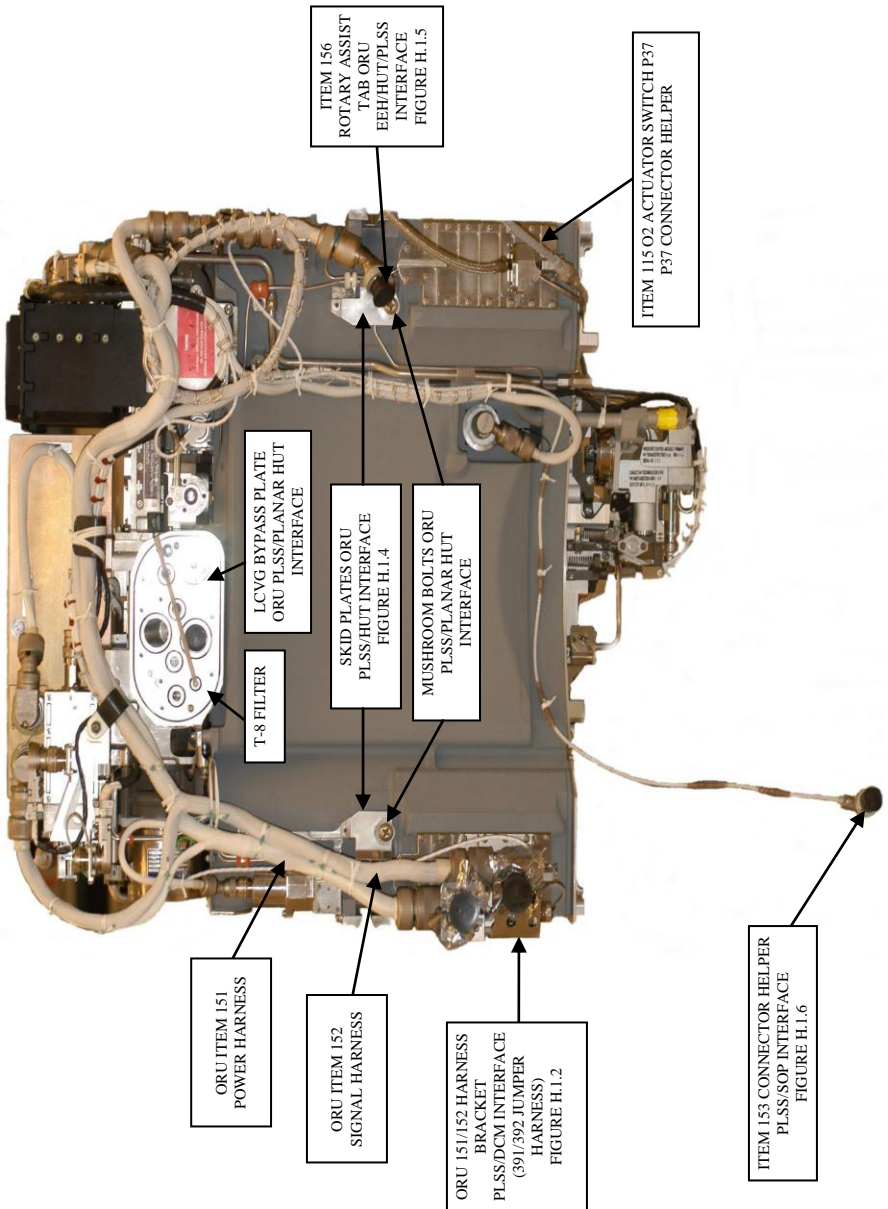


FIGURE 2.11.2

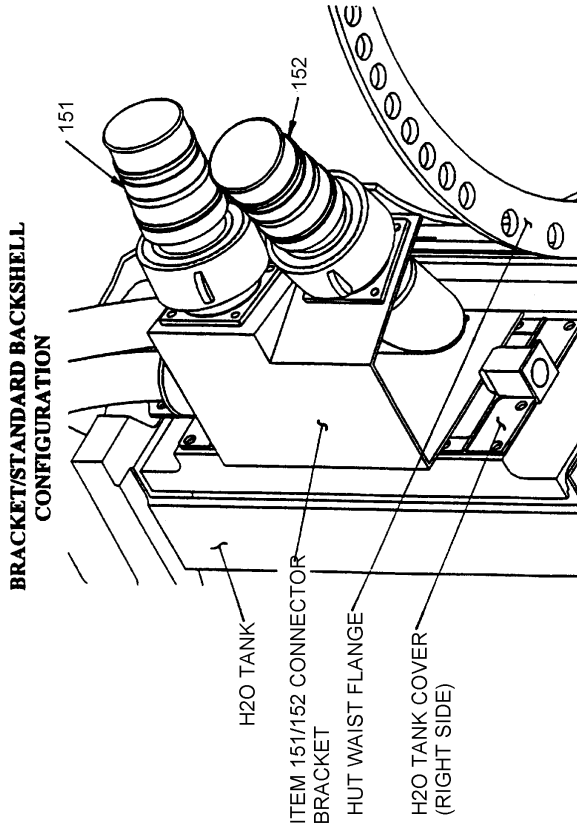
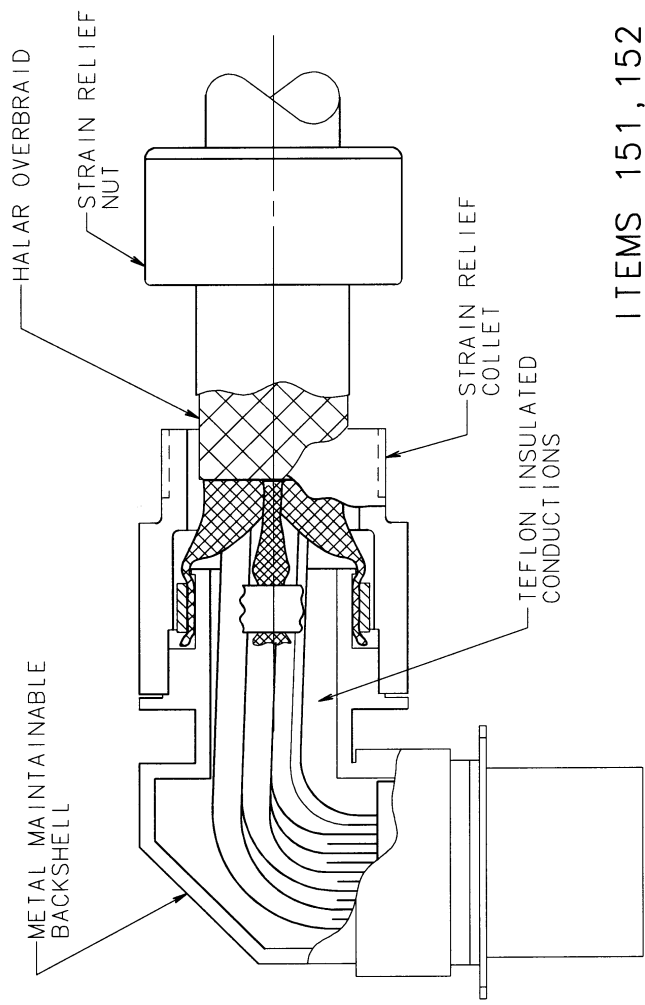
ITEM 151/152 BRACKET AND  
HARNESS ASSEMBLY

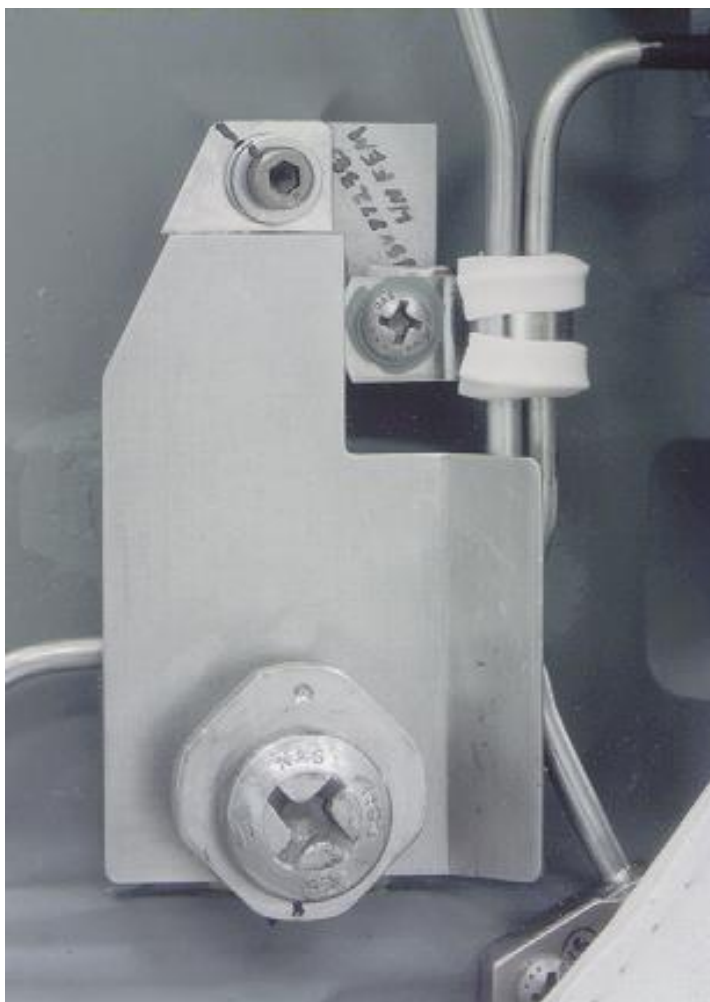
FIGURE 2.11.3      ORU HARNESS TYPICAL CONNECTOR



ITEMS 151, 152

- Skid plates on the PLSS provide alignment for PLSS (mushroom bolt) to planar HUT (trailer hitch) during assembly. The skid plates also provide protection for water tank transfer tubes during ORU change out at PLSS/ HUT interface (Figure 2.11.4).
- A rotary assistance tab on the PLSS Item 156 RTDS harness aids the crewmember with mate/demate of the P10B connector and EEH J10 connector during ORU PLSS/HUT change out (Figure 2.11.5).
- A rotary assistance tab on the PLSS Item 153 Caution and Warning harness aids the crewmember with mate/demate of the P32 connector during ORU PLSS/SOP change out (Figure 2.11.6).
- A filter in the LCVG bypass plate T-8 water fill line port filter maintains H<sub>2</sub>O loop cleanliness integrity during mate/ demate. The surface tension of the H<sub>2</sub>O on the filter screen retains the residual H<sub>2</sub>O in the loop.
- The O<sub>2</sub> actuator slide and fill line housing has captive fasteners (Figure 2.11.7).

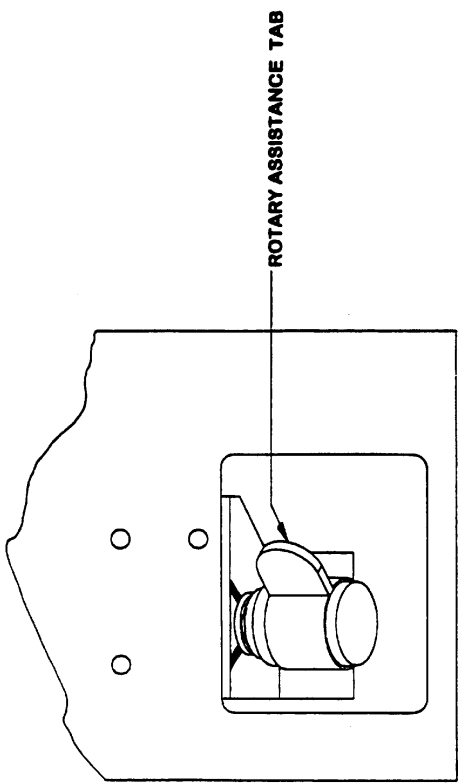
**FIGURE 2.11.4 PLSS SKID PLATE**



**FIGURE 2.11.5      ITEM 156 ROTARY ASSISTANCE  
TAB**



**FIGURE 2.11.6      ITEM 153 ROTARY ASSISTANCE  
TAB**



**SOP PRESSURE TRANSDUCER ELECTRICAL CONNECTOR  
IMPROVEMENT**

**FIGURE 2.11.7      O2 ACTUATOR SLIDE AND FILL LINE HOUSING**



**O2 FILL LINE  
HOUSING**

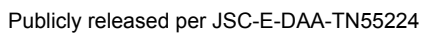
### **2.11.2 DISPLAY AND CONTROLS MODULE (DCM) ORU**

The DCM is separable from the EMU and change out can be performed by an unassisted crewmember without the use of special tools on-orbit (Figure 2.11.8).

The ORU DCM configuration includes:

Attaching the Items 391/392 jumper harnesses to the DCM allows the DCM to be serviced without pin damage or special tools (Figures 2.11.9).

- The O<sub>2</sub> high pressure fill line adapter plate has a three-bolt pattern and 3 captive fasteners on the DCM housing for on-orbit mate/demate operation (Figure 2.11.10).
- The alignment bracket plate bolts to existing DCM bolt holes to mount the O<sub>2</sub> actuator slide assembly. The actuator slide housing has captive fasteners. A removable handle guard also incorporates four captive fasteners (Figure 2.11.11).
- The DCM uses upper/lower captive brackets and captive fasteners. The bolt-on bracket incorporates captive, adjustable fasteners on DCM flanges to eliminate shimming. Standard tools can be utilized during assembly/disassembly (Figure 2.11.12).



**FIGURE 2.11.9      391/392 JUMPER HARNESSES**



**FIGURE 2.11.10      O<sub>2</sub> FILL LINE HOUSING AND  
ANDAPTER PLATE**



FIGURE 2.11.11 DCM ALIGNMENT BRACKET



**FIGURE 2.11.12      UPPER/LOWER DCM  
BRACKETS**



**2.11.3 SECONDARY OXYGEN PACK (SOP) ORU**

The SOP remains separable from the EMU and change out can be performed by an unassisted crewmember without the use of special tools. A helper tab on the Item 153 (PLSS/SOP interface) assists in mate/demate of the P32 connector without the use of tools.

Post-SOP ORU change out verification consists of depleting the primary O<sub>2</sub> bottle pressure and placing the O<sub>2</sub> actuator into EVA position to verify SOP regulator activation and delivery of SOP O<sub>2</sub> supply.

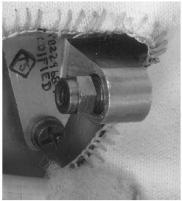
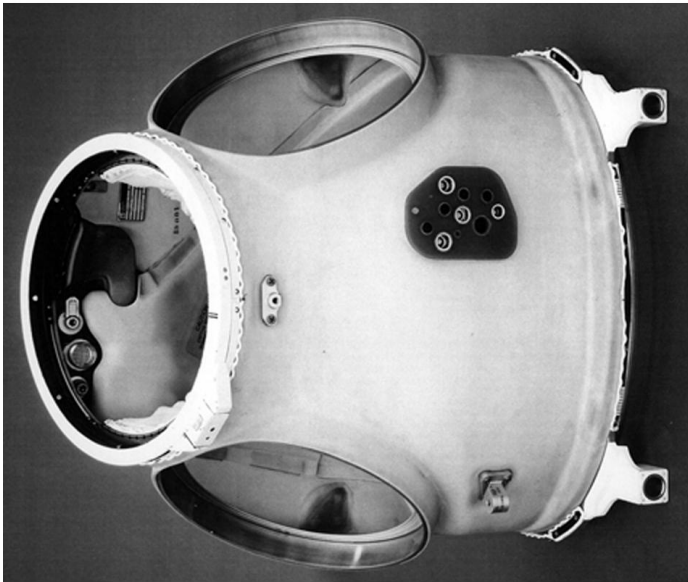
**2.11.4 HARD UPPER TORSO (HUT) ORU**

The HUT is separable from the EMU and change out is possible by an unassisted crewmember without the use of special tools. Two adjustable mounts on the HUT shell (Figure 2.11.13) and mushroom bolts on the backside of the HUT assist in mating the HUT to the PLSS.

**FIGURE 2.11.13      ORU HUT ADJUSTABLE  
MOUNTS**



**ORU UPPER  
MOUNT**



**ORU LOWER  
MOUNT**

### **2.11.5 ORU THERMAL MICROMETEOROID GARMENT (TMG)**

The TMGs for the ORU PLSS/SOP, HUT and DCM incorporate design features to support on-orbit component removal and maintenance (Figure 2.11.14).

The ORU TMG configurations include:

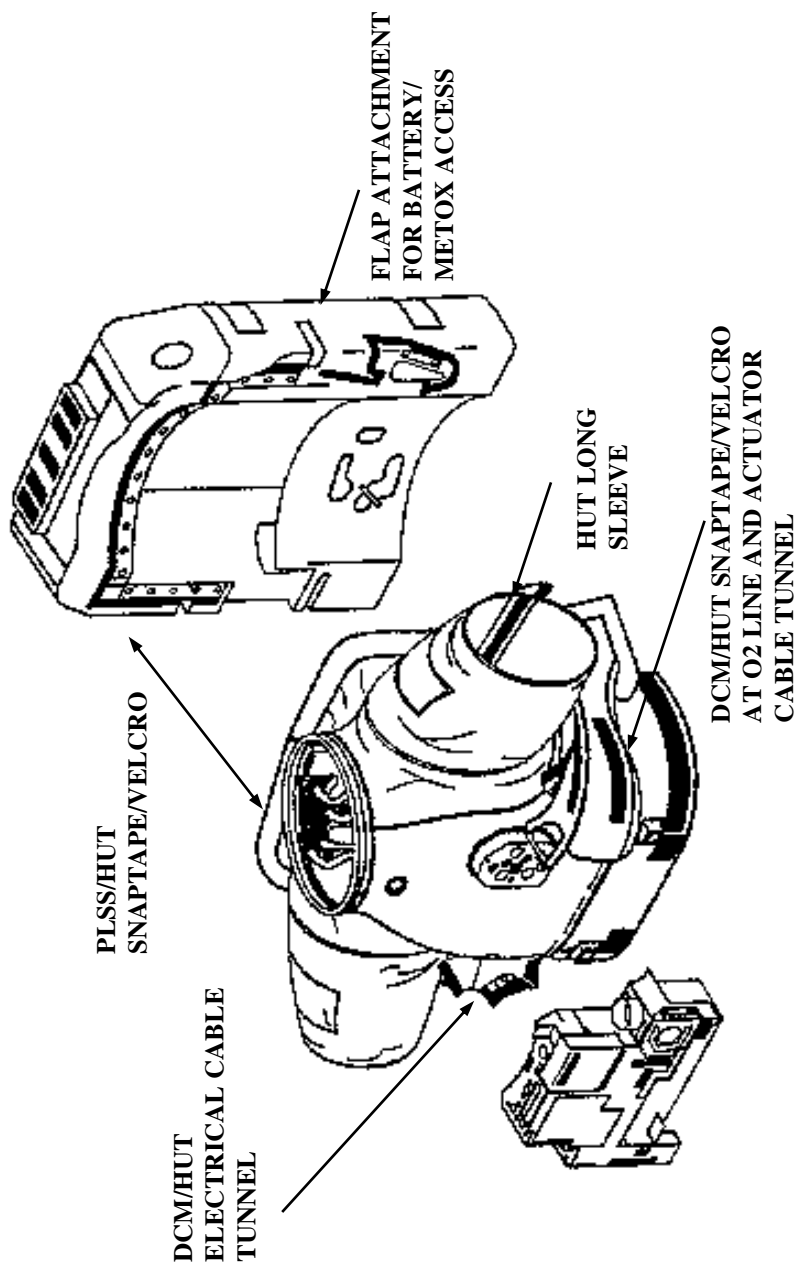
- Velcro, snaps, and zippers replace Looptape and lacing cord at the ORU interfaces.
- A cover flap encloses the space between the HUT and PLSS, enclosing the lengthened O<sub>2</sub> line, actuator cable and 391/392 jumper harnesses.
- The PLSS/SOP TMG Flap attachment allows access to the battery and Metox canister.
- TMG insulation was increased to 7 from 5 plies to improve HUT, DCM, and PLSS/SOP thermal characteristics.
- Long sleeves support heated glove use.

### **2.11.6 ORU ELECTRICAL SCHEMATIC**

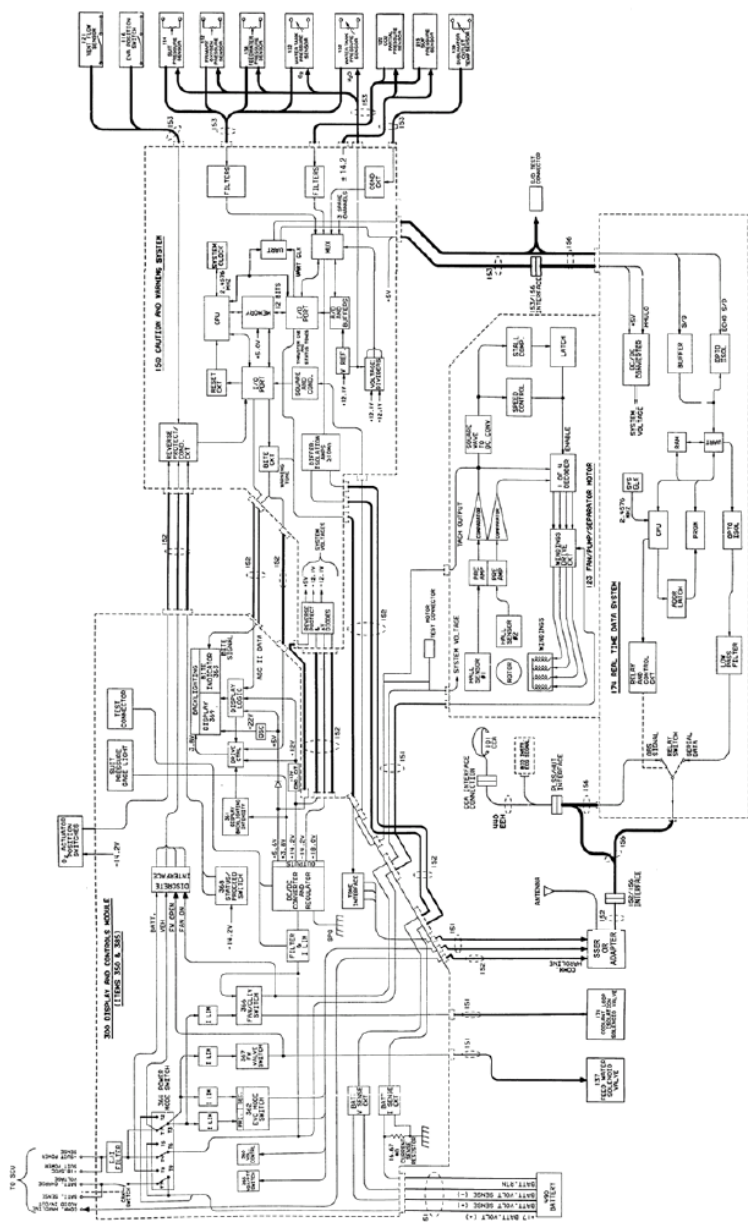
Figure 2.11.15 shows the ORU electrical schematic.

Figures 2.11.16, 2.11.17, 2.11.18 and 2.11.19 show the routing of the electrical harnesses in the ORU PLSS.

FIGURE 2.11.14 ORU TMG FEATURES



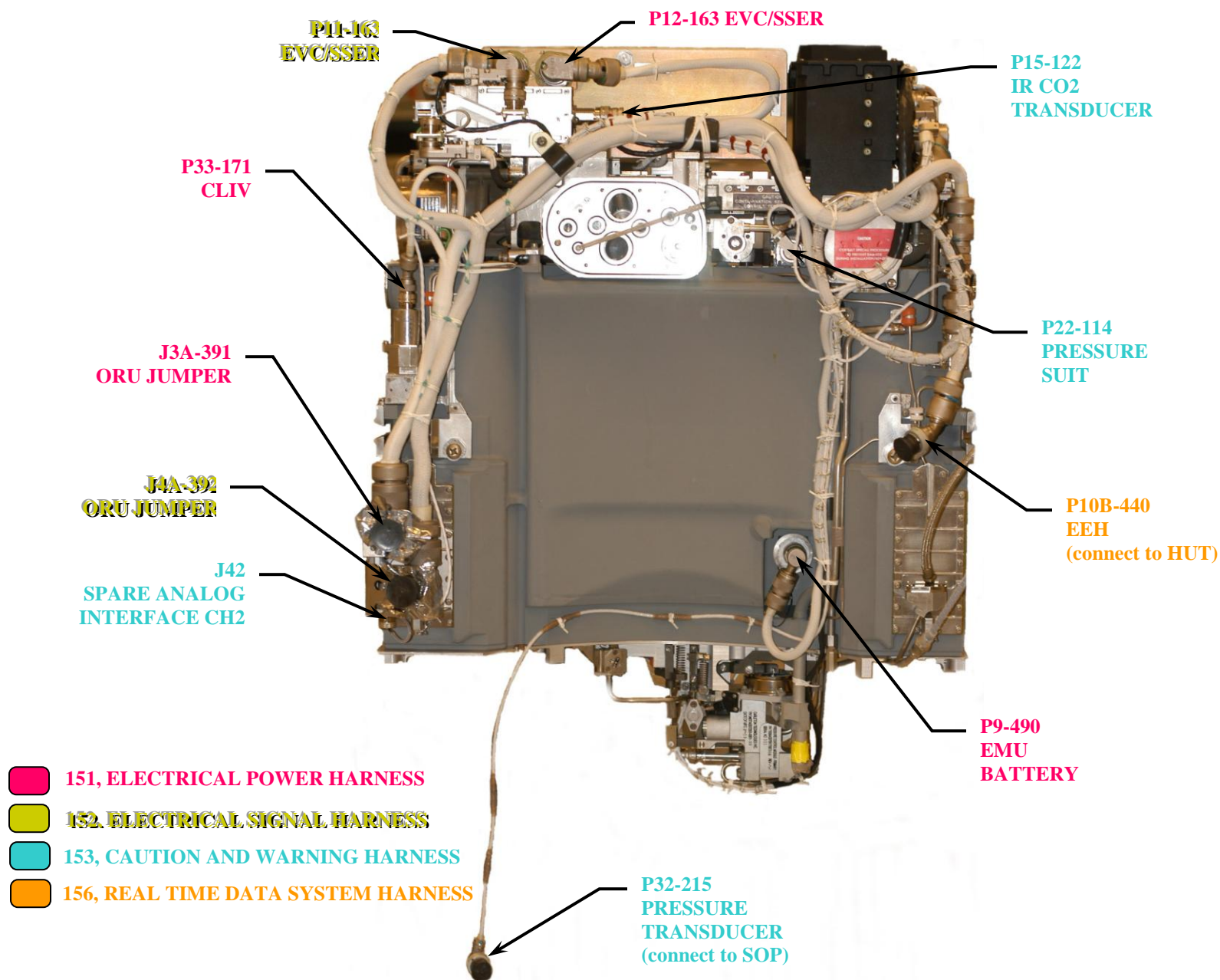
**FIGURE 2.11.15 EMU ORU ELECTRICAL SCHEMATIC**



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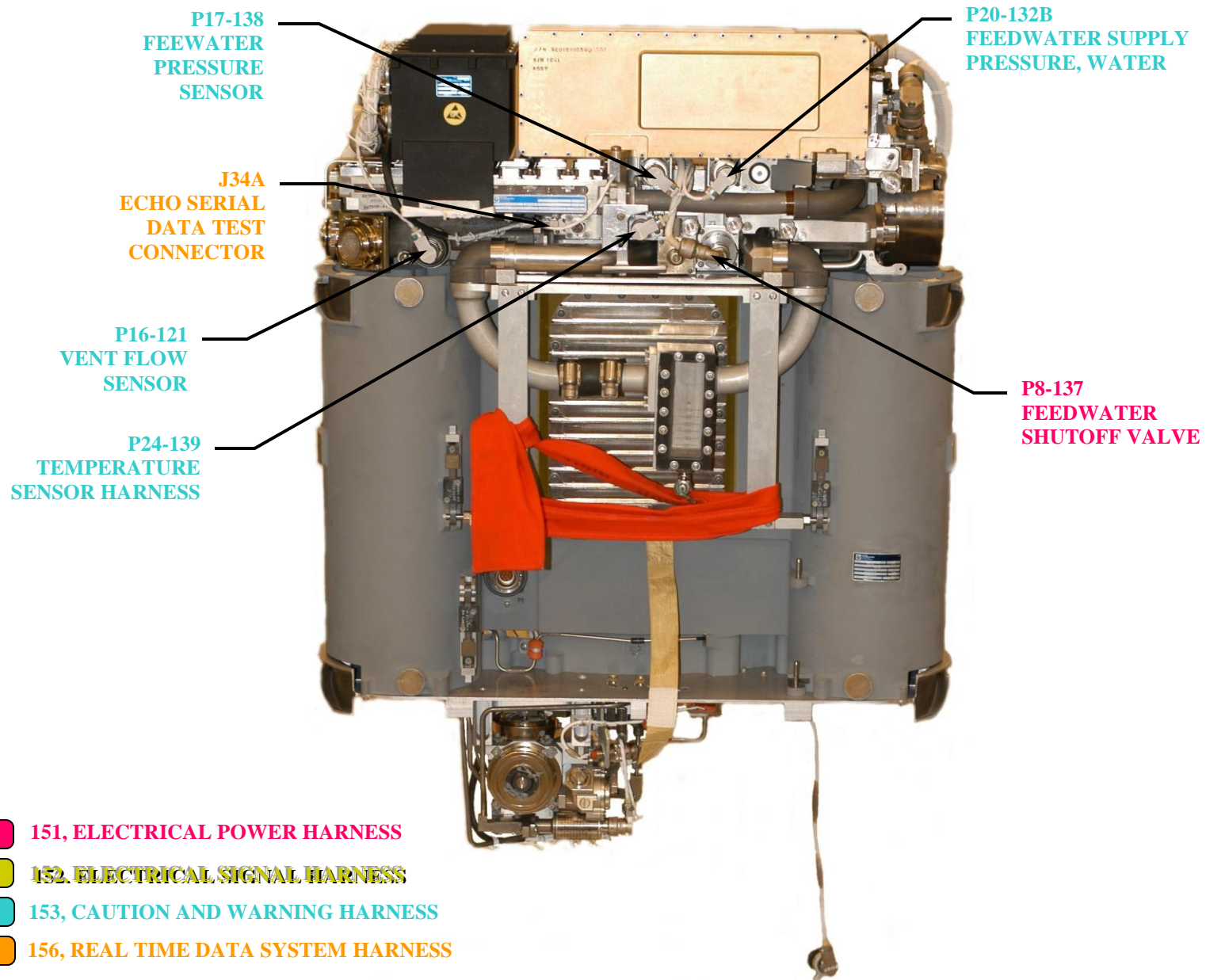
FIGURE 2.11.16 PLSS ELECTRICAL HARNESSES (HUT SIDE)



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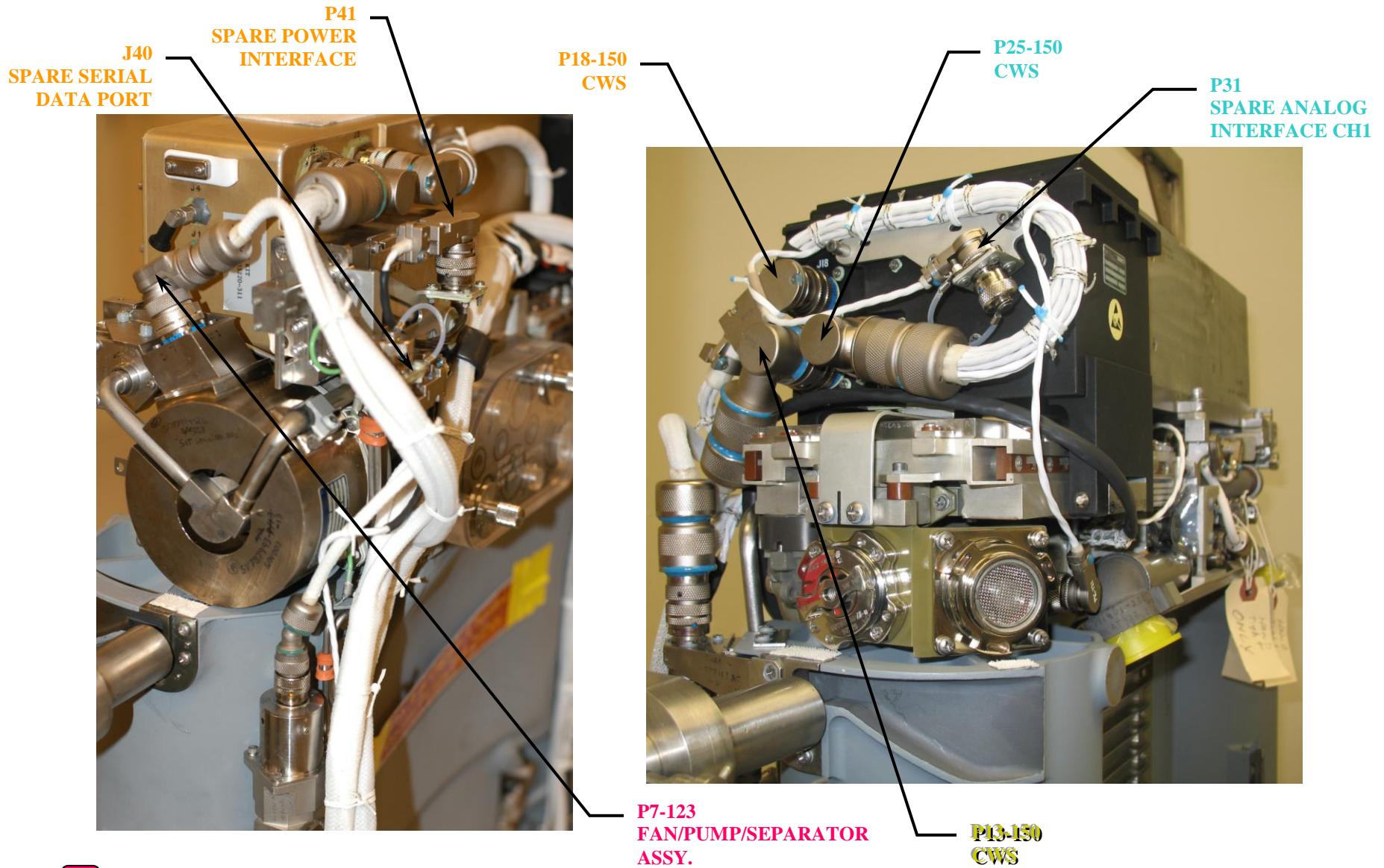
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FIGURE 2.11.17 PLSS ELECTRICAL HARNESSES (BACK SIDE)



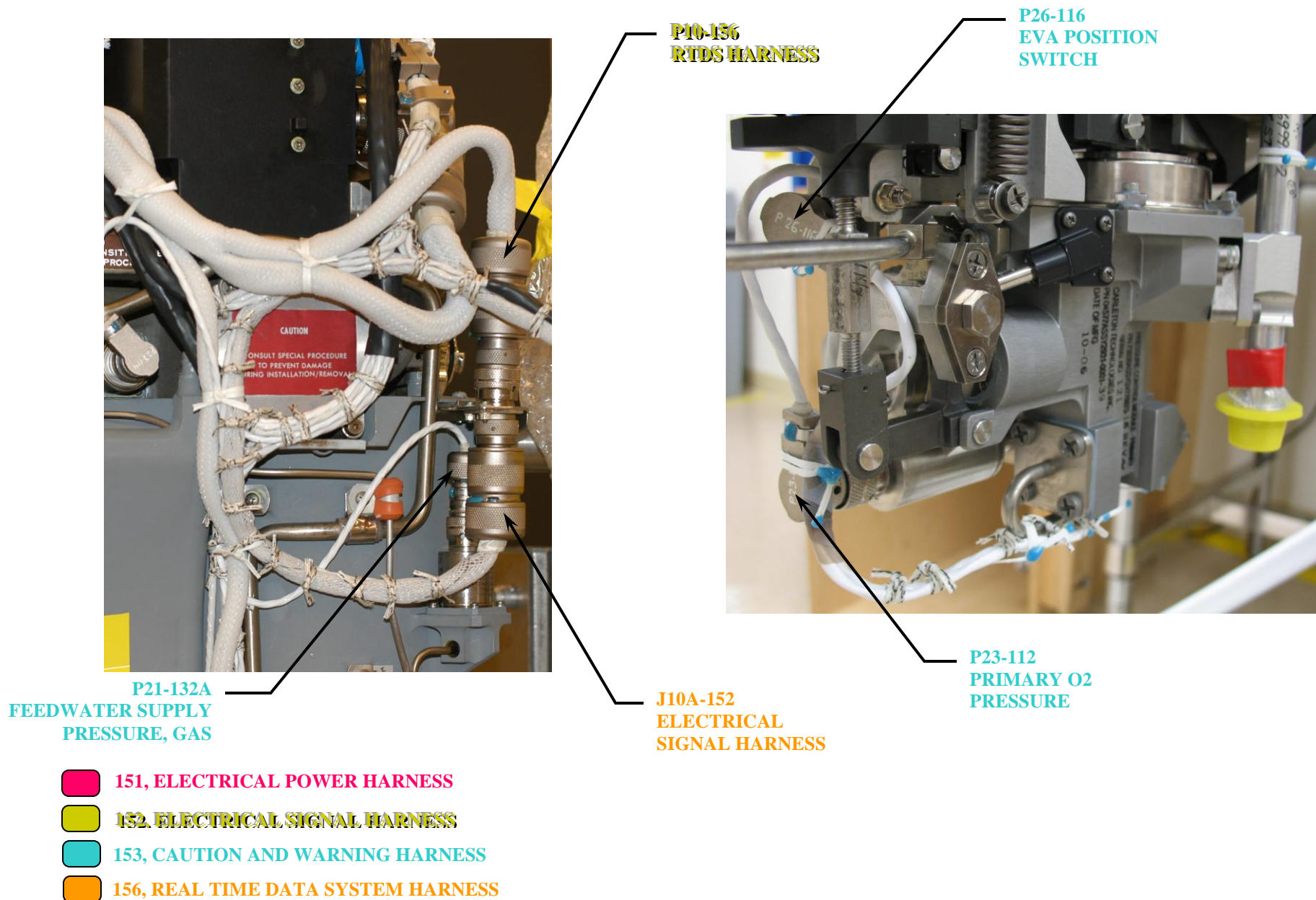
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FIGURE 2.11.18 PLSS ELECTRICAL HARNESSES



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FIGURE 2.11.19 PLSS ELECTRICAL HARNESSES



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# **SECTION 2.12**

## **COMPONENT ILLUSTRATION AND SPECIFICATION SUMMARY**

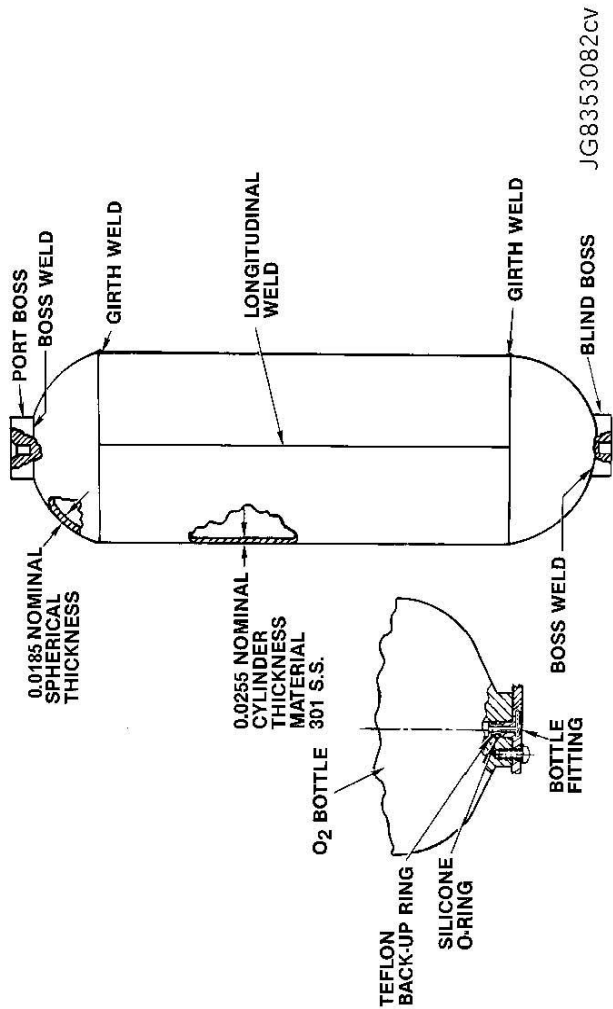
ITEM 111      PRIMARY OXYGEN BOTTLE

Stores oxygen for normal mission. Oxygen is used for pressurization, metabolic consumption and leakage make-up.

- Max operating pressure.....1050 psia
- Normal operating pressure.....900 ±50 psia
- Volume per bottle.....240 in <sup>3</sup> (min)  
(Usable oxygen 1.217 lbs for two bottles)
- Proof.....1575 psia
- Burst.....2100 psia (min)

ITEM 111  
(CONT'D)

# CRYGENICALLY FORMED STAINLESS STEEL PRIMARY OXYGEN BOTTLE



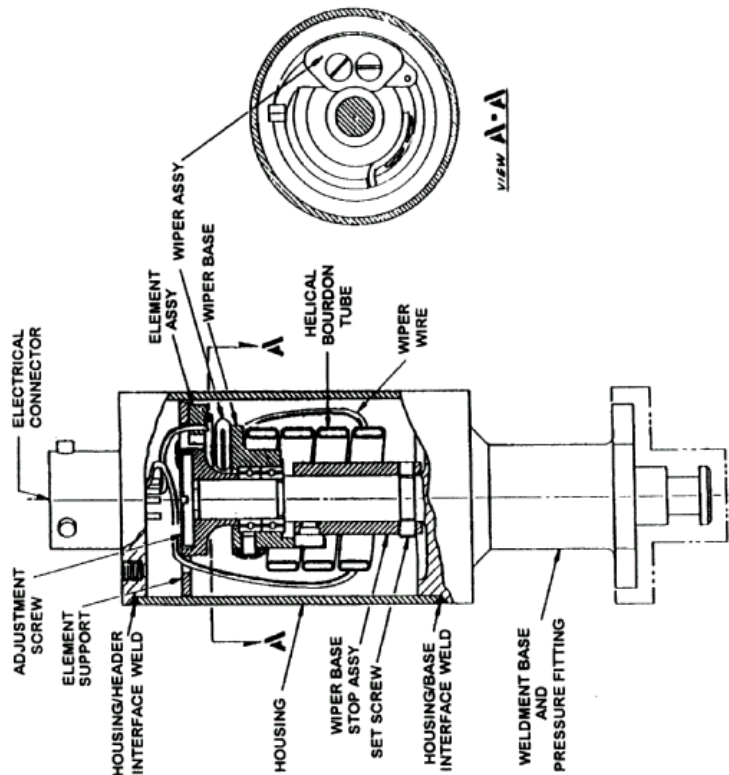
G-494

ITEM 112    PRIMARY O2 PRESSURE SENSOR

Senses the Primary Oxygen Tank pressure. The ECWS (Item 150) uses the signal to calculate O<sub>2</sub> use rate and mission time remaining. O<sub>2</sub> use rate is used to calculate crewmember metabolic rate.

- Pressure range..... 0 – 1100 psia
- Normal pressure measured..... 100 – 900 psia
- Input voltage..... 5 Vdc
- Output voltage..... 0 – 5 Vdc
- Error band..... ± 2.5 % FS or ± 27.5 psi  
(over 2 to 98% of FS)

ITEM 112  
(CONT'D)  
PRIMARY O<sub>2</sub> PRESSURE SENSOR (GULTON)



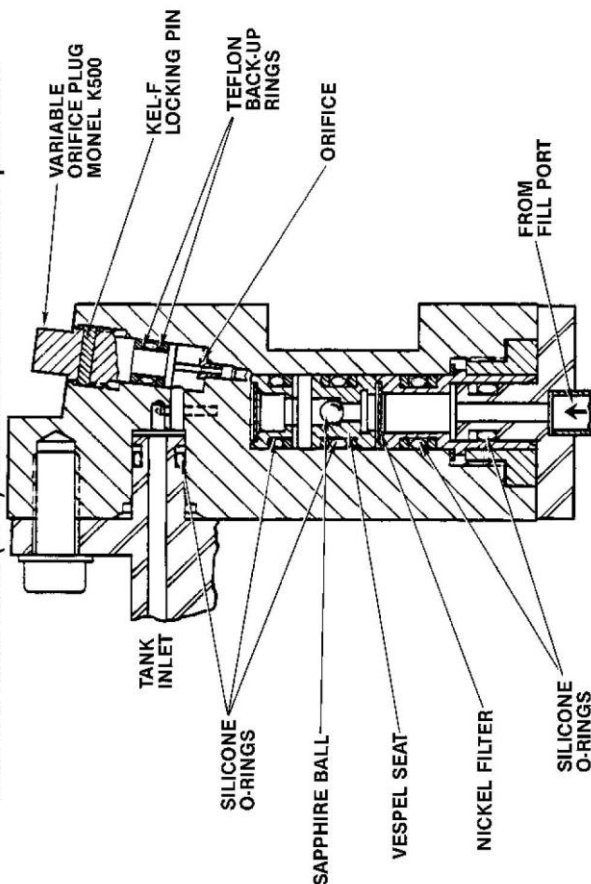
ITEM 113      PRIMARY PRESSURE CONTROL MODULE

Controls the suit and water tank pressure levels during IVA and EVA parts of the mission.

- Suit pressure regulation
  - EVA and PRESS.....4.3 ± 0.1 psid
  - IVA.....0.9 ± 0.5 psid
- Suit flow rate.....0.02 – 0.33 PPH O<sub>2</sub>
- Max flow.....5.5 – 7.1 PPH O<sub>2</sub> @ 900 ± 50 psia  
7.49 PPH O<sub>2</sub> @ 1050 psia MOP
- Feedwater pressure.....14.6 – 15.7 psig
- Leakage (Internal and External).....6 SCC/HR O<sub>2</sub> max  
(T1 @ 1050 psid, Item 113C closed)

**ITEM 113B****VARIABLE ORIFICE**

Prevents a failed open regulator (I113) from flowing more oxygen than the relief valve (I146) can flow at the maximum pressure.

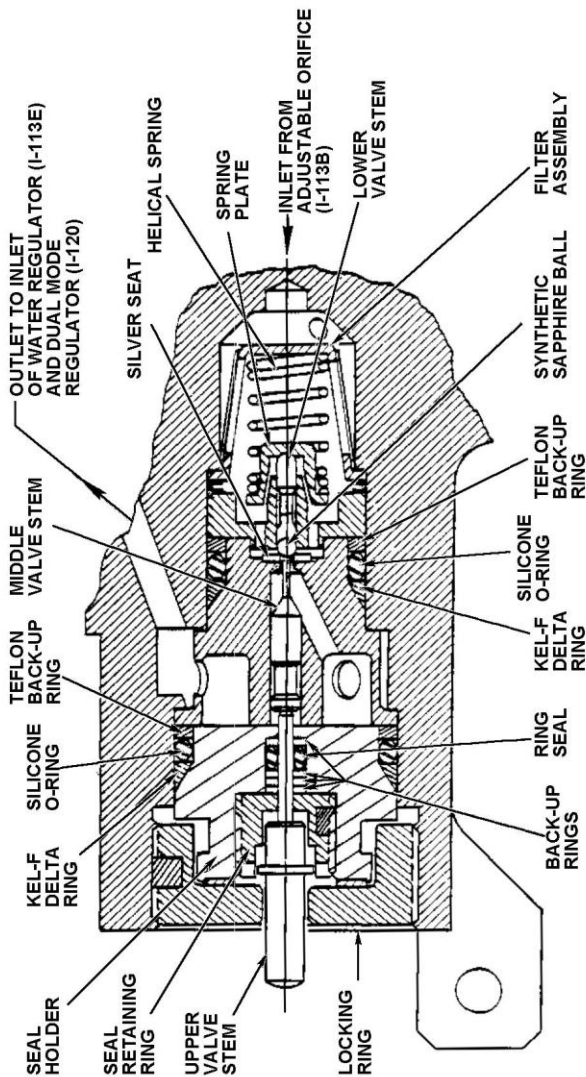
**ITEM 113A****CHECK VALVE**

Prevents backflow of oxygen when the SCU is disconnected.  
Redundant to the Multiple Water Connector (I330).

## ITEM 113C

O<sub>2</sub> SHUTOFF VALVE

Isolates O<sub>2</sub> supply from suit and water tanks

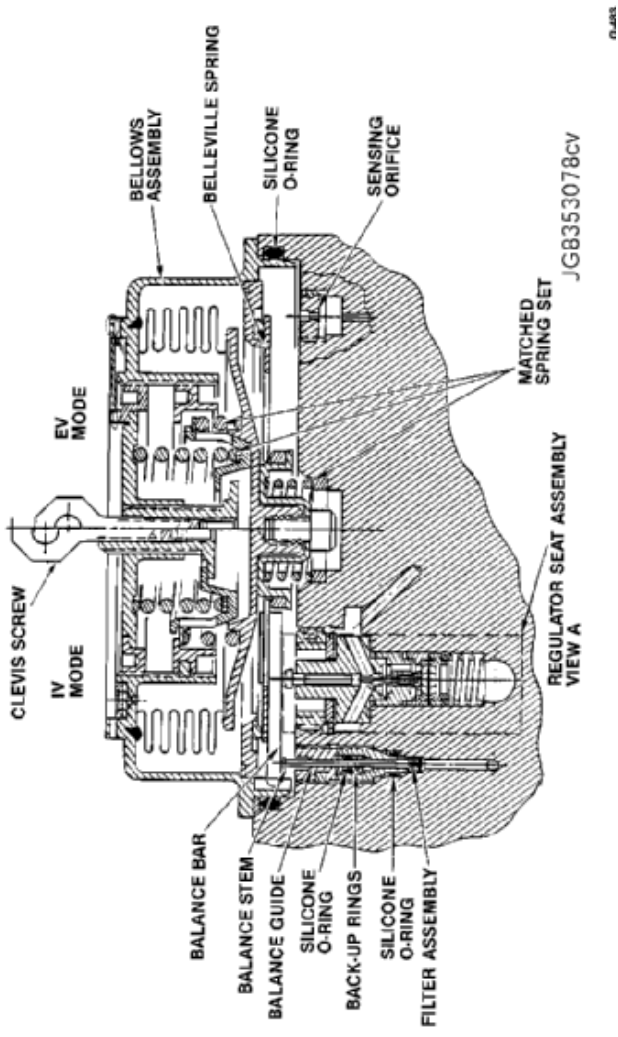


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ITEM 113D

DUAL MODE REGULATOR

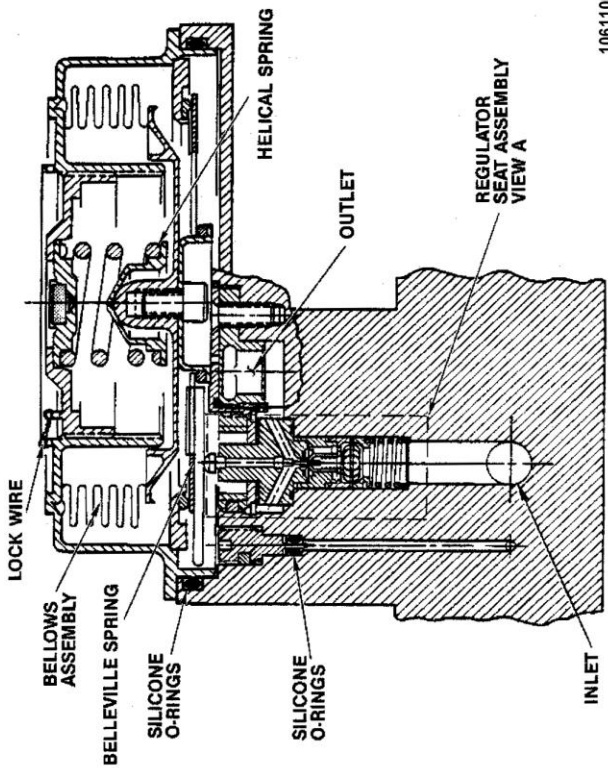
Controls suit pressure to  $0.9 \pm 0.5$  or  $4.3 \pm 0.1$  psig as desired.



ITEM 113E

WATER PRESSURE REGULATOR

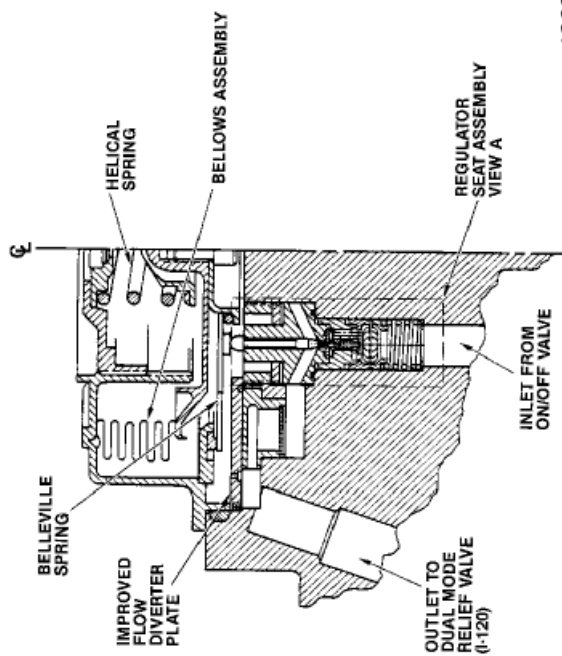
Controls the water tank pressure to 14.6 - 15.7 psig.



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ITEM 113E  
(CONT'D)

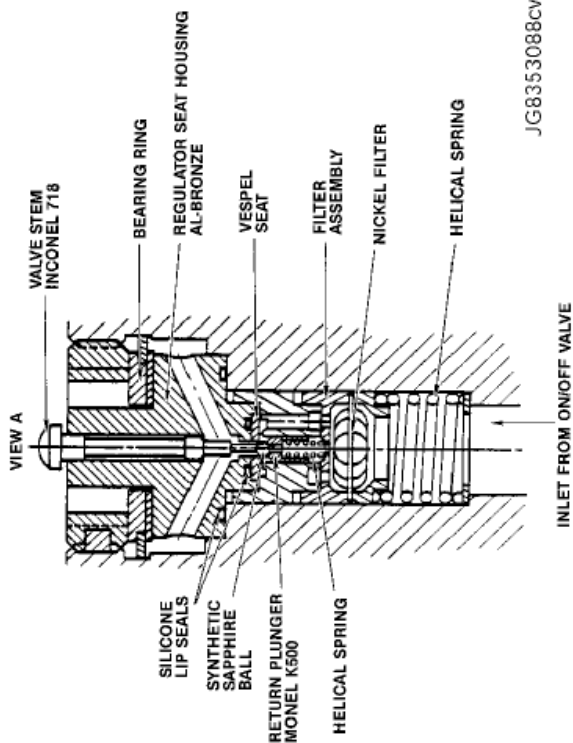
## WATER PRESSURE REGULATOR



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ITEM 113E  
(CONT'D)

## COMMON REGULATOR SEAT ASSEMBLY

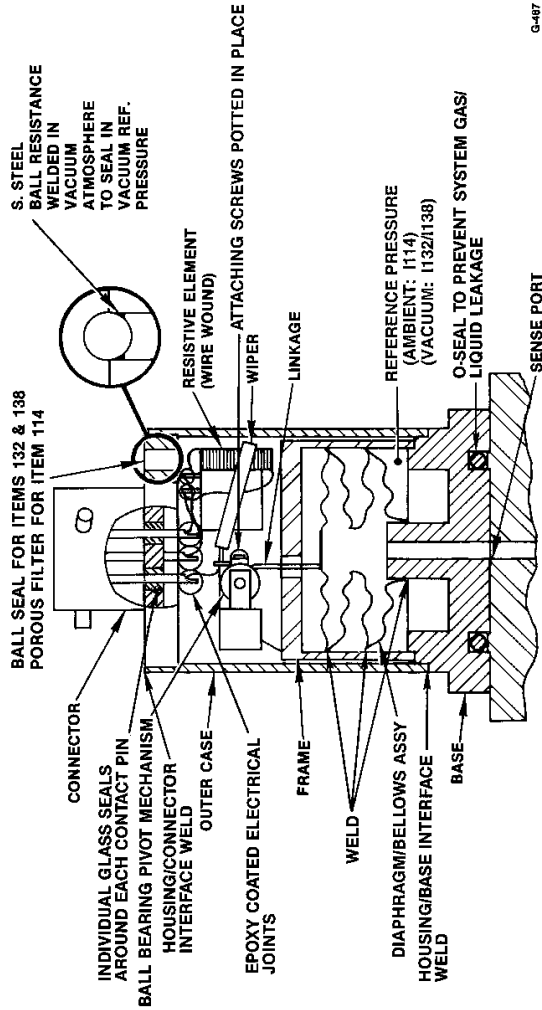


ITEM 114 PRESSURE SUIT SENSOR

Senses suit pressure above ambient pressure. ECWS (Item 150) uses the signal to confirm suit regulator, SOP regulator, and relief valve performance.

- Pressure range.....0 – 6 psid (ambient pressure reference)
- Normal pressure measured.....4.3 psid
- Input voltage.....5 Vdc
- Error band.....± 2.5% FS (± 0.15 psi)

# ITEM 114,132      POTENTIOMETER TYPE PRESSURE SENSORS AND 138



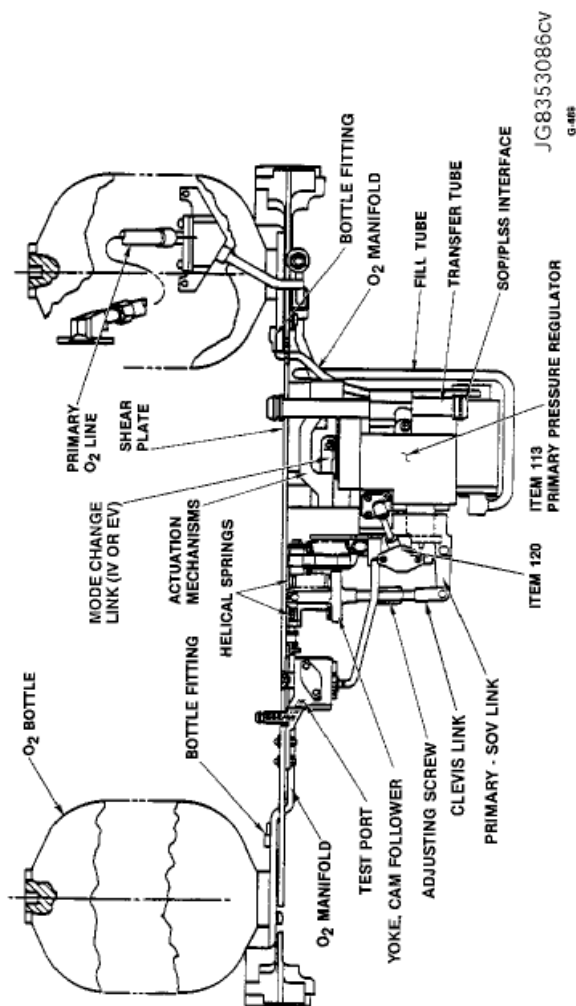
G-487

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## ITEM 115

## SHEAR PLATE ASSEMBLY

Assembly contains the primary oxygen storage, actuation, and regulation elements.

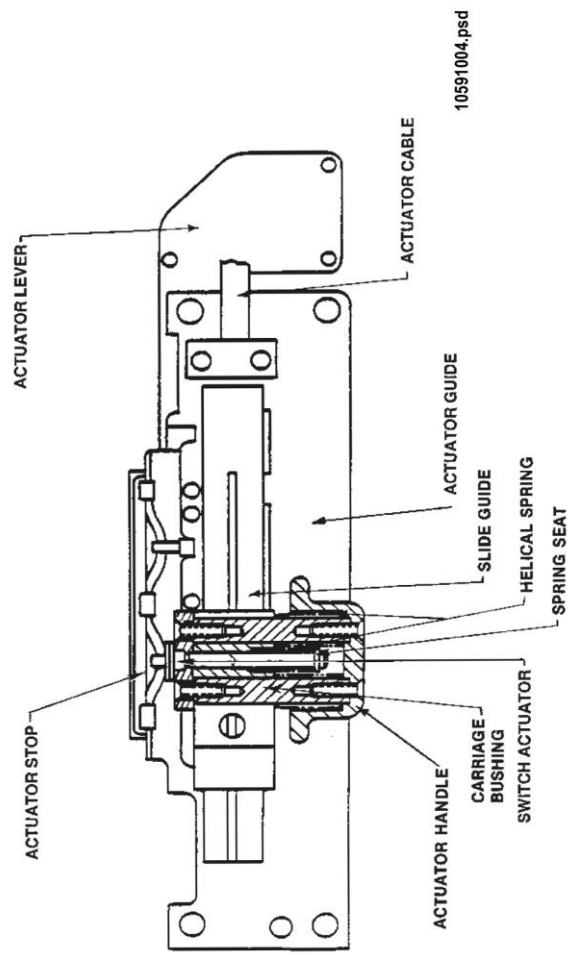


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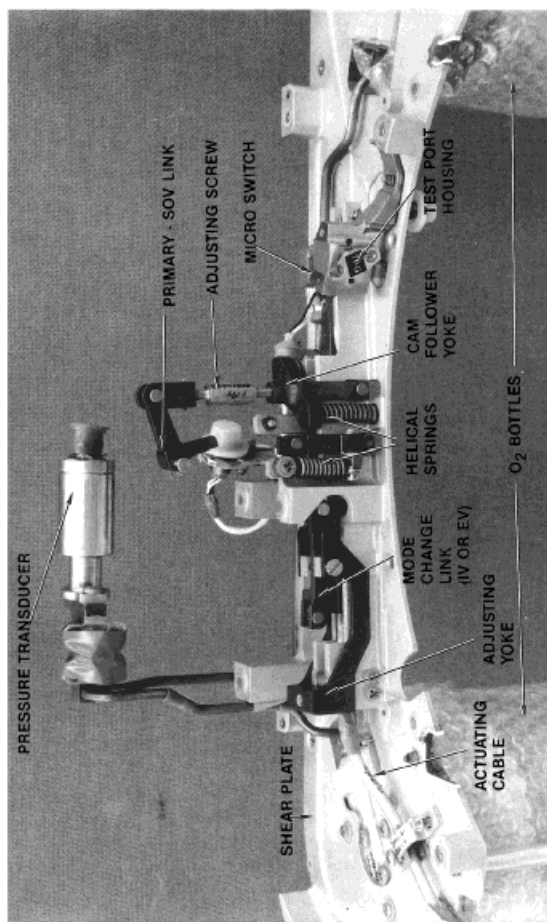
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ITEM 115  
(CONT'D)

ACTUATOR SLIDE MECHNISM



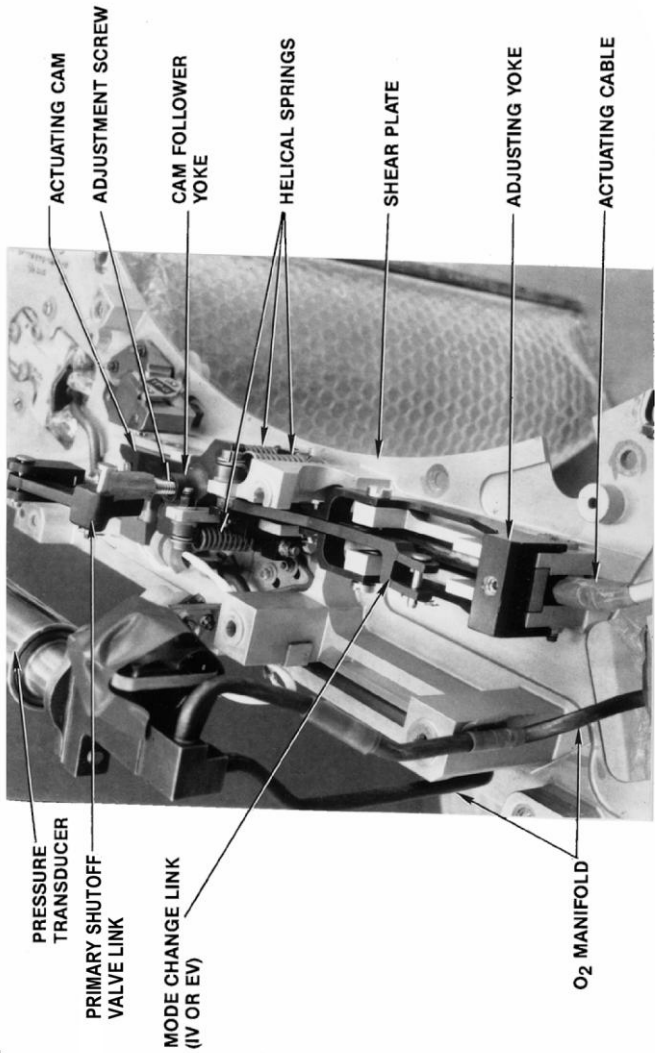
## SHEAR PLATE ASSEMBLY

ITEM 115  
(CONT'D)

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ITEM 115  
(CONT'D)

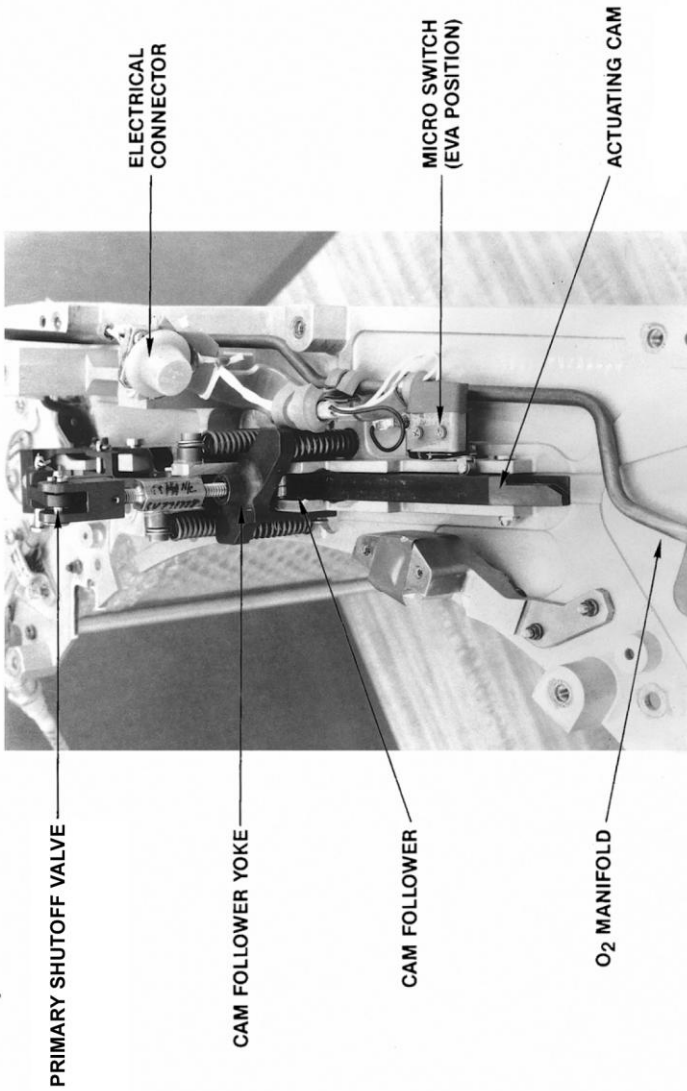
SHEAR PLATE ACTUATION MECHANISM



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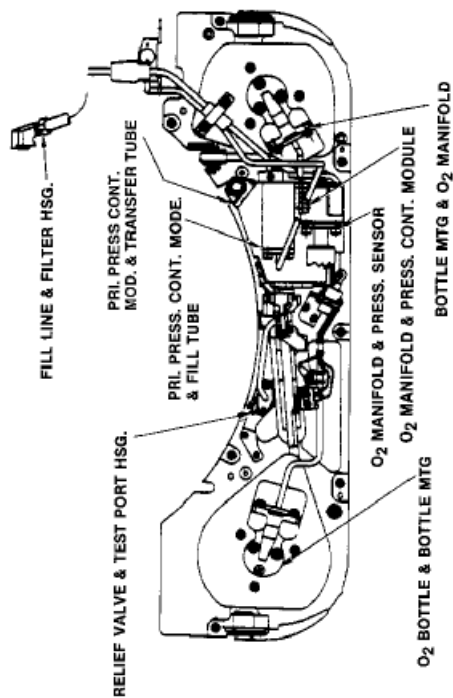
# **SHEAR PLATE ACTUATION MECHANISMS**

## **ITEM 115 (CONT'D)**



ITEM 115  
(CONT'D)

SHEAR PLATE ASSEMBLY

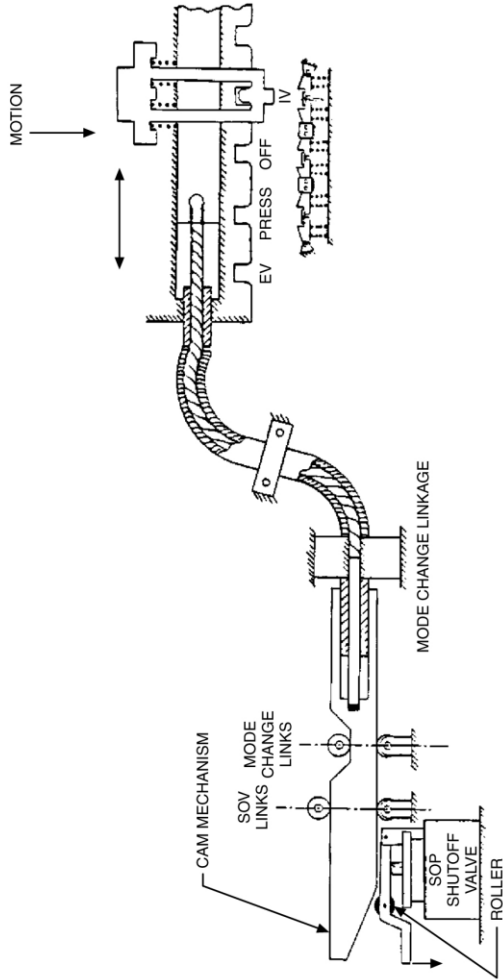


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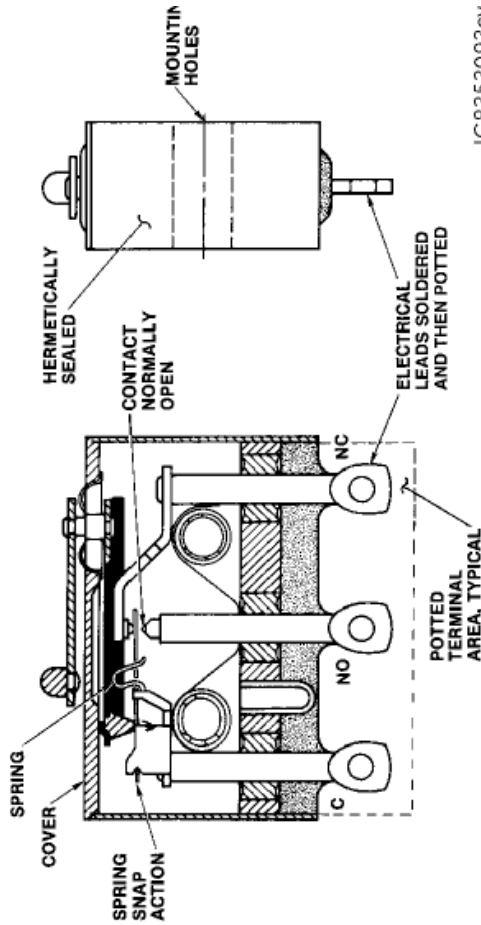
ITEM 115  
(CONT'D)  
SOP ACTUATION SYSTEM SCHEMATIC



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## ITEM 116

**EVA POSITION SWITCH**  
 Switch determines when O<sub>2</sub> actuator is in EVA position (SOP On Line). Signal goes to the CWS.



JG8353093CV

**ITEM 120 DUAL MODE RELIEF VALVE**

Limits pressure on the water tanks in the event of a regulator failure. Allows quick filling of the water tanks by venting the gas behind the bladders to the vent loop. Prevents "wet" gas from behind the bladders from reverse flowing through the regulators during shutdown.

**High Pressure Relief Mode**

- Flow.....7.5 PPH O<sub>2</sub> minimum
- Inlet (TPF) pressure.....24.25 psia max
- Test Port G pressure.....19.75 psia max
- Ambient pressure.....0 (zero)
- Downstream pressure.....6.9 psia max

**Low Pressure Relief Mode (Senses regulator supply pressure and tank gas pressure.)**

- Flow.....450 SCC/MIN. O<sub>2</sub> minimum
- TPG pressure.....1.0 ± 0.1 psi above regulator supply pressure
- Outlet port and Test Port F.....Ambient

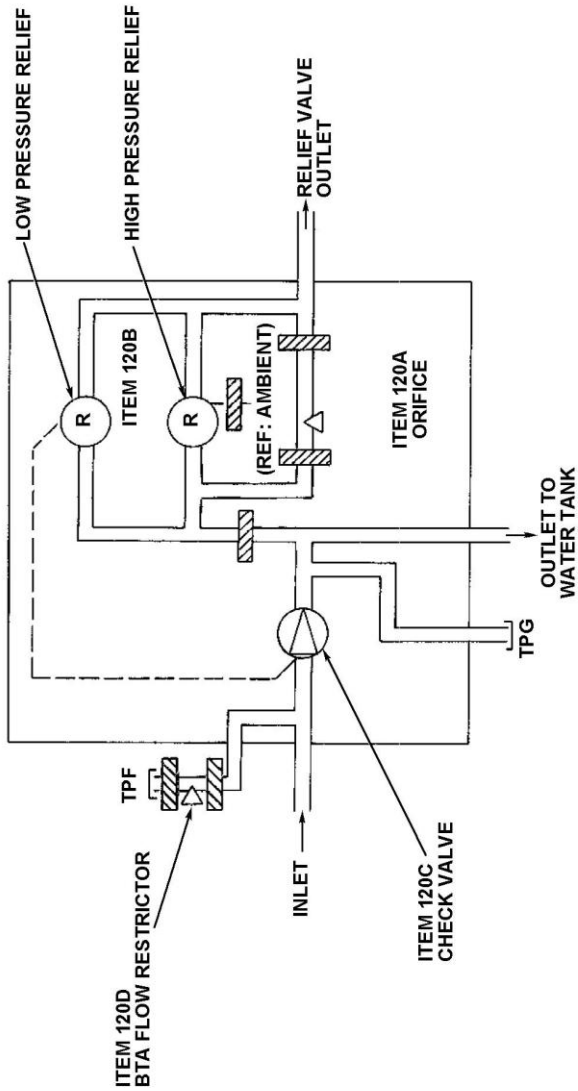
**Relief Valves Closed**

- Test Port F and Test Port G.....3.2 psig max
- Flow (assembly).....0.0143 – 0.023 PPH O<sub>2</sub>

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ITEM 120  
(CONT'D)

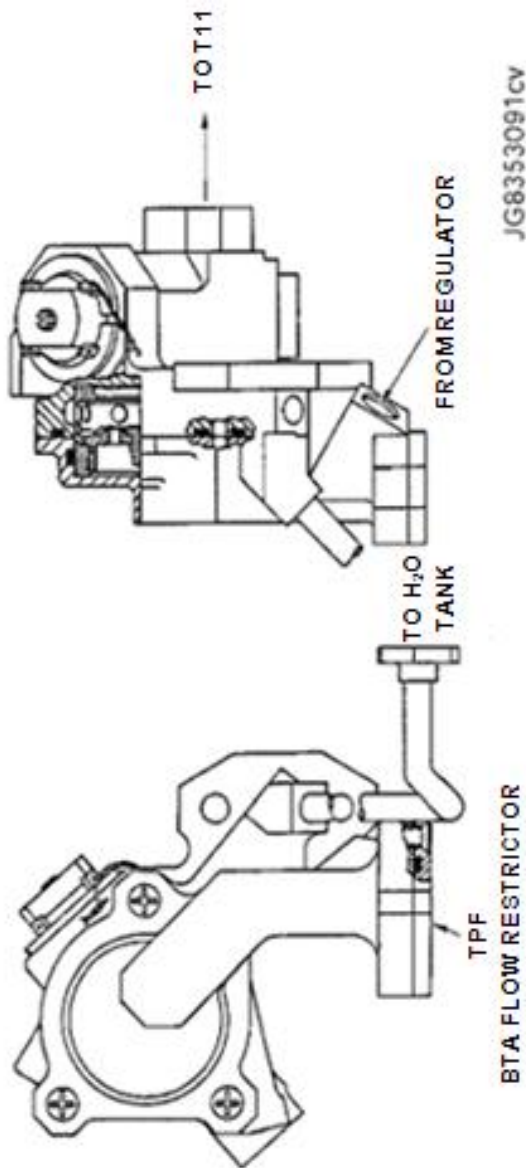
DUAL MODE RELIEF VALVE



10607004.r18

ITEM 120  
(CONT'D)

DUAL MODE RELIEF VALVE



JG8353091CV

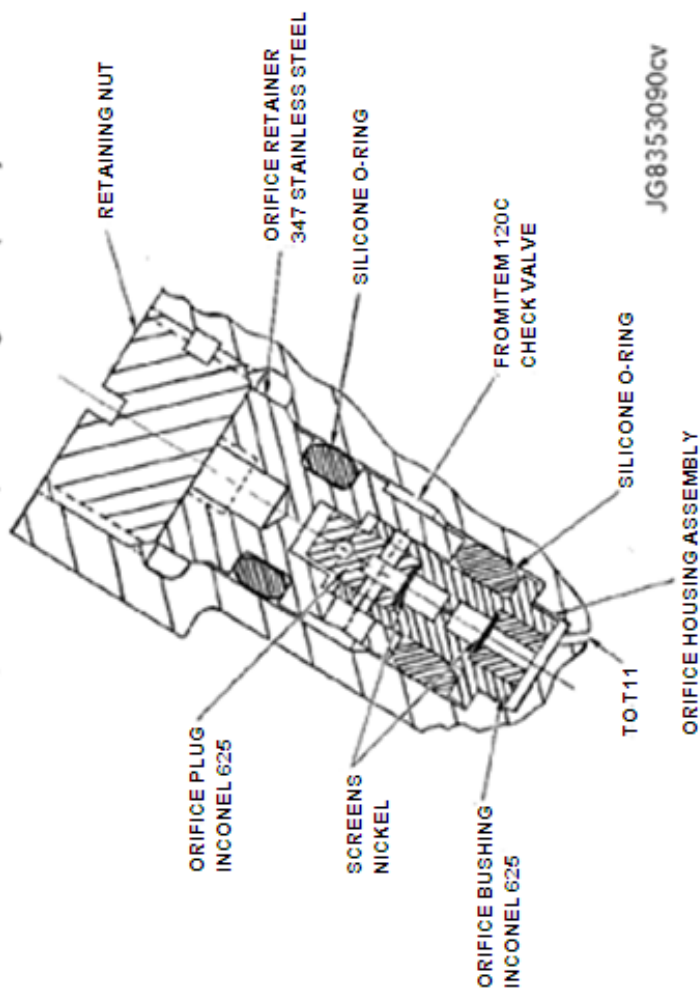
9.575

REV N

## ITEM 120A

## BLEED ORIFICE

Allows bleed flow at approximately 1/2 the minimum metabolic O<sub>2</sub> rate to prevent lockup of the water pressure regulator (I113E).

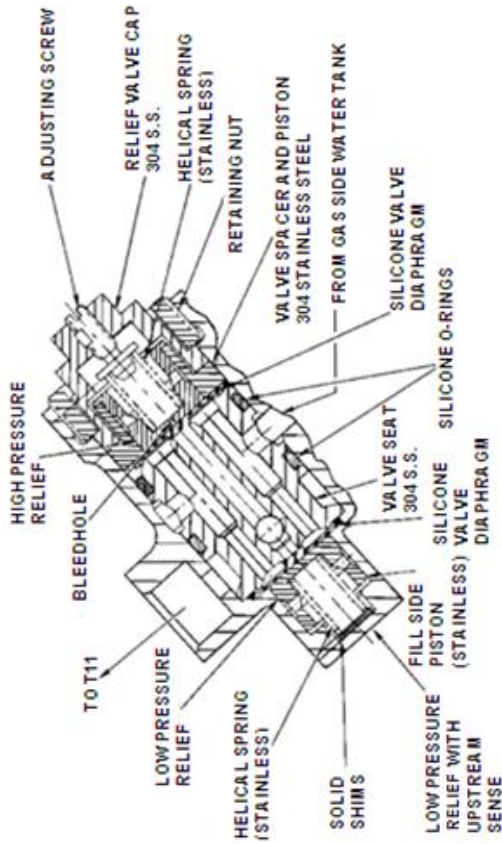


JG8353090cv

## ITEM 120B

## DUAL MODE RELIEF VALVE

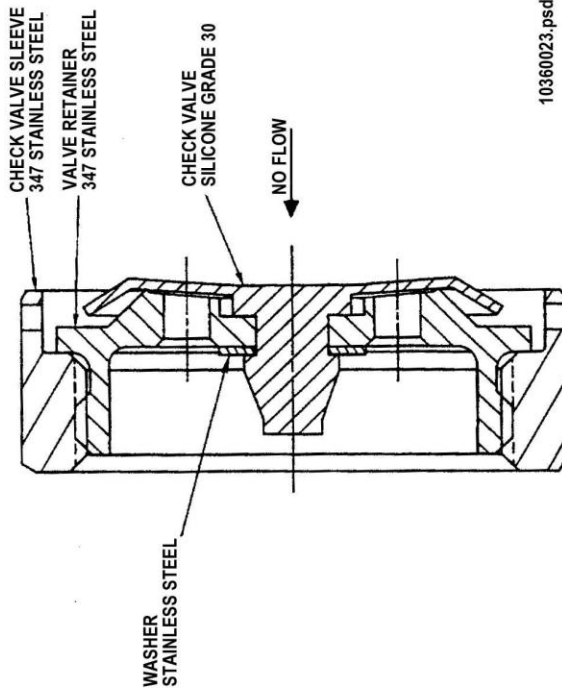
High pressure relief prevents over-pressurization of the water tanks if the water regulator fails open. Low pressure relief allows fast filling of the water tanks and BTA operation by venting the gas behind the bladders to the vent loop.



## ITEM 120C

## CHECK VALVE

Prevents "wet" oxygen from behind the bladders from reverse flowing through the regulators when the system is shut down.



10360023.psd

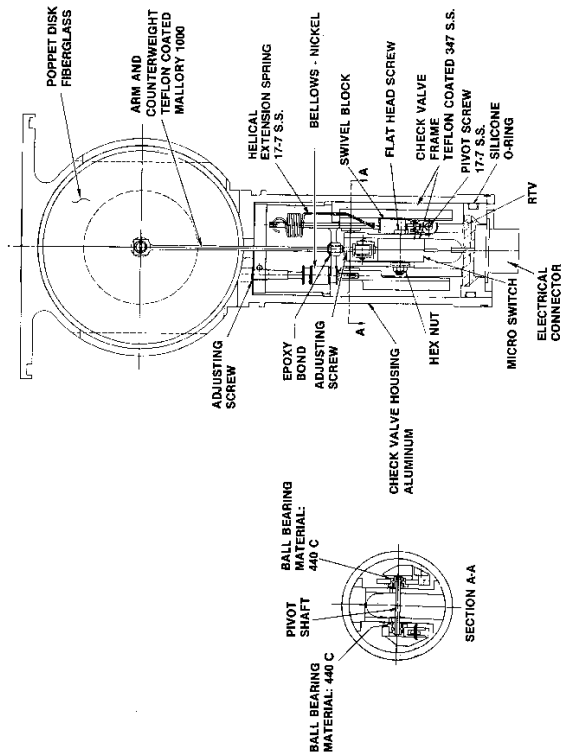
ITEM 121 CHECK VALVE AND VENT FLOW SENSOR

Directs SOP flow to the Helmet when the fan is off and determines that fan flow is within acceptable limits. Electrical output goes to the ECWS.

- Flow Indication
  - Flow on @ .....5.7 ACFM O<sub>2</sub> max and 3.35 psia  
.....5.4 ACFM O<sub>2</sub> max and 4.3 psia  
.....5.1 ACFM O<sub>2</sub> max and 3.35 to 19.1 psia
  - Flow off @ .....3.7 ACFM O<sub>2</sub> min and 3.35 to 19.1 psia
- Check valve characteristics
  - Flow direction
    - Flow delta P .....0.315 in. H<sub>2</sub>O max  
(@ 4.4 psia and 6.0 SCFM O<sub>2</sub>)
  - Check direction leakage.....0.05 PPH O<sub>2</sub> max  
(@ 0.1 – 0.15 psid across valve)
  - Reverse flow to cause valve to seat (check).....3.0 PPH O<sub>2</sub> max

# ITEM 121 (CONT'D)

## CHECK VALVE AND VENT FLOW SENSOR

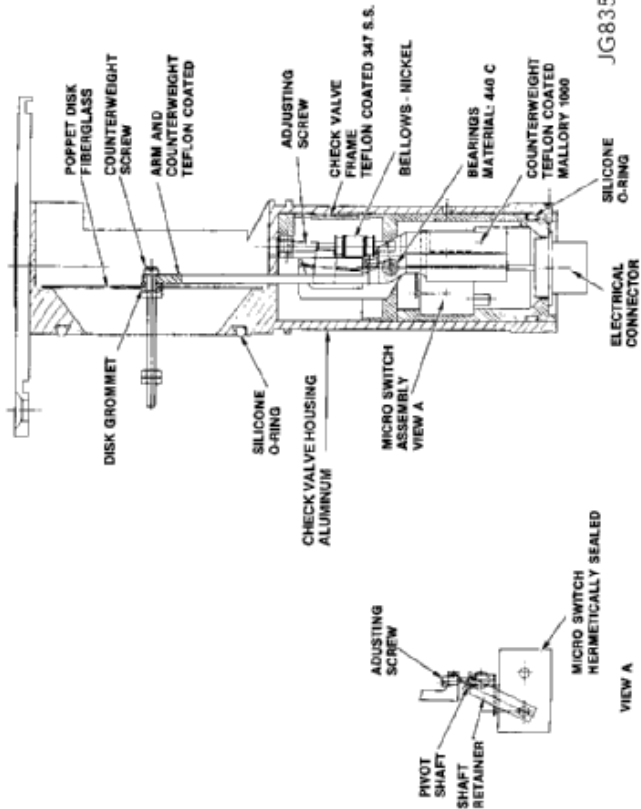


JG8353137CV

G-407

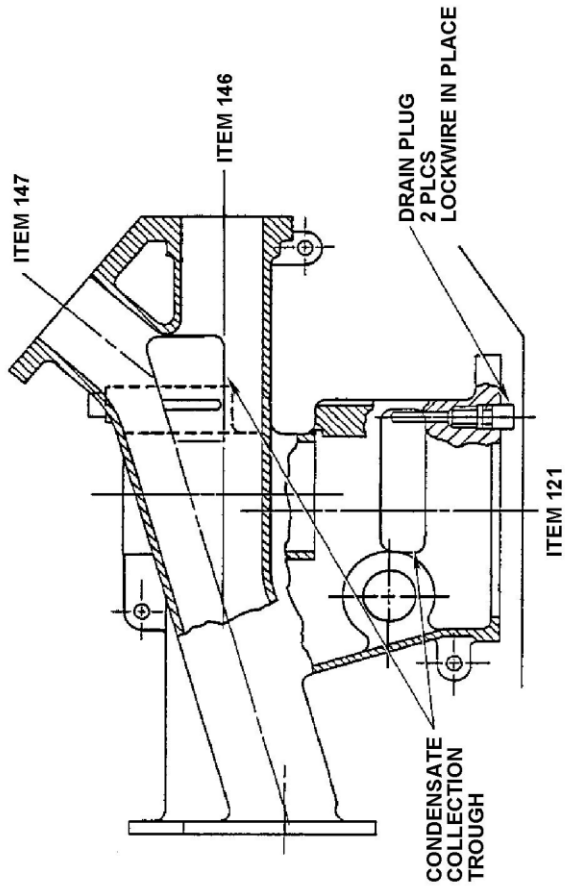
# CHECK VALVE AND VENT FLOW SENSOR

ITEM 121  
(CONT'D)



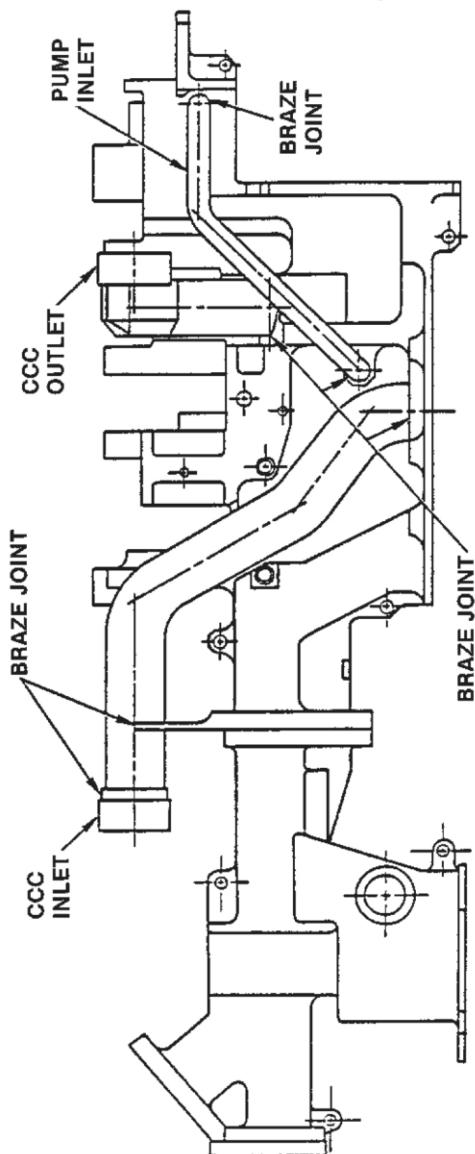
## PLSS VALVE MODULE – CAST ALUMINUM “HORN”

The Stainless Steel Valve Module and Aluminum Horn mount the majority of the Vent Loop and Water Loop Components. They contain internal flow passages, test/drain ports, and mounting points for equipment



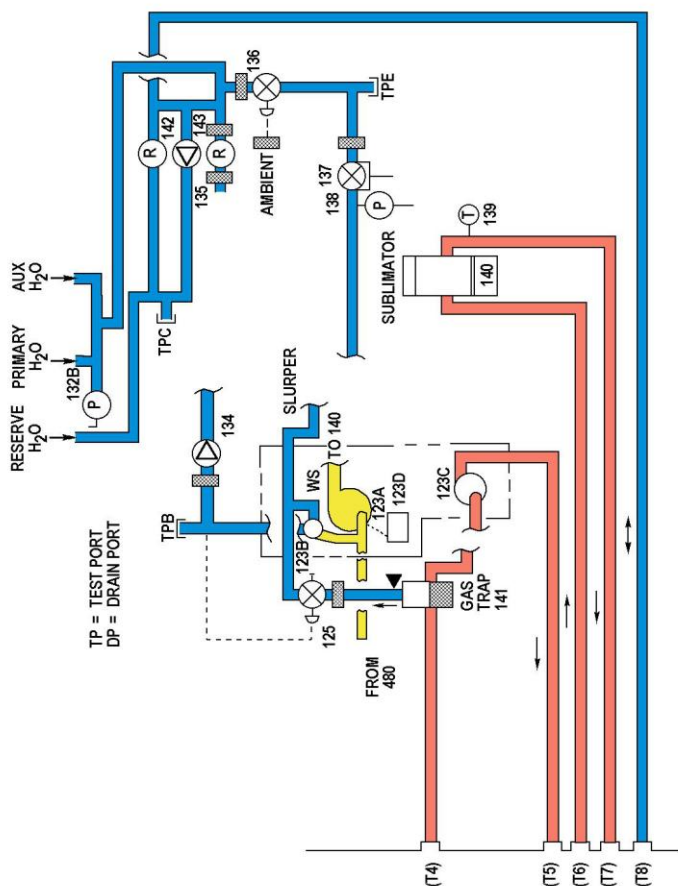
10907002.rls

# PLSS VALVE MODULE - ISOLATED TUBES



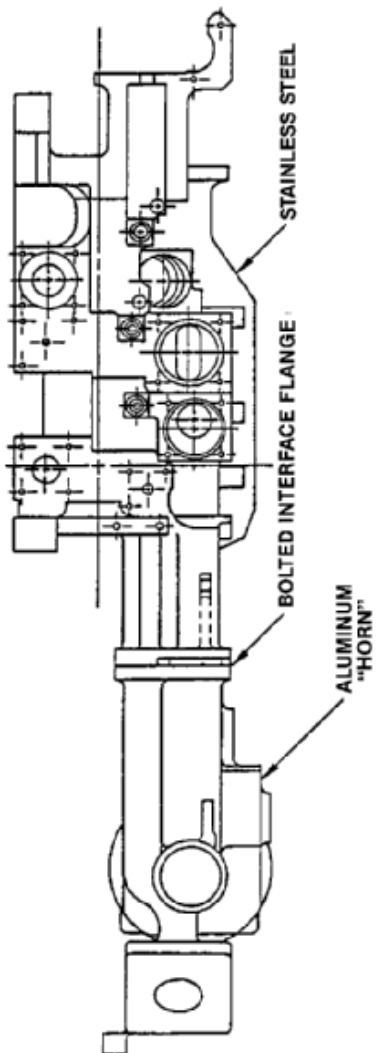
10591008.psd

# PLSS VALVE MODULE – FLOW DIAGRAM



10907016.m8

# PLSS VALVE MODULE

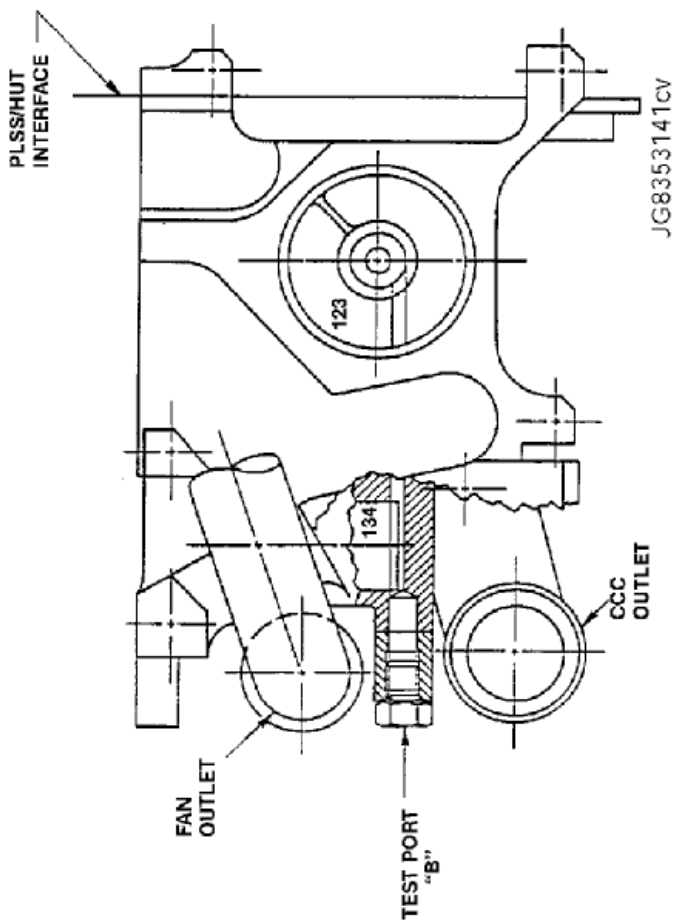


JG8353143cv

## JG8353142CV

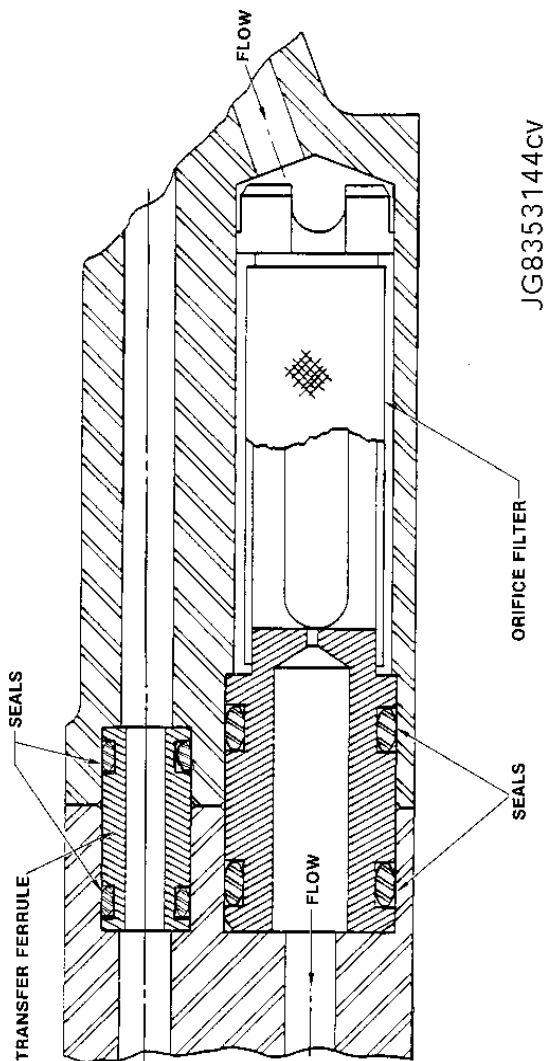


# PLSS VALVE MODULE TEST PORTS



# PLSS VALVE MODULE – FILTER AND ORIFICE

Limits and filters the flow to the CO<sub>2</sub> Transducer (I122).



G-587

REV M

**ITEM 122 IR CO<sub>2</sub> TRANSDUCER**

Senses the CO<sub>2</sub> partial pressure level. The ECWS will issue an alert when the CO<sub>2</sub> partial pressure exceeds 3 mmHg, and a warning when the CO<sub>2</sub> partial pressure exceeds 8 mmHg.

- Input voltage:  $\pm 13.5$  Vdc
- Outputs:
  - 0-5 Vdc into a minimum load of 100K ohms corresponding to a CO<sub>2</sub> pressure of 0.1 to 30 mmHg CO<sub>2</sub>
  - Error band:
    - Set at the calibration point of 8.0 psia in oxygen to be  $\pm 1$  mmHg CO<sub>2</sub> from 0 to 10 mmHg CO<sub>2</sub> with a linear rise to  $\pm 2$  mmHg CO<sub>2</sub> at 20 mmHg CO<sub>2</sub>. The error remains at  $\pm 2$  mmHg CO<sub>2</sub> from 20 – 30 mmHg CO<sub>2</sub>.
    - Unit is sensitive to pressure as shown in Figure. The key output parameter is to cause the CWS to activate a warning tone at 15 mmHg CO<sub>2</sub>.
- Response time:
  - Fifteen seconds maximum to reach 90% of output when exposed to step change in CO<sub>2</sub>

## ITEM 122 IR CO2 TRANSDUCER (Cont'd)

- Test Interfaces

- Inputs

**TEST\*:** Transistor/Transistor Logic (TTL) logic level, active low, used to put the item into a ground test mode, turns on the serial port. This input also unprotects the electrically erasable memory (EEPROM)

**CAUTION:** DO NOT CONNECT TO THIS INPUT DURING NORMAL GROUND TESTING TO AVOID CORRUPTING THE EEPROM. ONLY USE WHILE CALIBRATING THE ITEM.

**RX\* TTL level serial input** used to reprogram calibration levels and the sensor lookup table. Operates at a 9600 baud rate. Can be used in conjunction with an RS232 buffer to connect up to a terminal.

- Outputs:

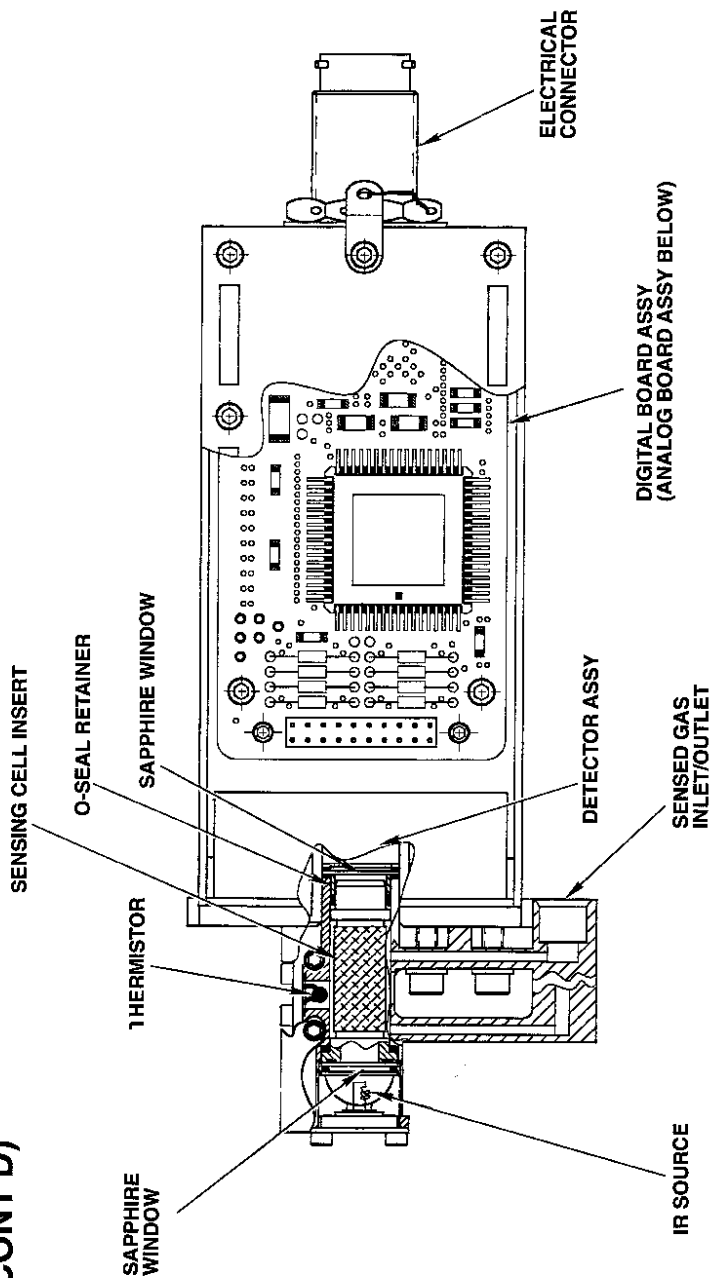
**BITFLG\*:** TTL logic level output which indicates a failure has occurred, active low.

**TX\*:** TTL logic level serial output used to display internal transducer operational parameters and self-health status information. Operates at a 9600 baud rate. Can be used in conjunction with an RS232 buffer to connect up to a terminal.

The Item 126 orifice size is  $0.022 \pm 0.001$  inches per drawing SV809637 Rev.C.

ITEM 122  
(CONT'D)

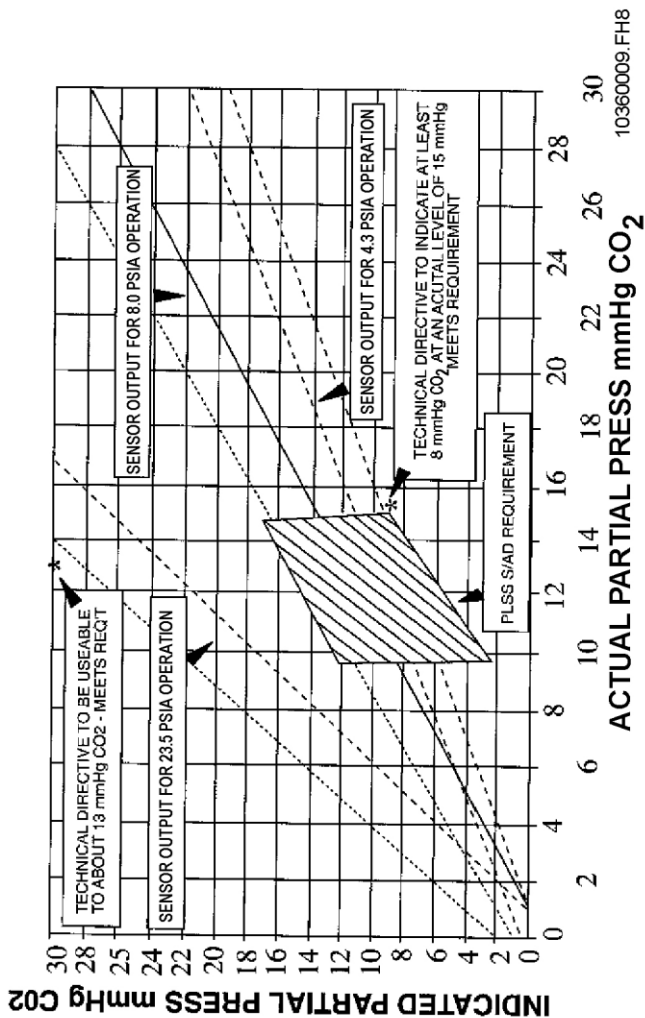
# IR CO2 TRANSDUCER



JG8353140cv

ITEM 122  
(CONT'D)

IR CO<sub>2</sub> TRANSDUCER OUTPUT



10360009.FH8

REV M

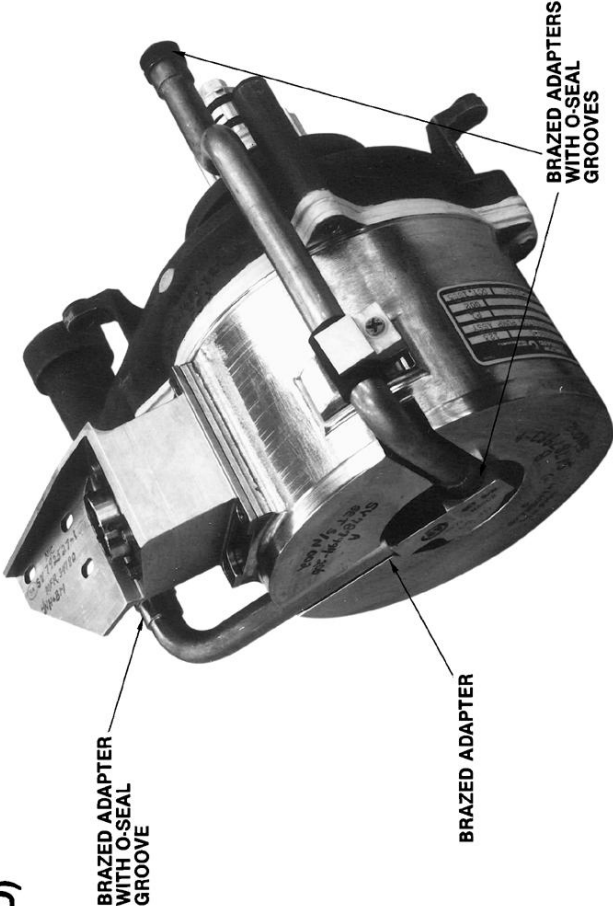
ITEM 123      FAN/SEPARATOR/PUMP ASSEMBLY

A single electric motor drives the vent loop fan, the water separator, and the coolant loop pump.

- Fan (EVA)
  - Flow to suit.....6 ACFM min.
  - Delta P of suit.....1.05 in. H<sub>2</sub>O
- Pump (EVA)
  - Flow to suit.....240 PPH min.
  - Delta P of suit.....2.0 psid
- Water separator (IVA)
  - Water flow.....9.0 ± 0.1 PPH
  - Delta P.....16.6 psid

FAN / SEPARATOR / PUMP ASSEMBLY

ITEM 123  
(CONT'D)



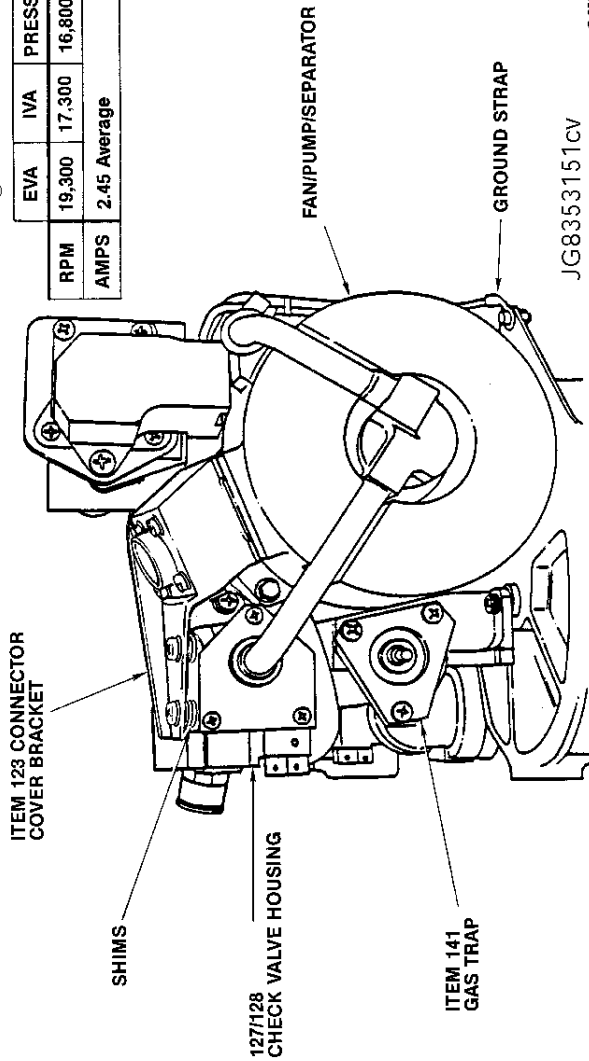
JG8353138cv

G-581

## FAN / SEPARATOR / PUMP ASSEMBLY

ITEM 123  
(CONT'D)TYPICAL PERFORMANCE  
@ 16 VOLTS

	EVA	IVA	PRESS
RPM	19,300	17,300	16,800
AMPS	2.45 Average		

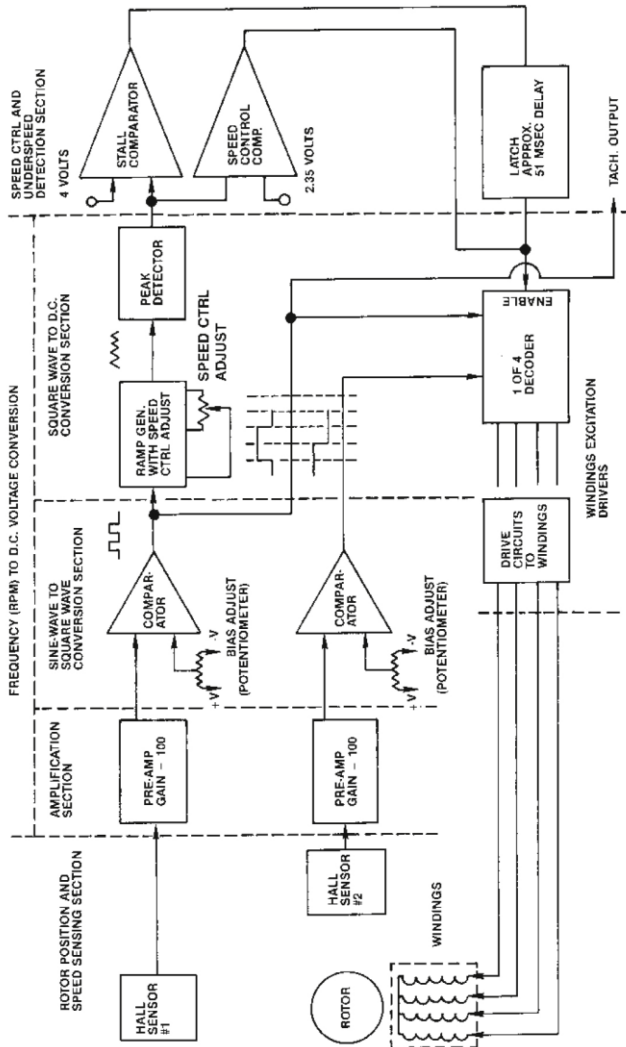


JG8353151cv

G-956

## EMU MOTOR ASSEMBLY BLOCK DIAGRAM

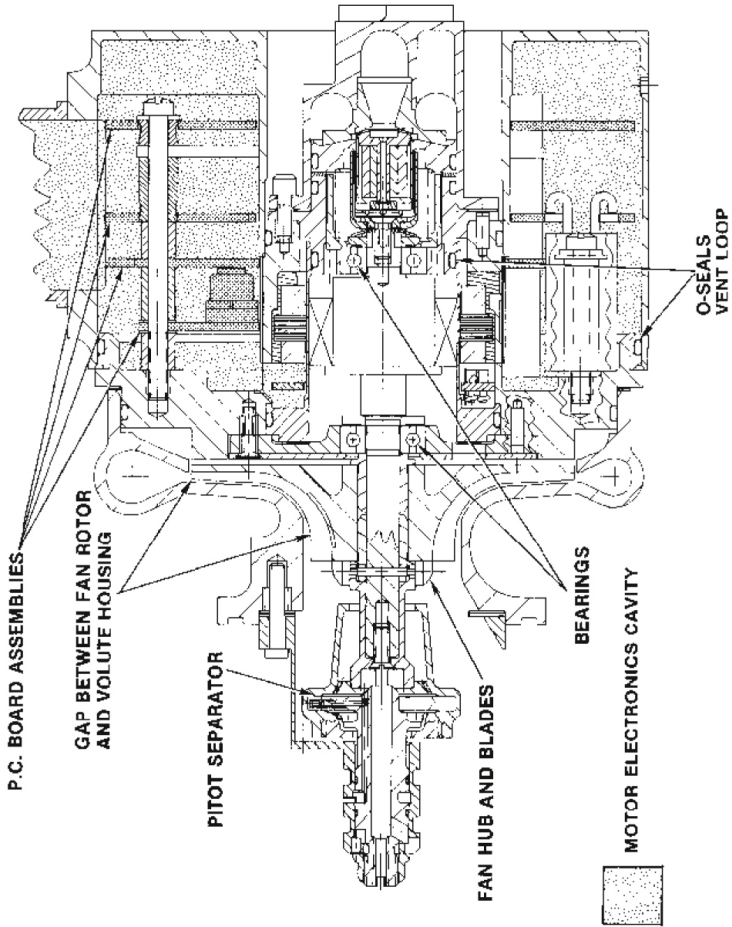
**ITEM 123  
(CONT'D)**



10625003.psd

ITEM 123  
(CONT'D)

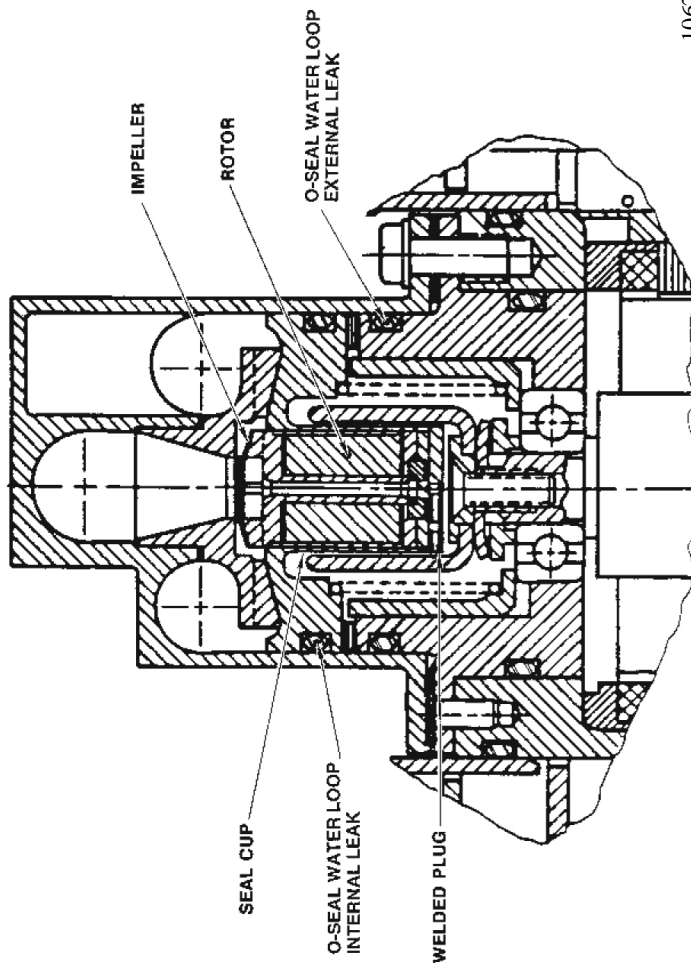
FAN/SEPARATOR/PUMP/MOTOR ASSEMBLY



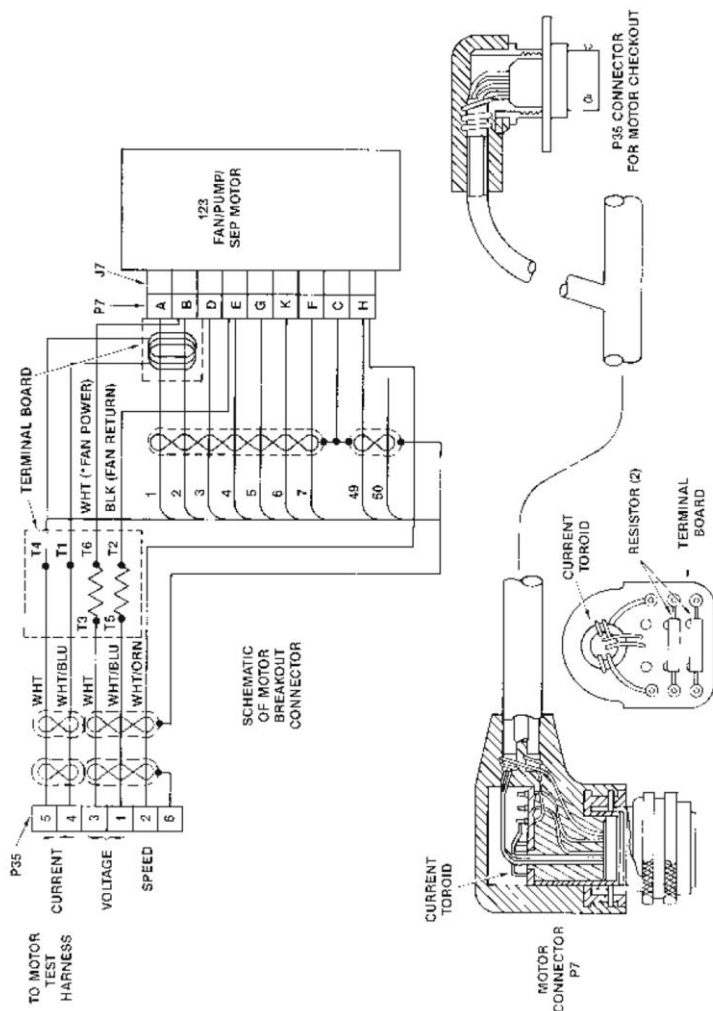
10625002.psd

## ITEM 123C

## WATER PUMP ASSEMBLY



## MOTOR BREAKOUT HARNESS



10625001.psd

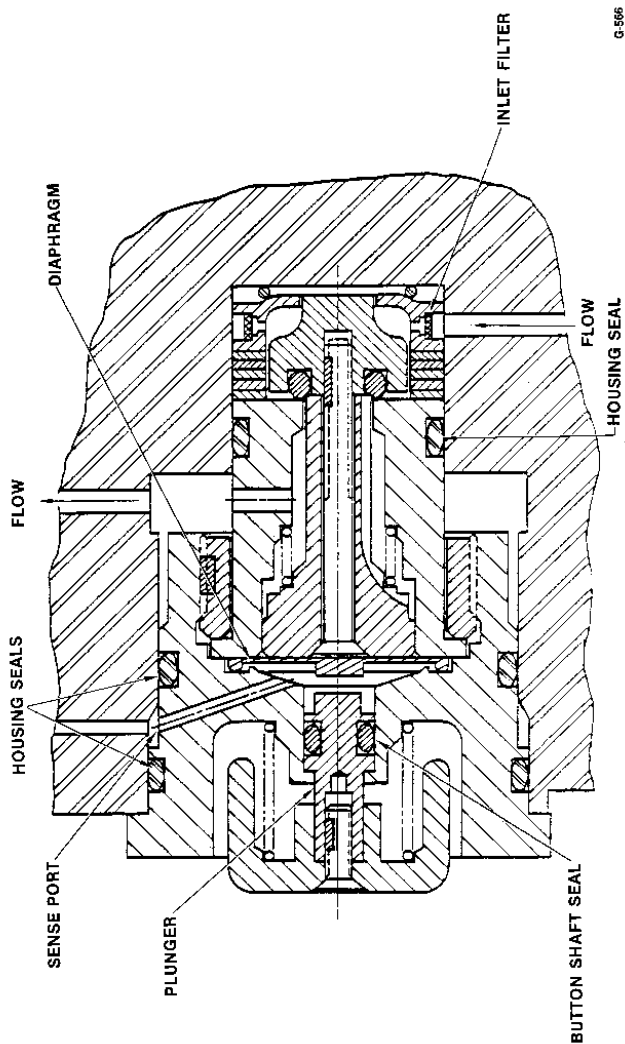
ITEM 125     PITOT ACTUATED VALVE

This valve isolates the vent loop from the coolant loop. When condensate reaches the Water Separator, the pressure increases and the valve opens allowing the coolant loop to degas. The coolant loop may be degassed by manually actuating the valve open.

- Flow rate.....8.3 ± 0.3 PPH
- Delta P.....0.2 psid max.
- Cracking/Reseat pressure.....2 – 5 psid
- Manual actuation force.....3 – 9 lbs.

ITEM 125

## PITOT ACTUATED VALVE



G-566

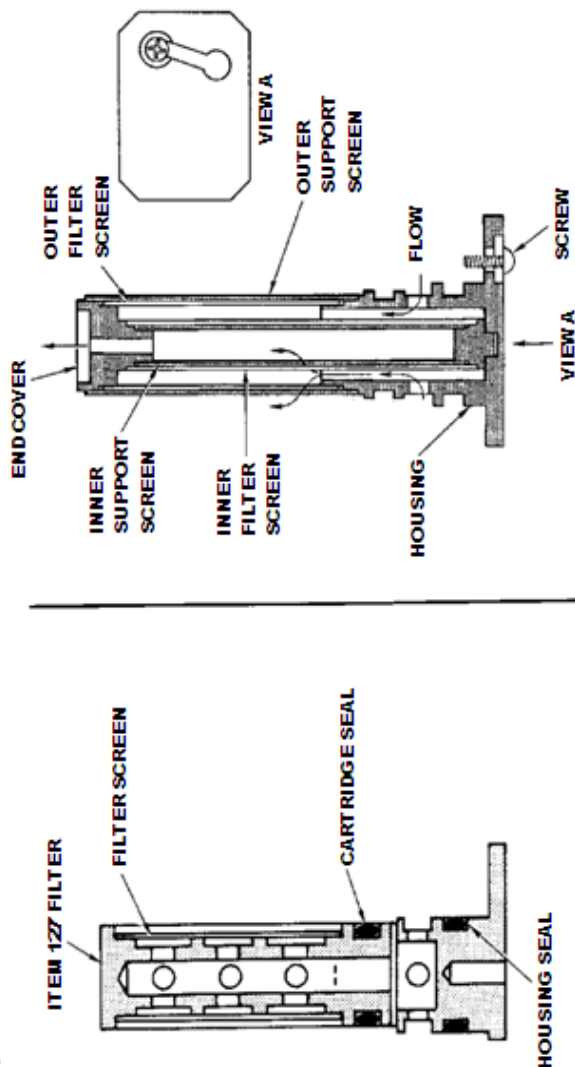
JG8353145cv

**ITEM 127 PUMP INLET FILTER**

- **Flow rate.....11.0 PPH  
(@ 0.15 psid max)**
- **Delta P.....4.1 in. H<sub>2</sub>O**
- **Screen mesh.....635 x 635 (20 μ abs.)**

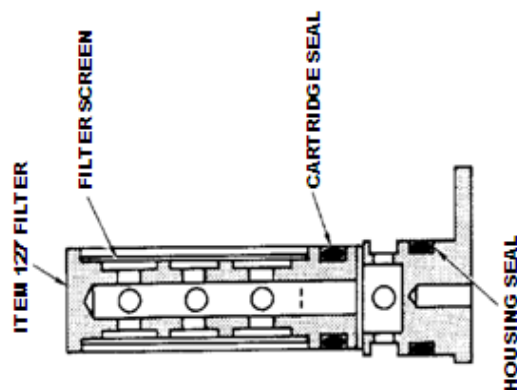
# PUMP INLET FILTER

ITEM 127



JG8353161cv

## ENHANCED PUMP INLET FILTER



## PUMP INLET FILTER

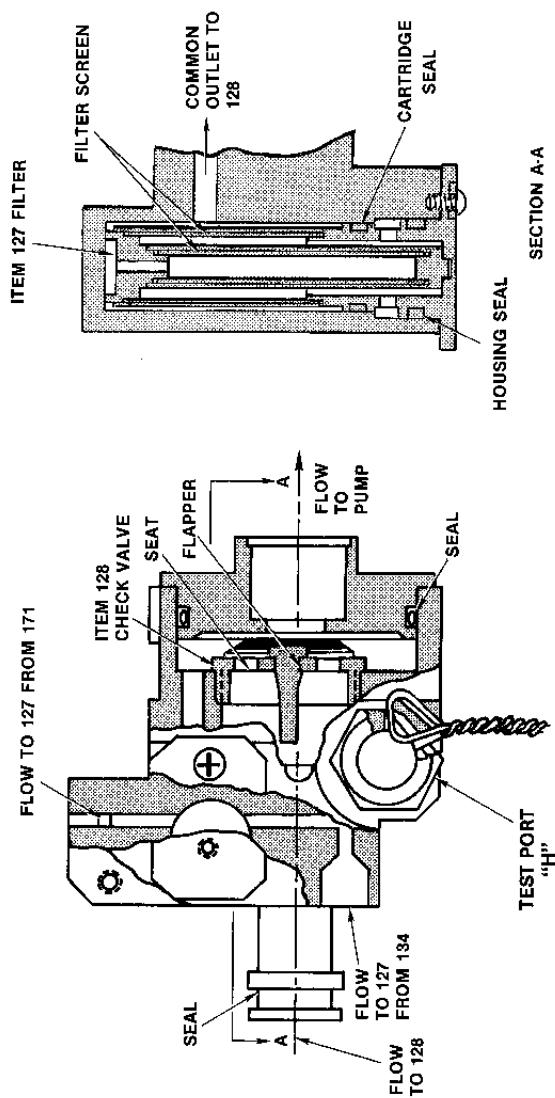
ITEM 128 CHECK VALVE

Prevents reverse coolant flow and allows the pump to be flushed of free gas (bubbles).  
Insures the pump will start with gas in the coolant loop by directing makeup water flow directly to the pump.

- Flow.....260 PPH
- Delta P.....0.15 psid max.
- Internal leakage @ 1 psid.....0.5 PPH max.
- External leakage.....zero (0.001 cc/hr) @ 25 psid

## ITEM 127/128

## CHECK VALVE AND FILTER



Q-530

JG8353159cv

ITEMS 131 AND 162 PRIMARY WATER TANKS

Stores expendable water for cooling and acts as an accumulator for the coolant loop.

- **P<sub>max</sub>**.....20 psid
- **Capacity**.....8.35 lbs. H<sub>2</sub>O  
(Total of both I-131 & I-162)

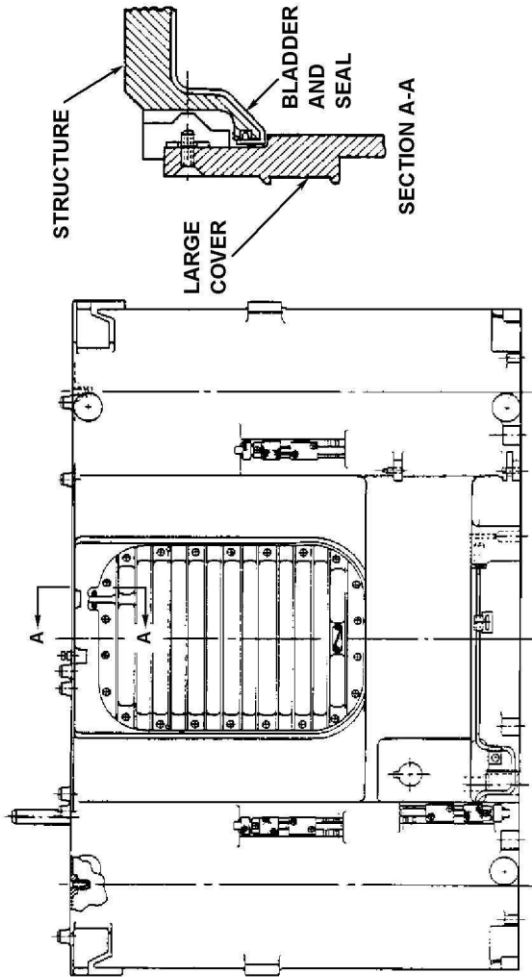
ITEM 148 RESERVE WATER TANK

Contains expendable water for ½ hour of cooling. Tank isolated by Items 142 and 143 until main tank pressure falls below 4 psid.

- **P<sub>max</sub>**.....25 psid
- **Capacity**.....0.83 lbs. H<sub>2</sub>O min.

ITEM 131, 148,  
162 (CONT'D)

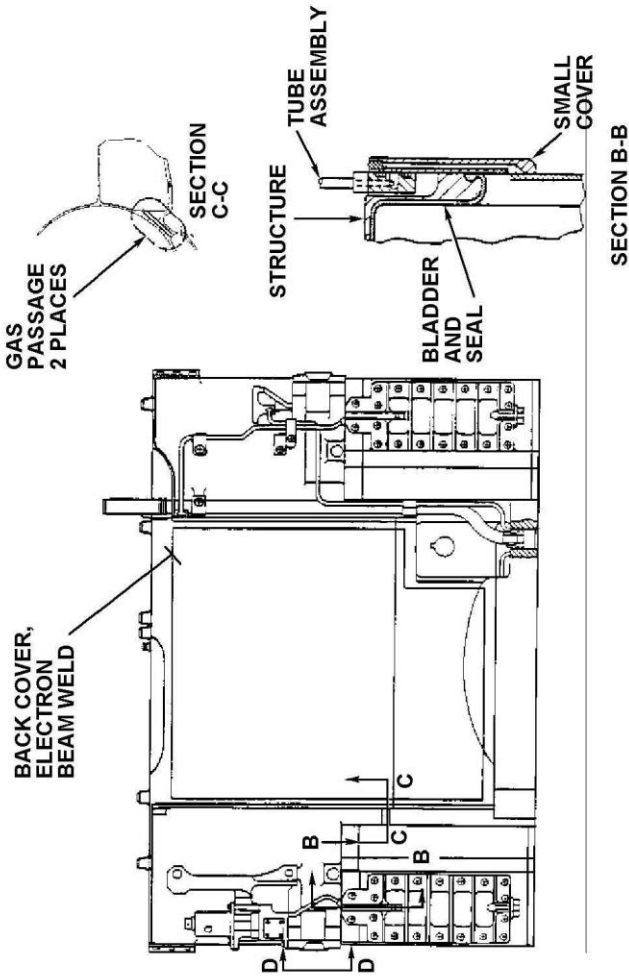
WATER TANK ASSEMBLY



10907015.fm8

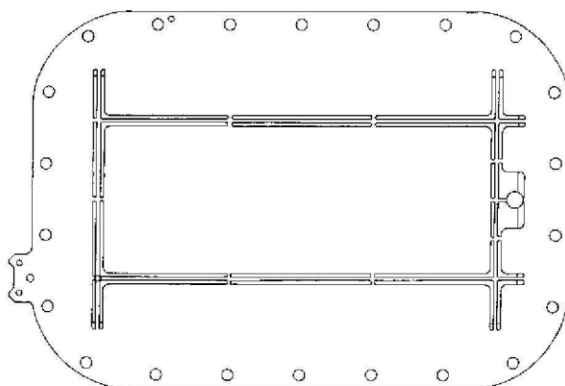
# WATER TANK ASSEMBLY

ITEM 131, 148,  
162 (CONT'D)



10907014.fh8

LARGE WATER TANK COVER

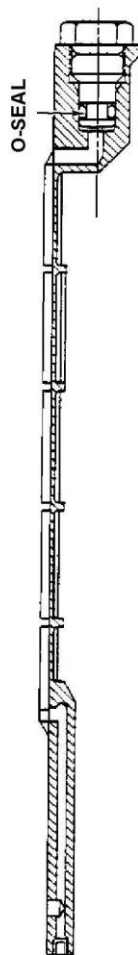
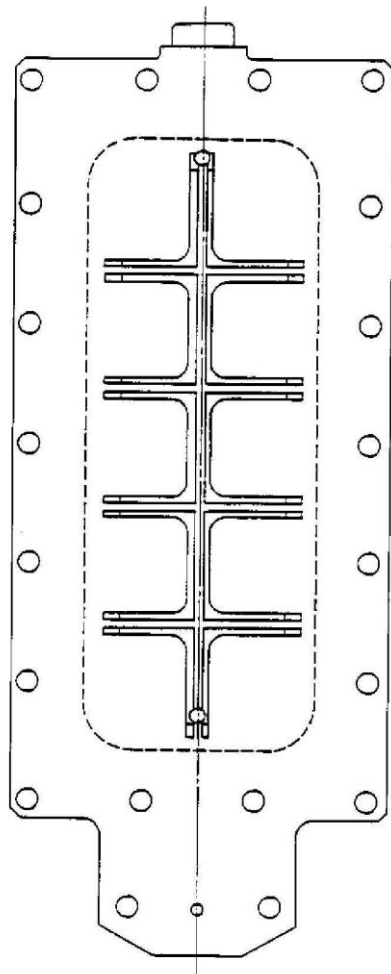


ITEM 131  
(CONT'D)

10607013.fh8

ITEM 148, 162  
(CONT'D)

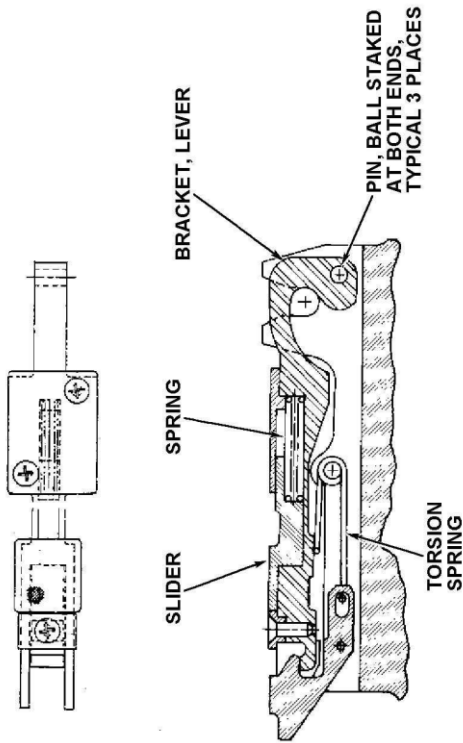
## SMALL TANK COVER



10607012.R/S

**ITEM 131,  
148, 162  
(CONT'D)**

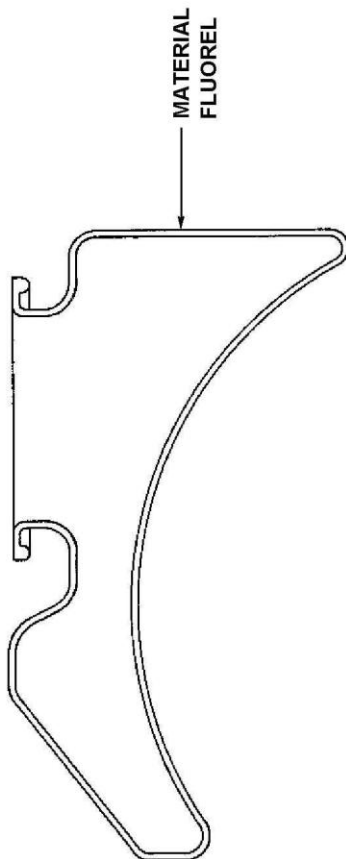
**LEVER AND LATCH ASSEMBLY  
MOUNTED TO WATER TANK STRUCTURE**  
Two latches attach the CCC (I480) to the Water Tank  
and one latch to attach the Battery (I490)



10907011.m3

SMALL WATER TANK BLADDER

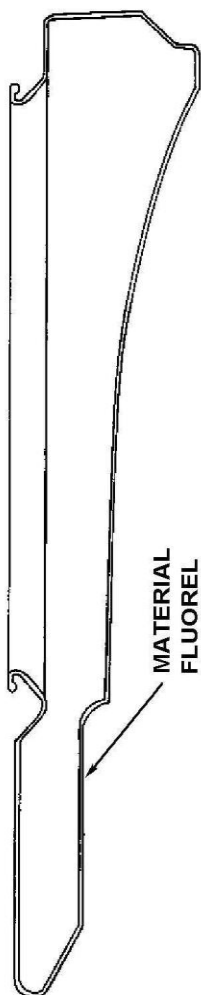
ITEM 148, 162  
(CONT'D)



10907010.m8

# LARGE WATER TANK BLADDER

ITEM 131  
(CONT'D)



10907009.rls

**ITEM 132 A & B      FEEDWATER SUPPLY PRESSURE SENSORS**

Senses the gas pressure (A) and the water pressure (B) in the water tanks. Pressure is displayed by the DCM. When 132A pressure > 2.1 psid over 132B pressure, ECWS indicates primary water supply depleted; reserve H<sub>2</sub>O on.

**SEE ITEM 114 FOR CROSS SECTION**

- Pressure range.....0-40 psia (vacuum reference
- Normal pressure measured.....15 psi above ambient
- Input voltage.....5 Vdc
- Error band.....±2.5% F.S. or ± 1.0 psi

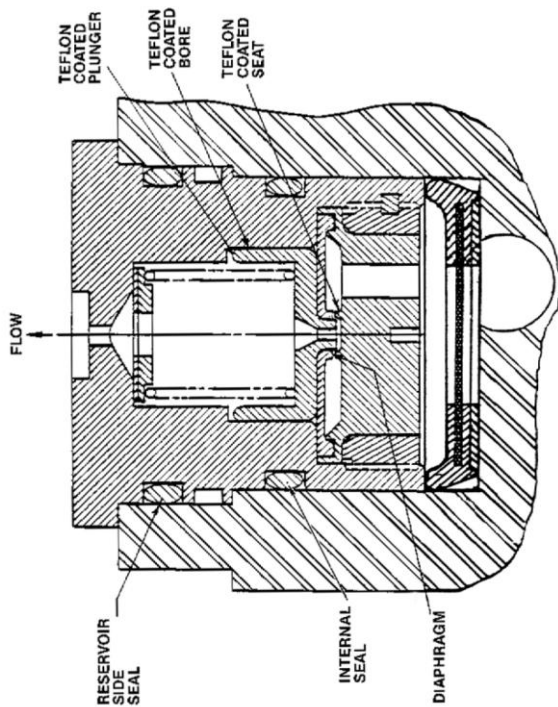
**ITEM 134     CONDENSATE WATER RELIEF VALVE**

**Prevents flooding of the Vent Loop when the F/S/P (Item 123) is off and back pressures the water separator to ensure efficient gas separator function.**

- **Relief/reseat.....2.0 – 3.2 psid**
- **Internal leakage (H<sub>2</sub>O)**
  - **Flow direction.....0.1 PPH at 2.0 psid**
  - **Reverse direction.....0.1 cc/hr at 12 psid**
- **Flow rate ..... 13.2 +1.0/-0.0 PPH**
- **Delta P.....2.35 – 3.5 psid**
- **Inlet filter.....140 micron**

10360008.FH8

## CONDENSATE WATER RELIEF VALVE

ITEM 134  
(CONT'D)

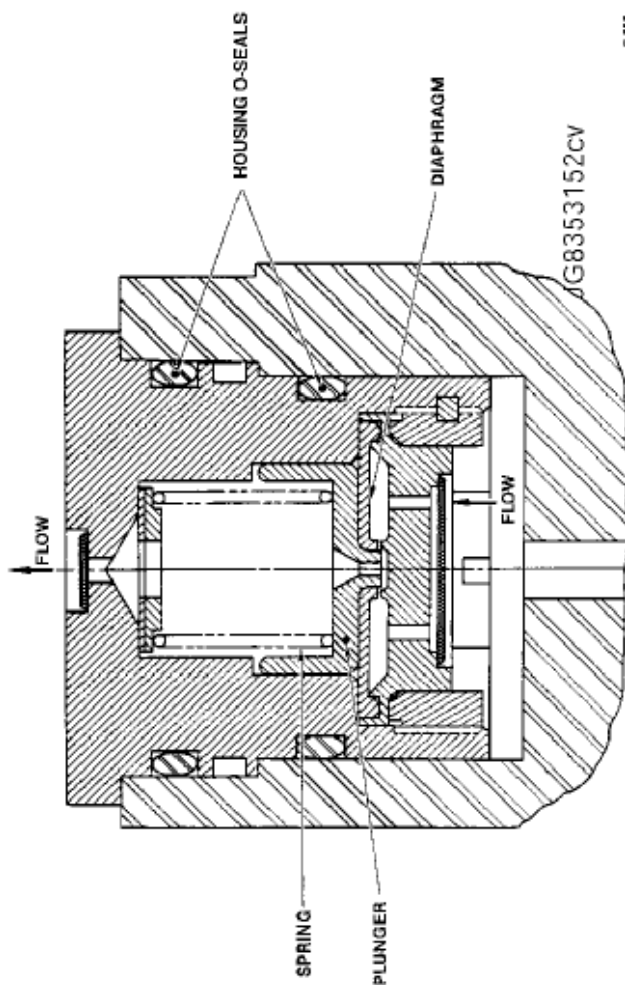
ITEM 135 FEEDWATER RELIEF VALVE

Prevents overpressurization of the coolant and feedwater systems.

- Cracking/reseat.....18 – 20 psid
- Flow @ 20 psid.....0.12 PPH H<sub>2</sub>O min.
- Leakage @ 16 psid.....0.05 cc/hr H<sub>2</sub>O

ITEM 135  
(CONT'D)

## FEEDWATER RELIEF VALVE



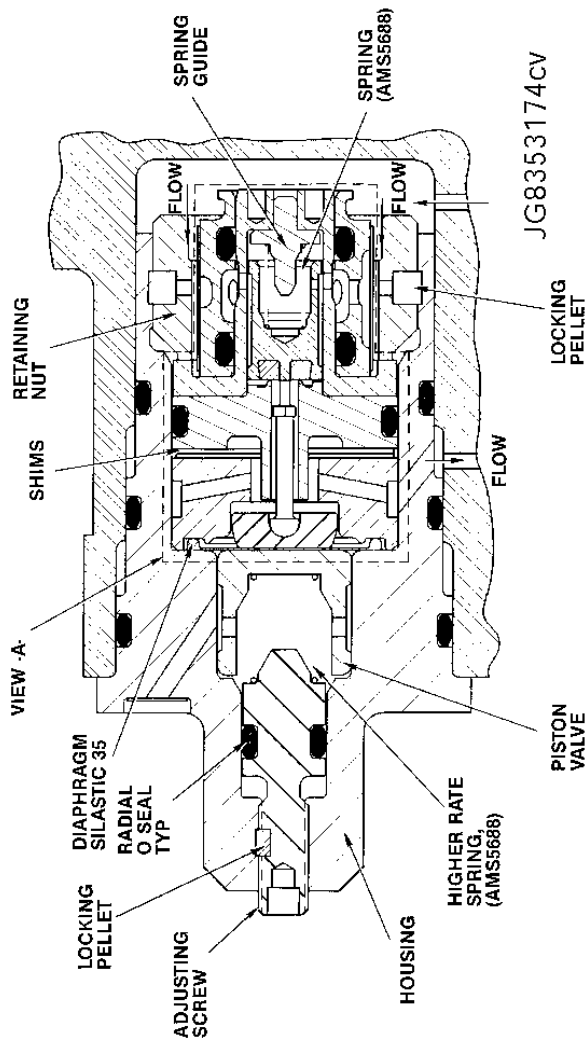
ITEM 136 FEEDWATER PRESSURE REGULATOR

Regulates the pressure of the sublimator feedwater to prevent sublimator breakthrough. Prevents high pressure liquid lockup by allowing reverse flow to the water tanks.

• Inlet pressure.....	9.8 – 15.7 psig
• Flow rate vs. outlet pressure	
	Outlet pressure @
	test port
	Sublimator inlet (design)
0.1 lbs/hr	2.35 – 4.15 psid
5.0 lbs/hr	2.35 – 3.80 psid
• No feedwater demand.....	4.6 psid max. (after 1 min.)
• Reverse flow.....	40 psid max.
• External leakage.....	0.01 cc/hr @ 23 – 25 psid

ITEM 136  
(CONT'D)

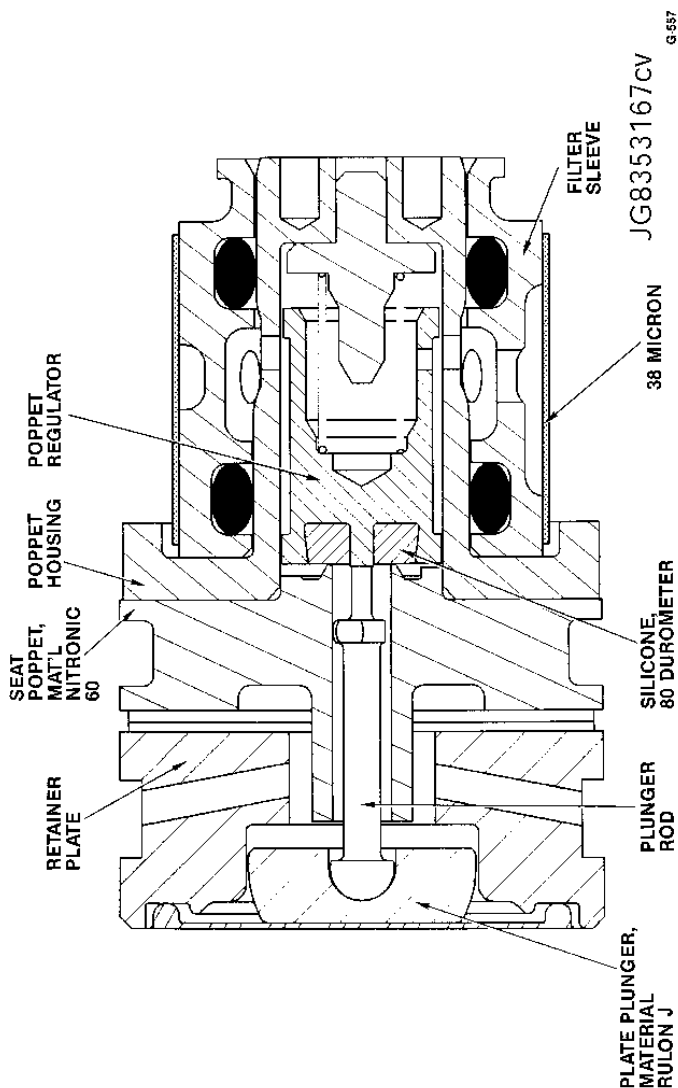
FEEDWATER PRESSURE REGULATOR



G-556

ITEM 136  
(CONT'D)

FEEDWATER PRESSURE REGULATOR, VIEW -A-



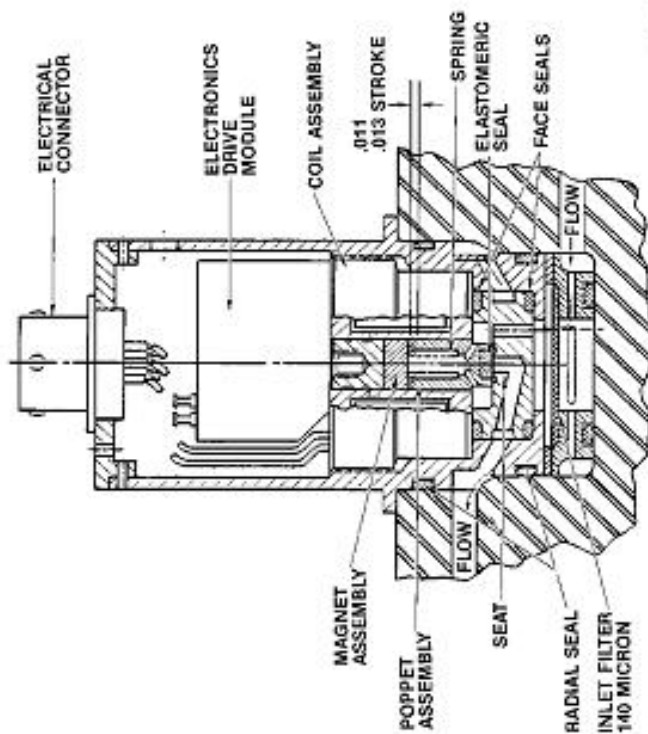
**ITEM 137 FEEDWATER SHUTOFF VALVE**

Isolates the feedwater from the sublimator when not at vacuum and when cooling is not desired. The valve is actuated by a manual switch on the DCM. The valve is magnetically latched in the open position. The Item 137 and Item 171 are of similar design.

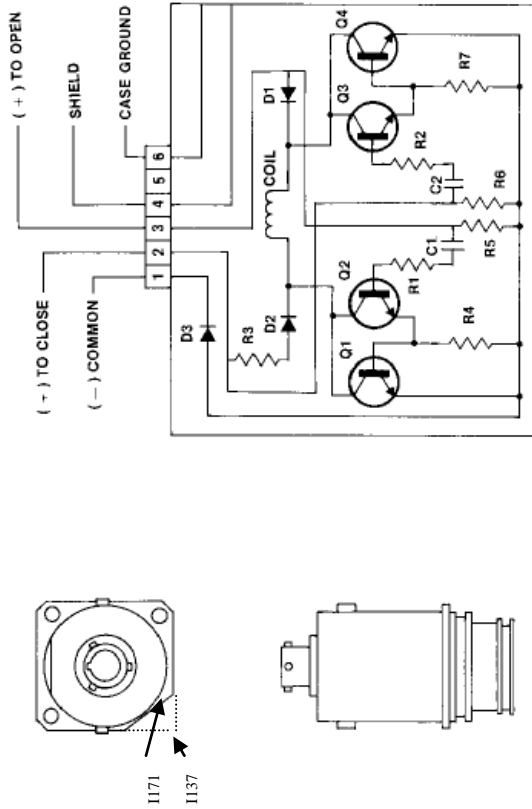
- External leakage.....Zero bubbles at 47 psid
- Internal leakage.....0.01 cc/hr at 60 psid
- Pressure drop.....0.3 psid max at 3 PPH H<sub>2</sub>O flow

## FEED WATER SHUTOFF VALVE

ITEM 137



ITEM 137 FEED WATER SHUTOFF VALVE ELECTRICAL SCHEMATIC  
(CONT'D)



JG8353191CV

ITEM 138    FEEDWATER PRESSURE SENSOR

(SEE ITEM 114 FOR CROSS SECTION)

Senses sublimator feedwater pressure or ambient pressure when the sublimator is not active. Signal is used by the ECWS to determine airlock pressure and the health of the regulator (I136) and the sublimator (I140).

- Pressure range:.....0 – 16 psia (vacuum reference)
- Normal pressure measured:.....3.5 psia
- Input voltage:.....5 Vdc
- Output voltage:.....0-5 Vdc
- Error band:.....±2.5 FS or ±0.4 psi

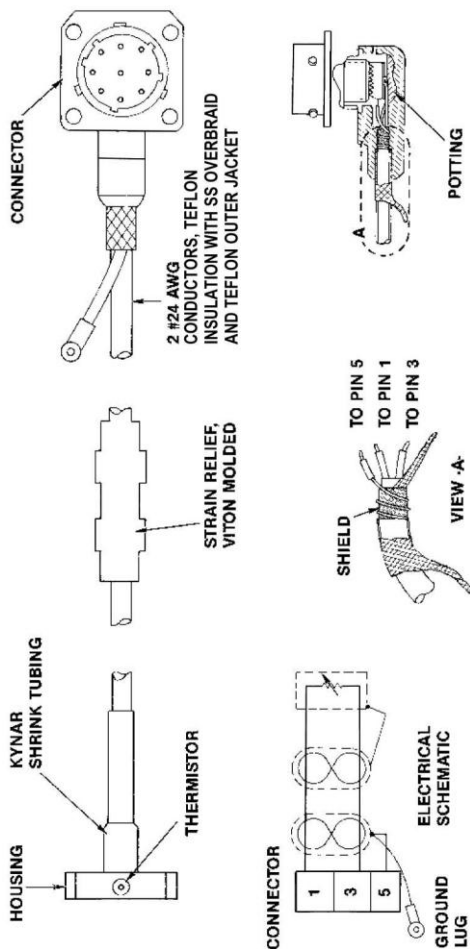
ITEM 139      SUBLIMATOR OUTLET TEMPERATURE SENSOR

Senses the temperature of the coolant leaving the sublimator and helps to determine the health of the sublimator (Item 140). The temperature is displayed by the DCM.

- Temperature range operating:.....32 to 125°F
- Temperature range non-operating:.....-65 to 120°F
- Resistance at temperature.....32°F, 32, 650  $\pm$  452 ohms  
.....70°F, 11,882  $\pm$  150 ohms  
.....77°F, 10,000 ohms nominal
- Time response.....63% of temperature within 4 seconds in flowing water
- Accuracy..... $\pm$ 1.5°F

ITEM 139  
(CONT'D)

TEMPERATURE SENSOR HARNESS

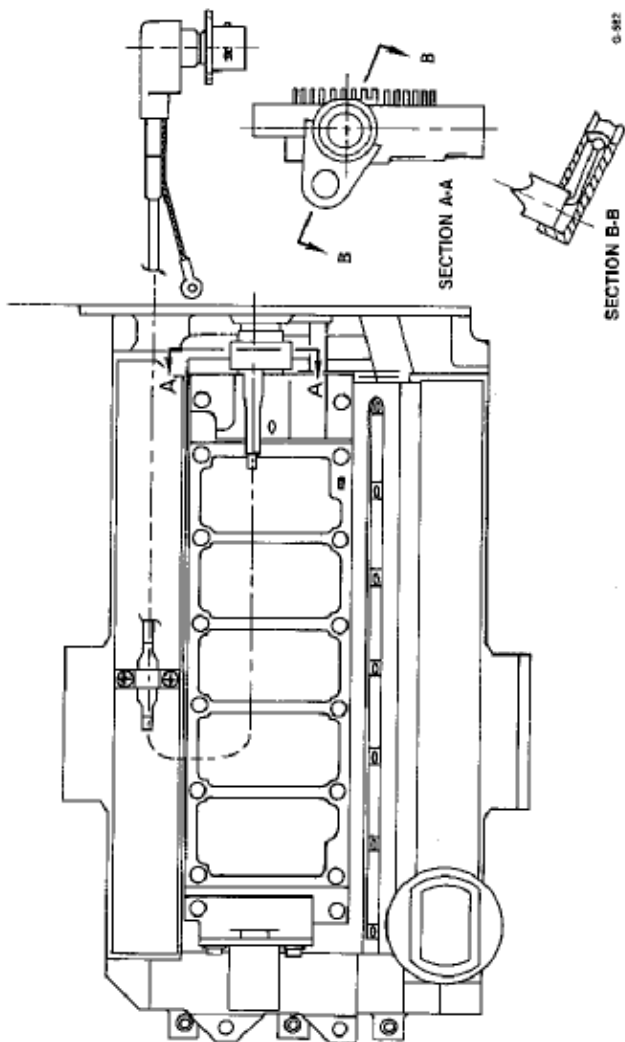


10360012.psd

REV M

ITEM 139,140

SUBLIMATOR AND HARNESS



JG8353171CV

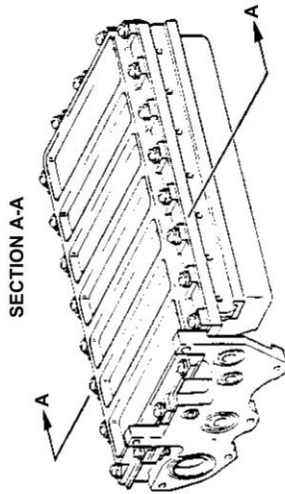
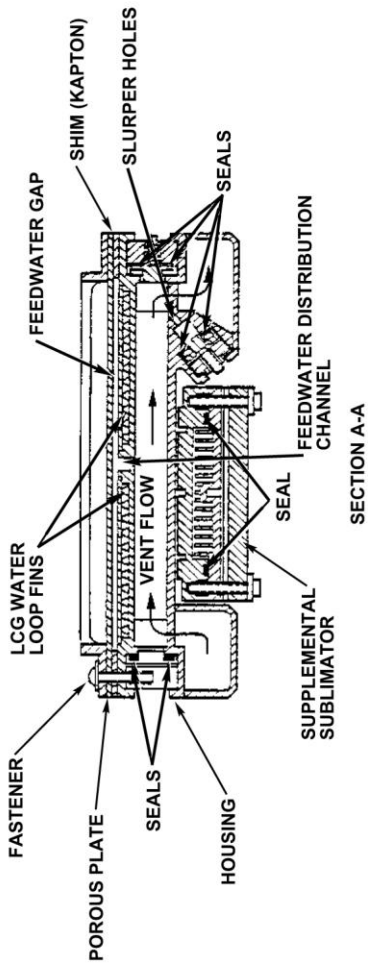
**ITEM 140    SUBLIMATOR**

**Cools the vent and coolant loops by sublimating feedwater to vacuum. Also cools the vent loop with the coolant loop when connected to the vehicle heat sink by the SCU.**

- **Performance:**
- **UA.....120 BTU/HR/°F minimum**
- **Slurper gas flow rate.....0.8 ACFM max.**
- **Vent inlet dew point.....91.4°F max.**
- **Condensate flow.....0.57 PPH (expected)**
- **Vent outlet dew point.....55.2°F max.**
- **Coolant loop inlet.....59.7°F**
- **Coolant loop outlet.....53°F max.**

ITEM 140  
(CONT'D)

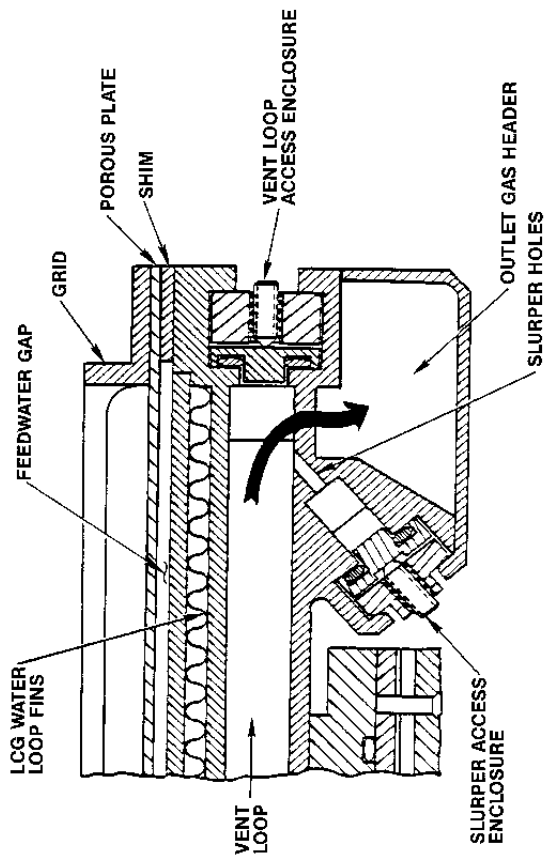
## SUBLIMATOR



11048001.fh7

ITEM 140  
(CONT'D)

## SUBLIMATOR SLURPER CONFIGURATION



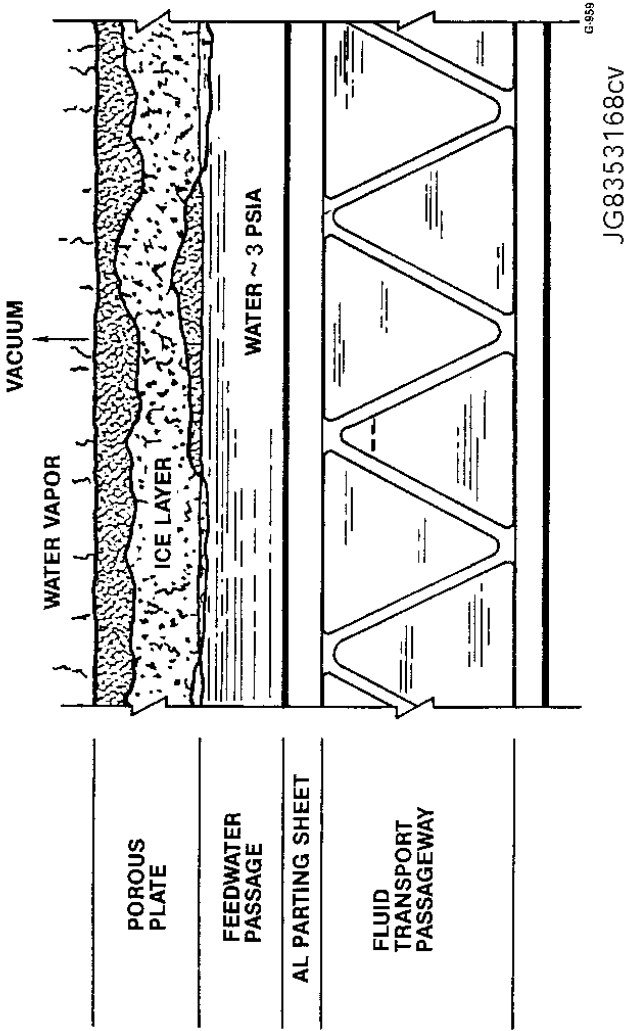
REV M

G-503

JG8353169cv

ITEM 140  
(CONT'D)

SUBLIMATOR



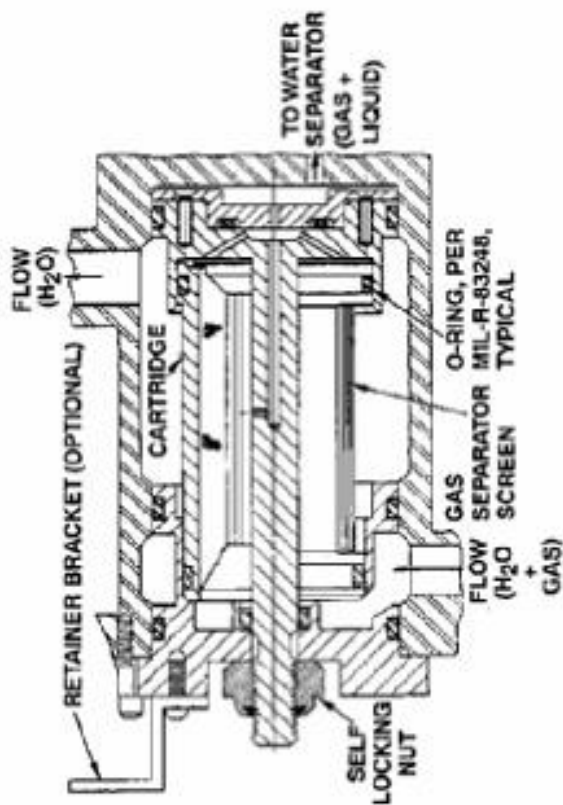
ITEM 141 GAS TRAP

Removes particulate contamination from the water flow to the pump and concentrates and directs free gas in the coolant loop to the gas separator. The enhanced gas trap was designed with a special screw retainer bracket to prevent escape of the screws and washers during ORU changeout.

- Orifice flow.....9.5 ± 0.8 PPH at 11 ± 0.2 psid
- Gas separation.....360 acc/min at 200 PPH H<sub>2</sub>O at 8.33 ± 2.5 psid
- Bubble point.....1<sup>st</sup> bubble – 7.5 in. H<sub>2</sub>O min. (alcohol)  
.....Open bubble – 12.0 in. H<sub>2</sub>O max. (alcohol)
- Pressure loss.....0.82 in. H<sub>2</sub>O max. at 260 PPH at 70°F

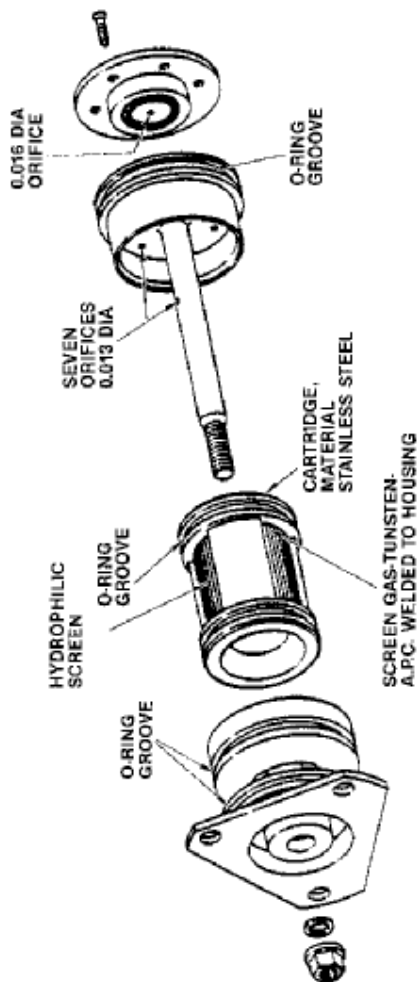
ITEM 141  
(CONT'D)

## Enhanced Gas Trap



ITEM 141  
(CONT'D)

# EXPANDED AREA GAS TRAP



JG8353165cv

6-587

REV M

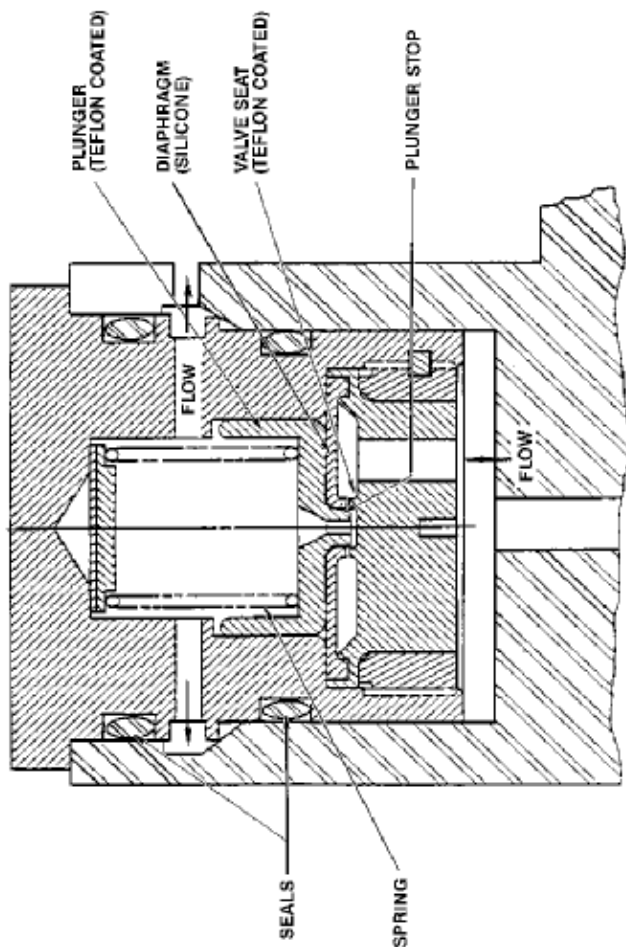
**ITEM 142    WATER RELIEF VALVE**

Isolates the reserve water tank (148) until the primary water tank is empty. Prevents the reserve feedwater from being used until the primary tank water pressure drops 4 psi minimum below reserve water tank pressure.

- Flow.....40 pph at 15 psid
- Relief .....Cracking – 4 psid min  
Flow 5 pph min at 5 psid  
Reseat 3.0 psid min
- Internal Leakage:.....1.0 cc/hr max at 3.5 psid
- Flow.direction.....1.0 cc/hr max at 3.5 psid
- Reverse direction.....10 cc/hr max at 0.3 psid

ITEM 142  
(CONT'D)

## WATER RELIEF VALVE



G-345

JG8353164CV

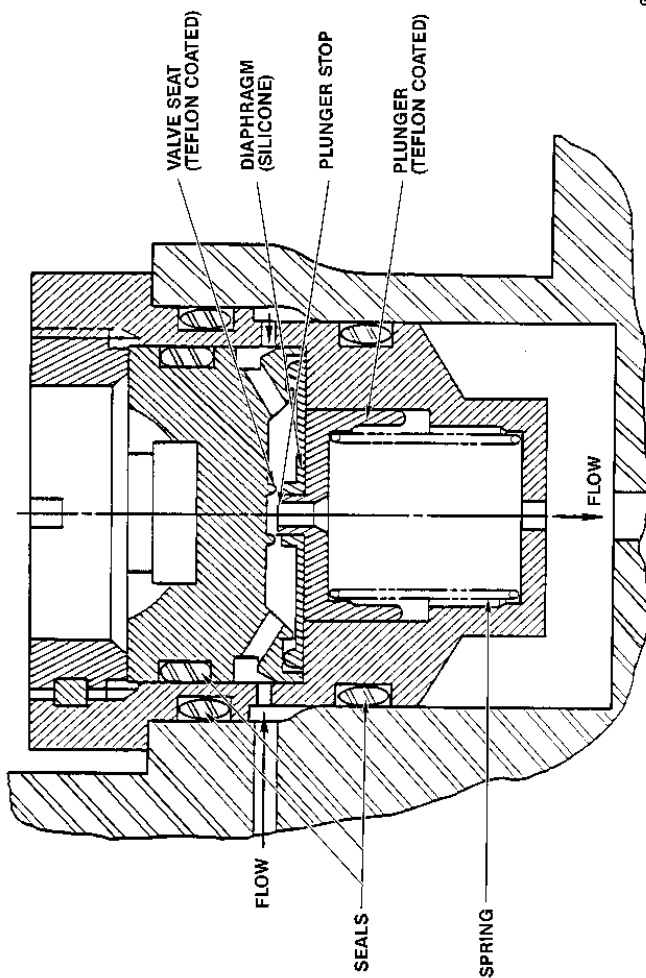
**ITEM 143 WATER CHECK VALVE**

**Isolates the reserve water tank from the primary water tank during the mission. Permits reserve water tank charging in parallel with the primary water tank.**

- **Relief pressure.....1.0 psid max.**
- **Reseat pressure.....0.5 psid min.**
- **Flow.....50 PPH min. at 17 psid**
- **Reverse leakage.....1.0 cc/hr max. at 5 psid**

ITEM 143  
(CONT'D)

## WATER CHECK VALVE



G 542

JG8353163CV

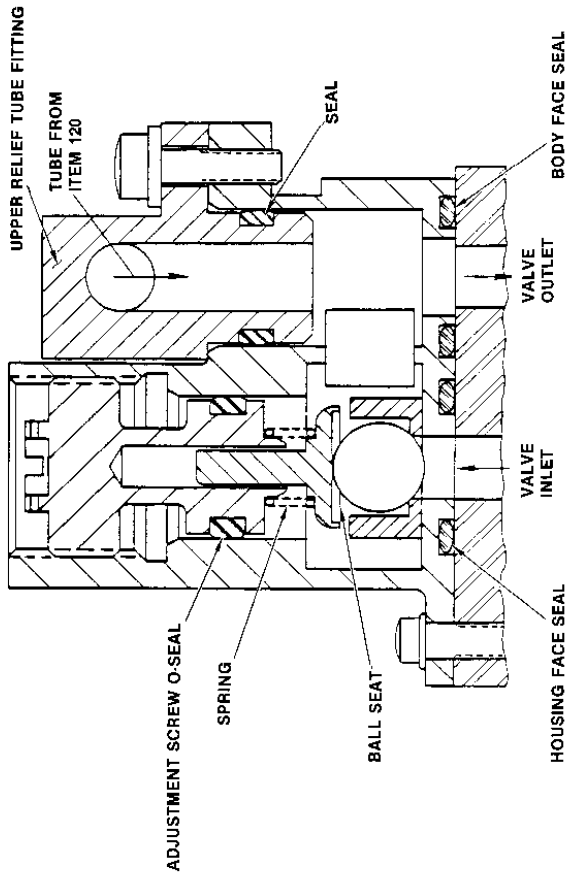
ITEM 145 RELIEF VALVE AND ORIFICE

Item seal closed.

- Internal leakage .....85 SCCM w/  
0.15 PSID @ 4.3 PSID

ITEM 145  
(CONT'D)

RELIEF VALVE



G-543

JG8353162cv

(Adjustment screws bottom hard seal on sapphire ball to keep valve closed)

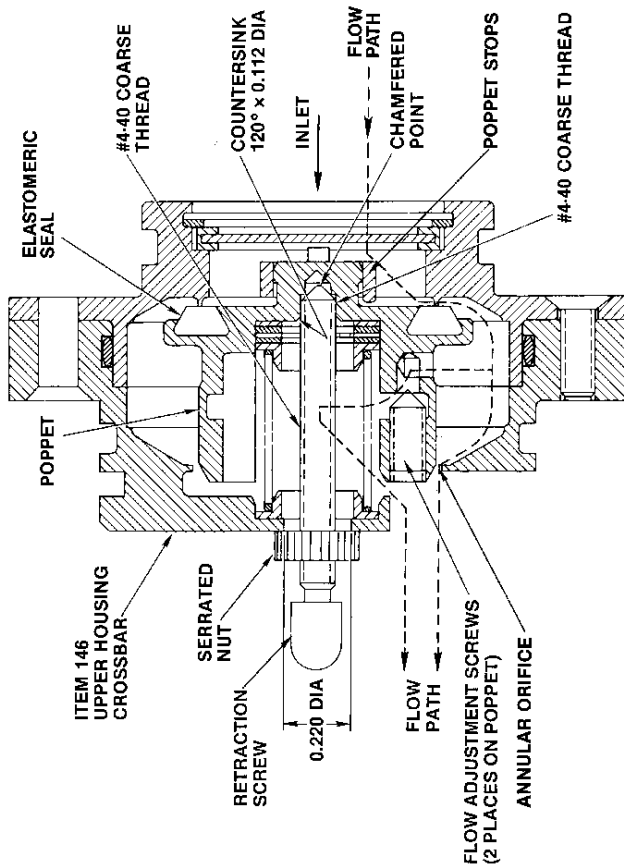
**ITEM 146 POSITIVE PRESSURE RELIEF VALVE**

Limits suit pressure during airlock depressurization and in the event of a regulator (Item 113 or Item 213) failure.

- Cracking pressure.....4.7 psid min.
- Reseat pressure.....4.6 psid min.
- Flow (failed open).....5.49 PPH dry O<sub>2</sub> max. at 3.42 psia
- Minimum flow .....7.79 PPH dry O<sub>2</sub> at 5.5 psia max  
equivalent to 7.49 PPH O<sub>2</sub> plus H<sub>2</sub>O  
vapor at 60°F dewpoint at 5.5. psia

# POSITIVE PRESSURE RELIEF VALVE

ITEM 146  
(CONT'D)



JG8353183cv

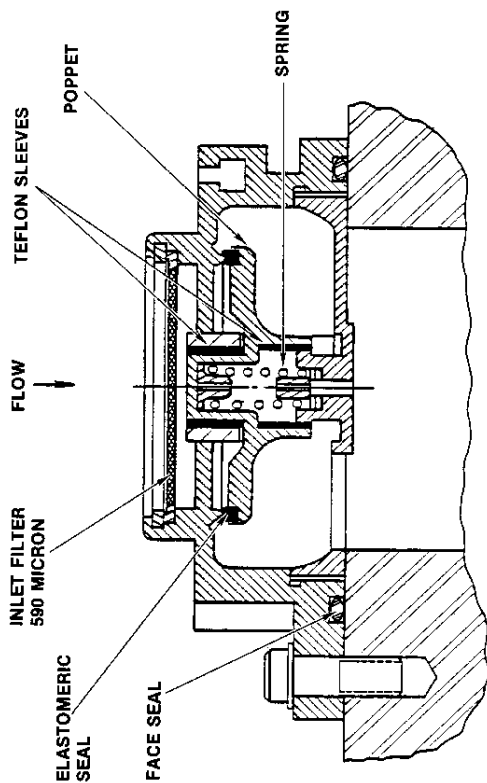
**ITEM 147      NEGATIVE PRESSURE RELIEF VALVE**

**Limits suit negative pressure in the event of emergency airlock repressurization with low O<sub>2</sub> tank pressures.**

- **Cracking pressure.....0.2 psid min.**
- **Reseat pressure.....0.2 psid min.**
- **Pressure drop.....0.8 psid max at 32 PPH air  
and 4.15 psia ambient  
pressure**
- **Leakage.....2.8 x 10<sup>-4</sup> scc/sec O<sub>2</sub> max. @  
4.0 psid and 14.7 psia  
ambient pressure**

**ITEM 147  
(CONT'D)**

**NEGATIVE RELIEF VALVE**



**REV M**

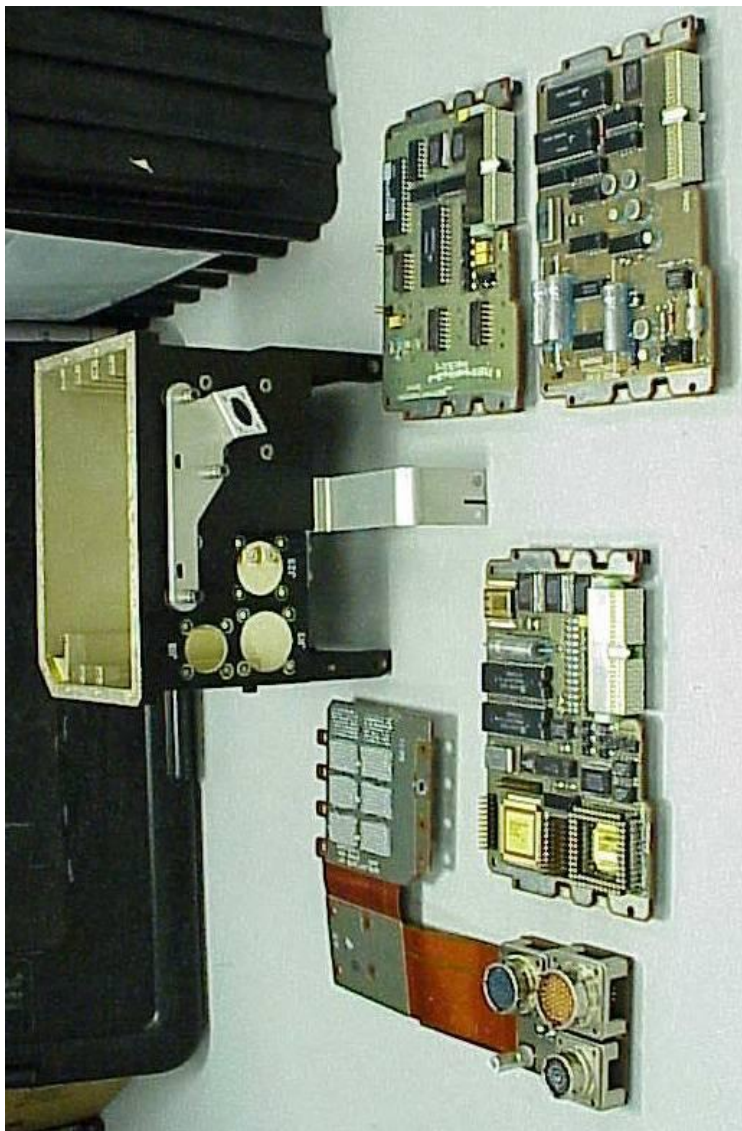
G544

JG8353182cv

**ITEM 150 ENHANCED CAUTION AND WARNING SYSTEM**

- Monitors analog and discrete signals from DCM, PLSS, and SOP
- Monitors speed of motor
- Detects EMU faults
- Calculates usage rates of consumables
- Calculates time left on primary O<sub>2</sub>, secondary O<sub>2</sub>, water, and battery
- Performs suit leak check
- Displays anomaly messages on DCM
- Displays status messages on DCM
- Generates warning, status, and alert tones using EVC
- Transmits sensor and calculated data to SSER for ground support

**ITEM 150      Enhanced Caution and Warning System Assembly  
Cont'd**



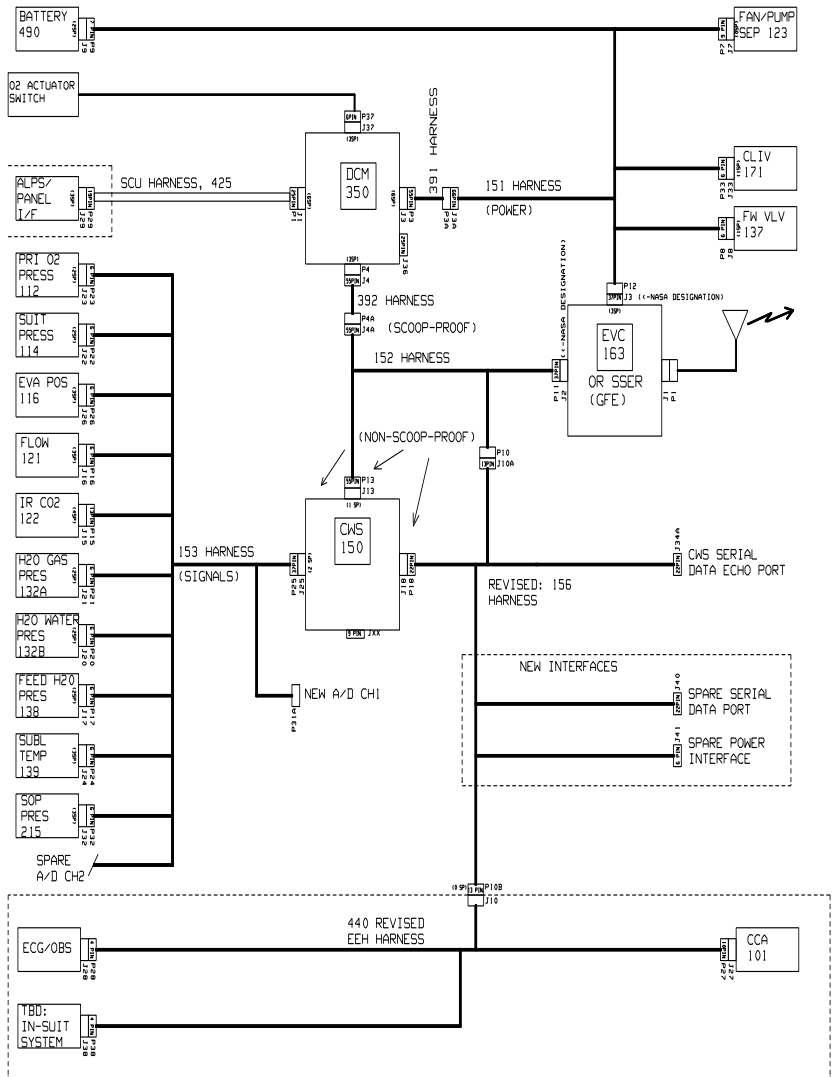
**REV M**

## ITEM 151, 152, 153 AND 156 PLSS HARNESES

### Function:

- **Item 151 – Electrical Power Harness**  
Connects battery power thru the DCM switches to the coolant water solenoid, motor, feedwater solenoid and SSER.
- **Item 152 – Electrical Signal Harness**  
Provides the power, signal and switching interfaces between the DCM and ECWS. Also provides the switching/power between the DCM and EVC and between the ECG and the SSER.
- **Item 153 – Caution and Warning Harness**  
Connects the sensor inputs/outputs to the ECWS.
- **Item 156 – Real Time Data System Harness or EMU Electrical Harness**  
Electrically connects the Real Time Data System, Item 174, to the ECG signal, the 5V power from the 153 harness, the serial data signal from the ECWS, and the serial data signals to the J34A test connector and the 153 harness. It also connects the CCA lines to the 152 harness.

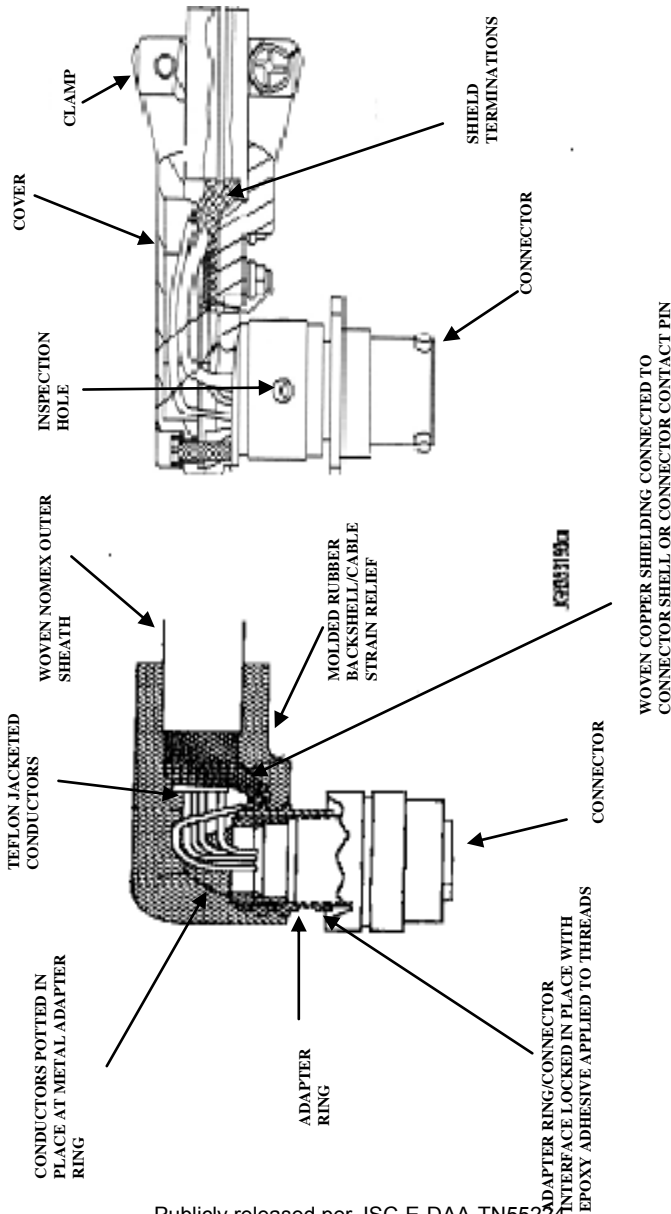
## EMU HARNESS BLOCK DIAGRAM WITH ECWS



(eemu/avs/retrodcn:  
9/18/2000)

ITEM 151,152, HARNESES TYPICAL RIGHT DANGLE CONNECTOR  
 153,156 OLD STYLE BACKSHELL METAL BACKSHELL

REV M



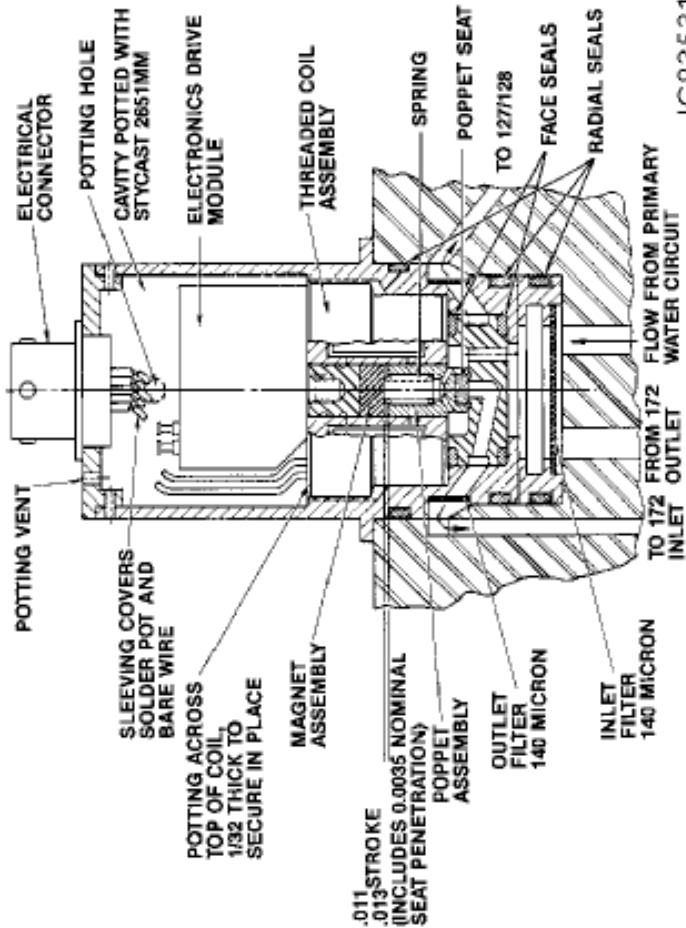
Publicly released per JSC-E-DAA-TN55224

**ITEM 171      COOLANT ISOLATION WATER SHUTOFF VALVE**

Isolates the coolant loop from the feedwater tanks. Prevents flooding of the vent loop in the event of an Item 134 or Item 125 failure and the Fan/Separator/Pump (Item 123) not running. Valve is actuated by the F/S/P (Item 123) switch on the DCM. The valve is open when the F/S/P is on. The valve is magnetically latched in the open position. Spring force holds the valve in the closed position. The Item 171 and Item 137 are of similar designs.

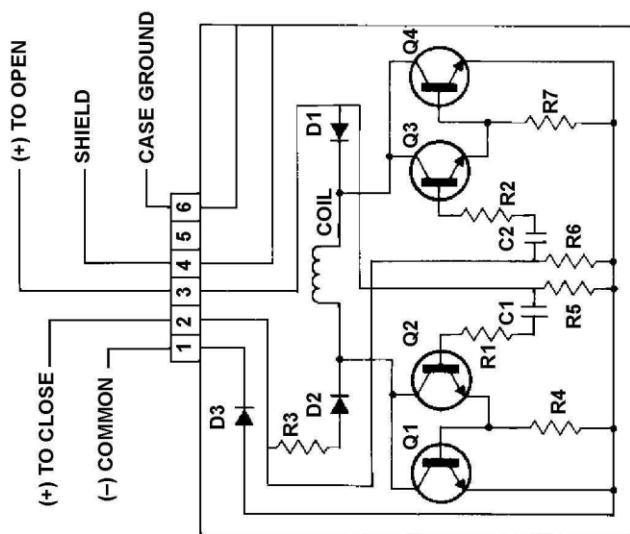
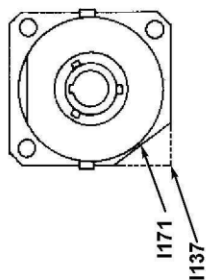
- Internal leakage.....0.1 cc/hr H<sub>2</sub>O at 20 psid
- Pressure drop.....4.0 psid max. at 47.0 PPH min. H<sub>2</sub>O flow
- Reverse direction pressure drop.....0.1 psid max. @ 0.3 PPH min.

## ITEM 171 COOLANT ISOLATION WATER SHUTOFF VALVE



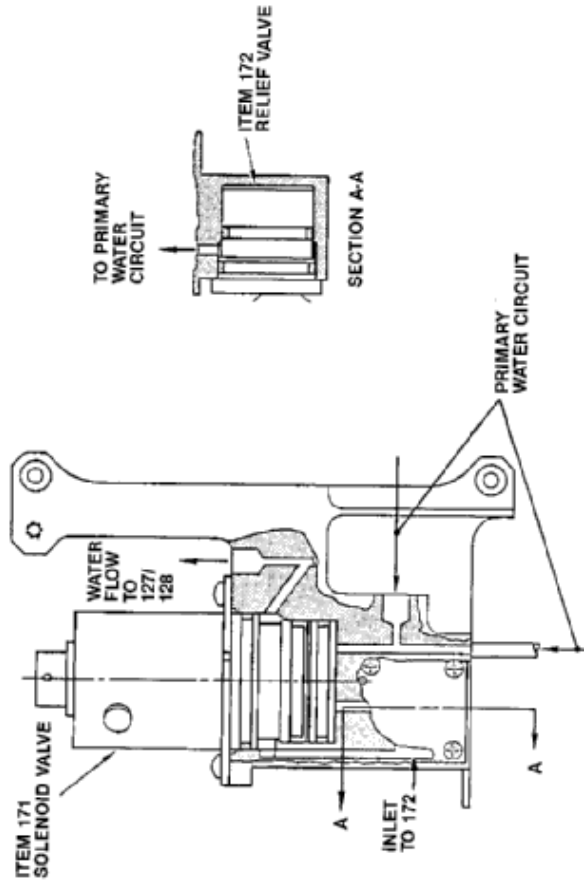
JG8353173cv

## ISOLATION VALVE ELECTRICAL SCHEMATIC

ITEM 171  
(CONT'D)

10807008.rls

# ITEM 171/172 COOLANT LOOP ISOLATION VALVE ASSEMBLY

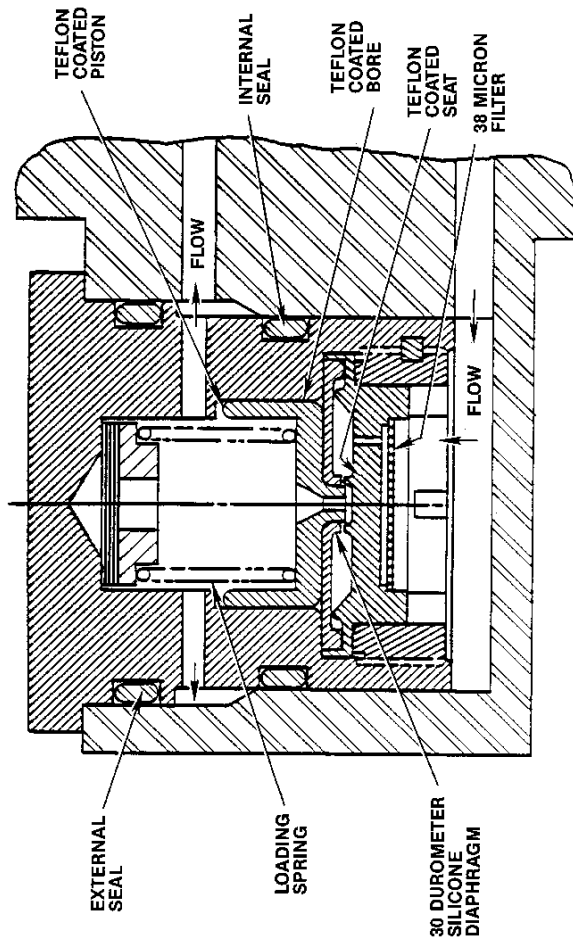


**ITEM 172 COOLANT RELIEF VALVE**

**Allows condensate to relieve to the feed water tanks when the Item 171 is closed.**

- **Cracking pressure.....0.3 psid min.**
- **Reseat pressure.....0.1 psid min.**
- **Internal leakage  
(H<sub>2</sub>O, reverse direction).....0.05 cc/hr max at 20 psid**
- **Flow rate..... 0.3 PPH H<sub>2</sub>O min. at 0.9  
psid max.**

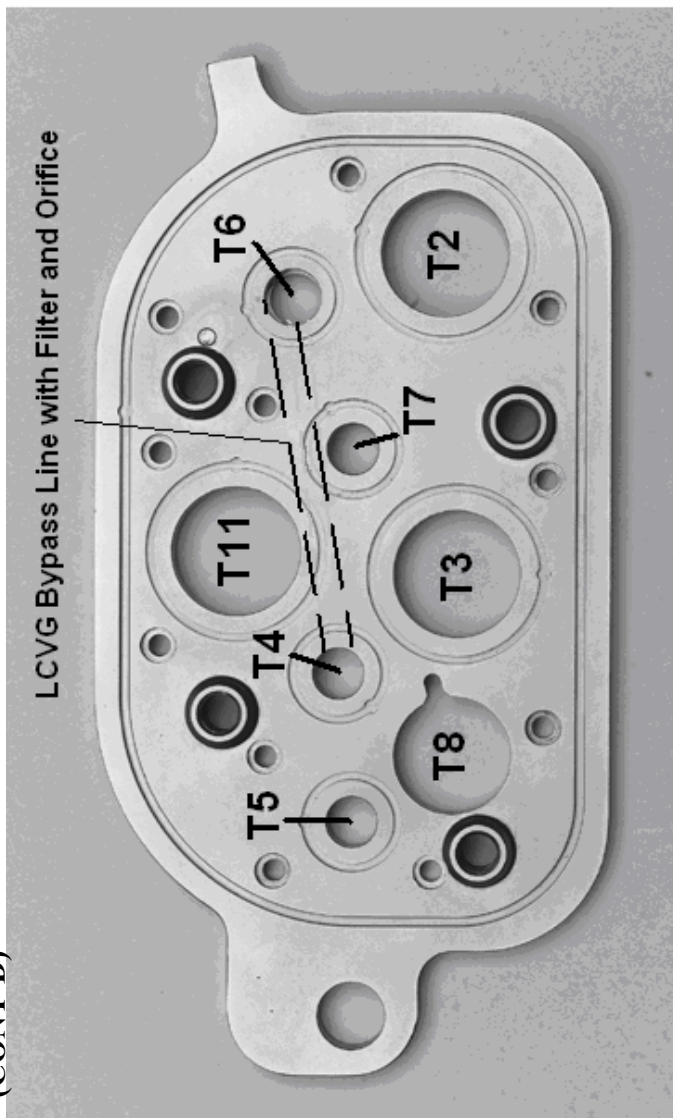
## COOLANT RELIEF VALVE

ITEM 172  
(CONT'D)

**ITEM 175 ORU PLANAR PLSS, CONNECTOR PLATE AND PIN**

**This item is fastened to the PLSS valve manifold and modifies the interface to allow attachment of the ORU Planar HUT. It also houses the LCVG Bypass line, orifice, and filter.**

**ITEM 175 ORU PLANAR PLSS, CONNECTOR PLATE AND PIN  
(CONT'D)**



**ITEM 176 WATER INLET FILTER**

This item removes particulate contamination from the feed water fill and drain line. The filter is located at T-8.

ITEM 176 ORU PLANAR PLSS, CONNECTOR PLATE AND PIN  
(CONT'D)



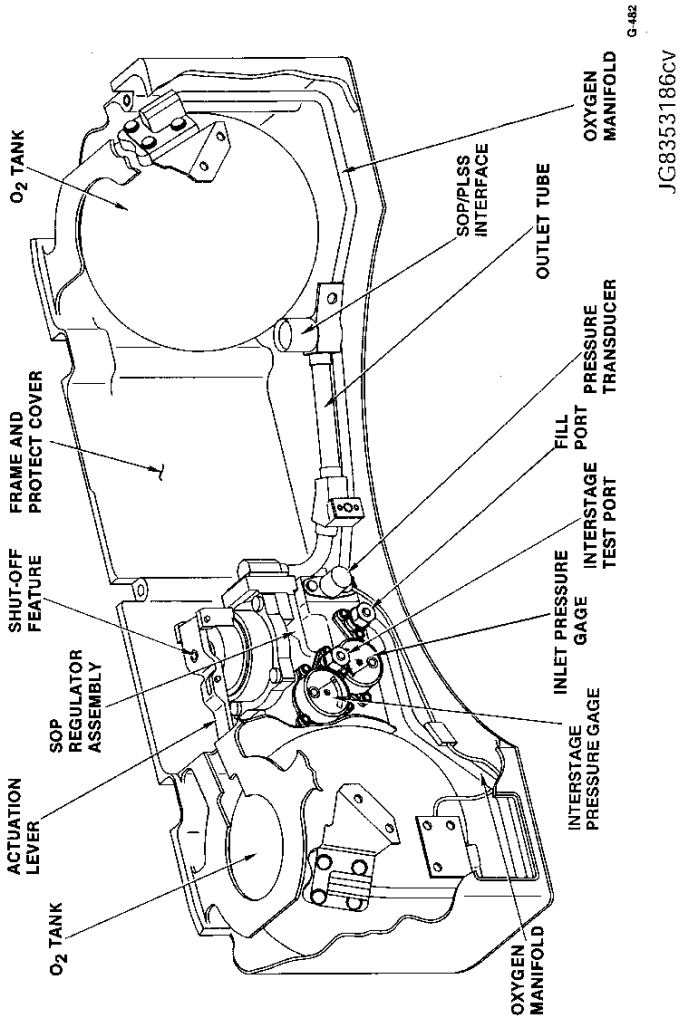
**ITEM 200 SECONDARY OXYGEN PACK**

**Provides emergency life support for 30 minutes in the event of the primary life support system failure. Provides oxygen for metabolic consumption and leakage make up, pressure control, cooling, and contaminant (CO<sub>2</sub> & H<sub>2</sub>O vapor) control.**

- **Flow.....0.06 – 5.26 PPH O<sub>2</sub>**
- **Pressure.....365 – 7400 psia**

# SECONDARY OXYGEN PACK (SOP)

ITEM 200  
(CONT'D)



ITEM 210      SOP O2 BOTTLE

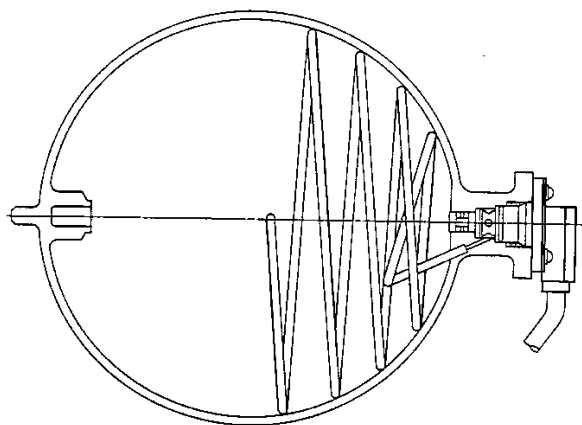
Emergency oxygen storage tank.

- Normal operating pressure.....6000 ± 200 psia (7400 psia max.)
- Volume.....89.2 in.<sup>3</sup> (min)  
(usable oxygen 2.631 lbs. for two bottles)
- Proof.....11,100 psid
- Burst.....14,800 psid

G-524

JG8353185cv

**SOP OXYGEN TANK**



**ITEM 210  
(CONT'D)**

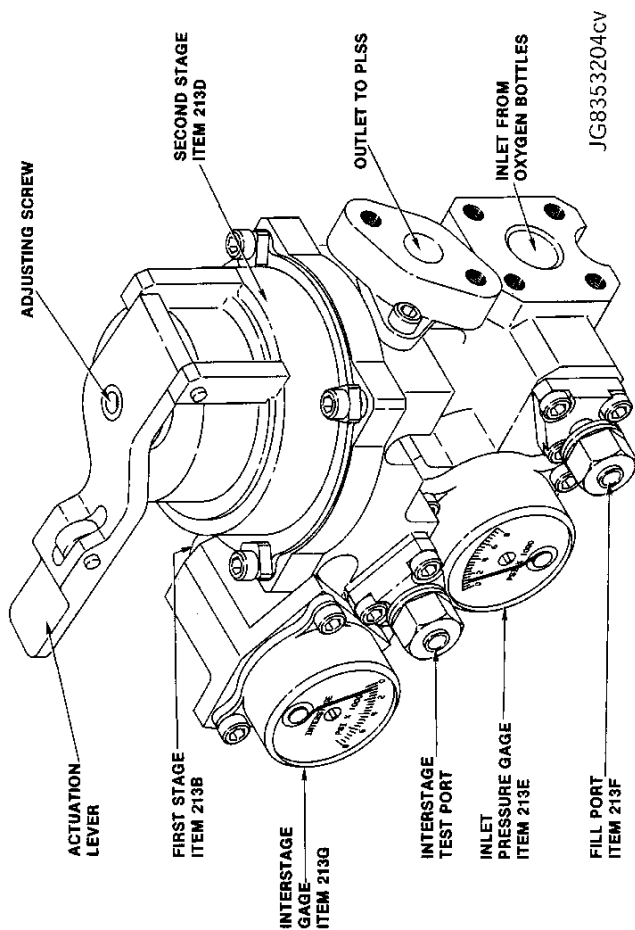
ITEM 213      SECONDARY OXYGEN PRESURE CONTROL MODULE

Emergency oxygen pressure regulator. Regulation band is set lower than the primary pressure band but above the minimum acceptable oxygen pressure. The regulator has two stages.

- Supply pressure range.....365 – 7400 psia
- Max flow limit.....7.49 PPH
- Regulated pressure at vacuum  
(Both first and second stage operating nominally or with 1<sup>st</sup> stage failed open)
  - at 0.00 – 1.00 PPH.....3.40 – 3.90 psid
  - at 1.01 – 4.50 PPH.....3.33 – 3.90 psid
  - at 4.51 PPH.....3.33 – 3.70 psid
  - at 5.26 PPH.....3.33 – 3.62 psid

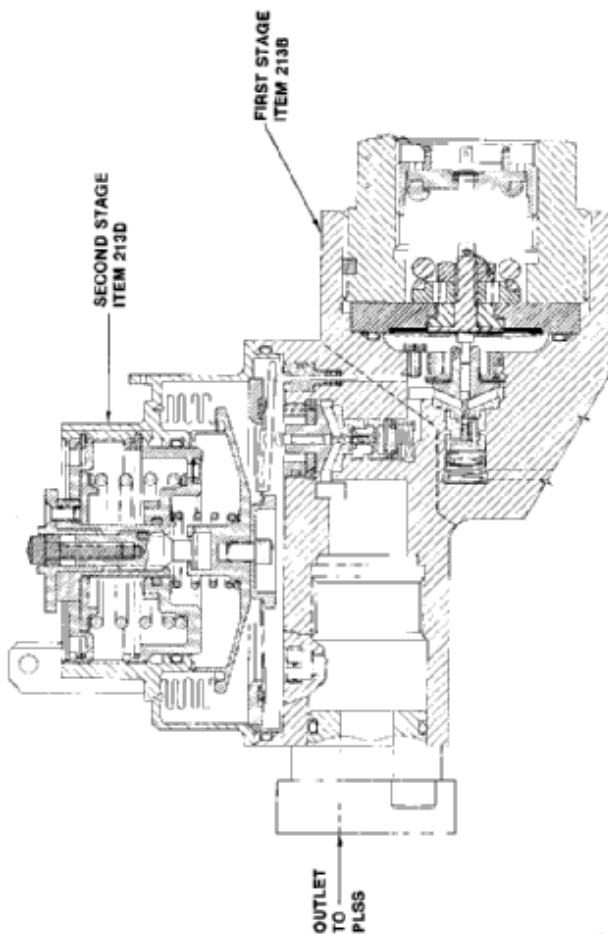
ITEM 213  
(CONT'D)

## OXYGEN PRESSURE REGULATOR



ITEM 213  
(CONT'D)

# OXYGEN PRESSURE REGULATOR



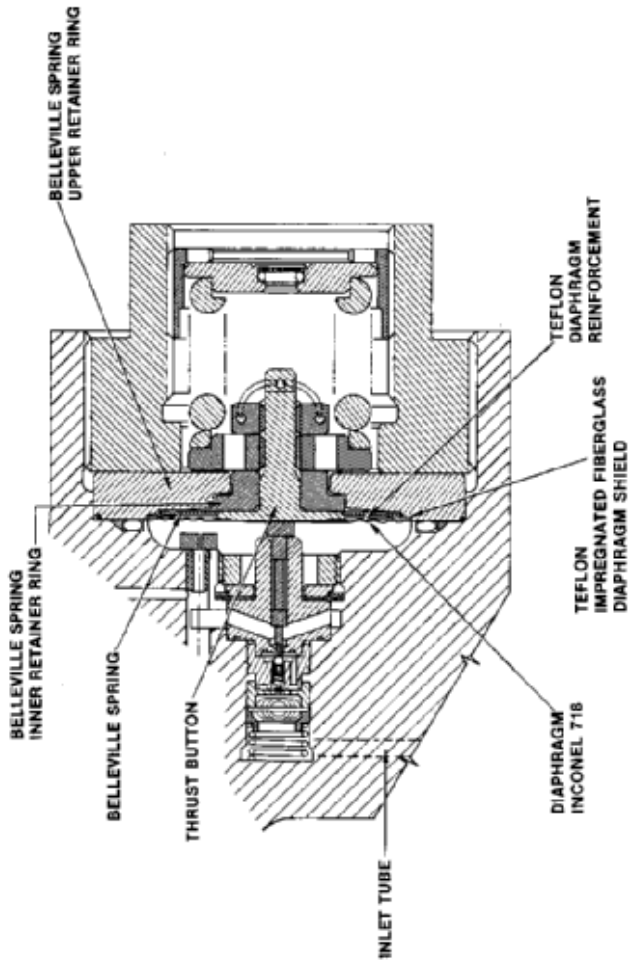
Q-800

JG8353203cv

## ITEM 213B

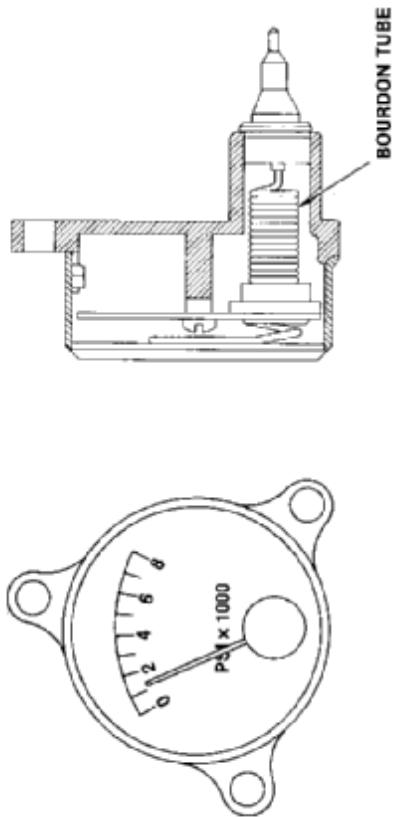
**OXYGEN PRESSURE REGULATOR**

Controls second stage inlet pressure for optimum regulator performance and limits the maximum flow in the event of a failed open second stage.



**ITEM 213E**

**SOP PRESSURE GAGE**  
Displays tank pressure.



JG8353201cv

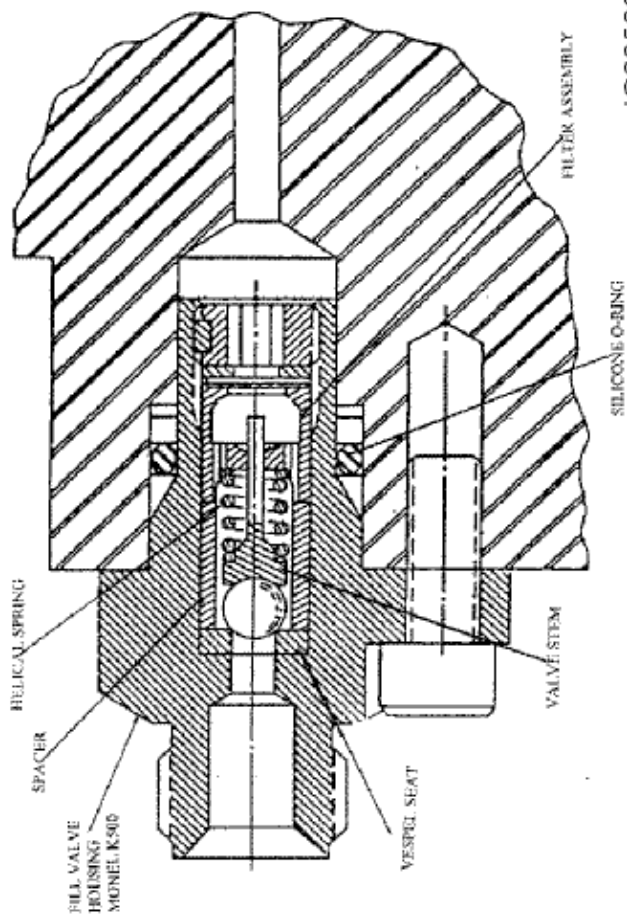
0.6280

**REV M**

## ITEM 213F

## FILL VALVE ASSEMBLY

Prevents backflow when the Fill Fitting is removed.



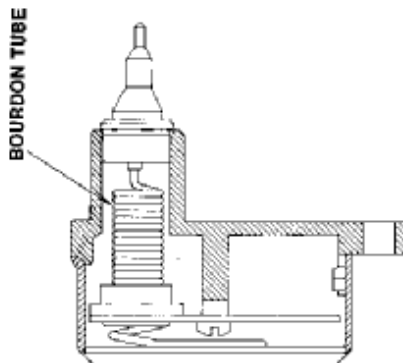
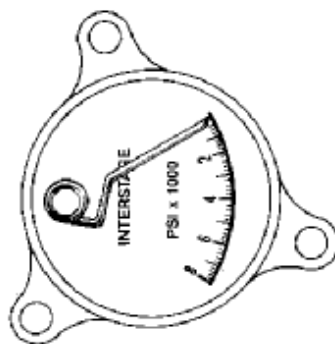
G 532

JG8353220cv

## ITEM 213G

### SOP INTERSTAGE PRESSURE GAGE

Measures 1st stage outlet pressure. Gage allows a check of the 1st stage performance prior to donning the suit, provides the ability to determine that the first stage is functioning properly.



REV M

JG8353219cv

95-021

# INTERSTATE GAUGE INDICATION MATRIX

Interstage Gauge Reading			First stage regulator is NOT failed open		
Before SOP Check	At End of SOP Check	Needle Path	First stage regulator is NOT leaking excessively		
			First stage regulator IS failed open		
0-600	0-600	Increased Decreased Remained	Possible first stage regulator pressure shift		
			Leakage bleed off		
0-600	600 – <Bottle P	Increased Decreased Remained	Possible first stage regulator excessive leakage		
			Indicated Action		
>600-Bottle P	Bottle P	Increased	X	X	Normal Use, Note 1
		Decreased	X	X	
>600 – <Bottle P	>600 – <Bottle P	Increased	X	X	Normally Do Not Use, Note 3
		Decreased	X	X	
>600 – <Bottle P	Bottle P	Increased	X	X	Normally Do Not Use
		Decreased	X	X	
>600 – <Bottle P	>600 – <Bottle P	Increased	X	X	Extend Flow Time or Establish Higher Flow. If Pressure Falls to -600, Use. Note 2
		Decreased	X	X	
>600 – <Bottle P	Bottle P	Increased	X	X	Establish Higher Flow. If Pressure Falls to -600, Use. Note 2
		Decreased	X	X	
Bottle P	600-Bottle P	Increased	X	X	Normally Do Not Use
		Decreased	X	X	

## Notes:

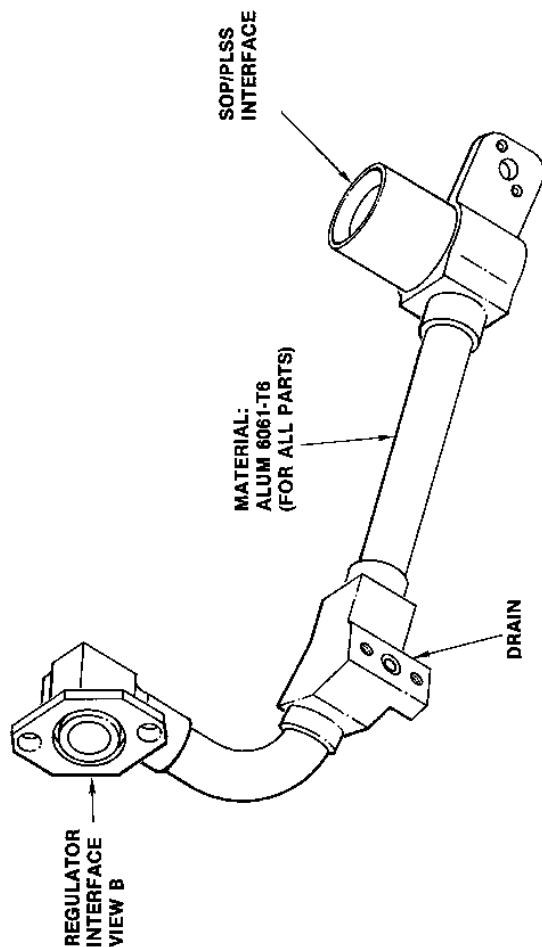
1. Normal Scenarios.
2. Contingency EVA only.
3. Gauge pressure considered equal if within 800 psia.

11133001.rh7

JG8353217cv

G-504

# OUTLET TUBE SOP/PLSS INTERFACE



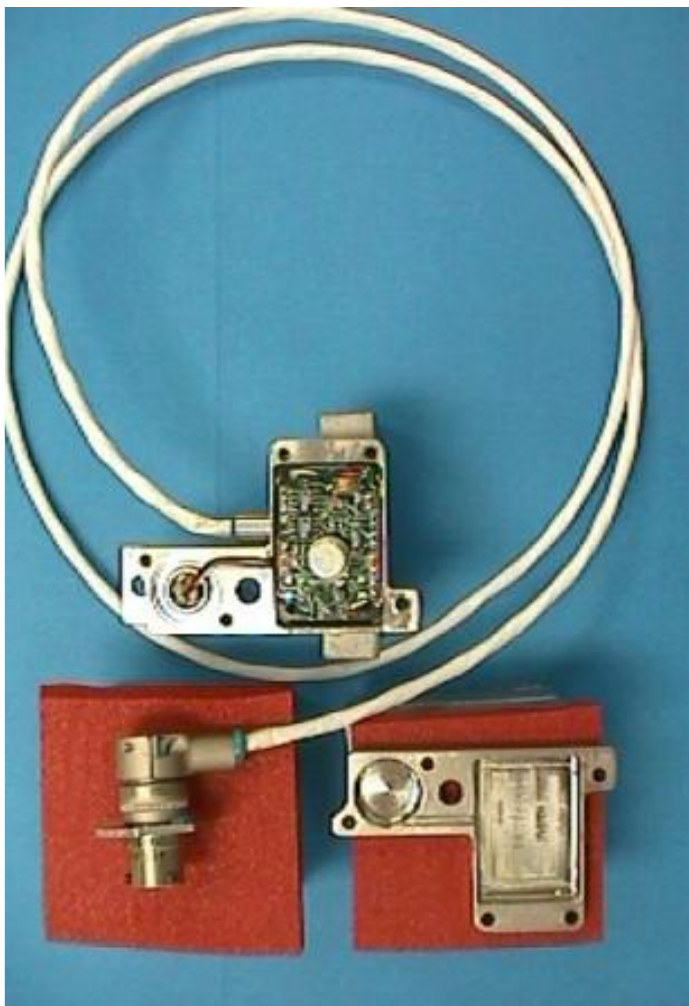
ITEM 215 PRESSURE TRANSDUCER

Measures O<sub>2</sub> tank pressure. Measurement is used to determine the health of the emergency systems and the time remaining during usage. Pressure is displayed by the DCM. The ECWS monitors the pressure and sends audible alarms and cautions to the EVC.

- Pressure range.....0-7400 psia
- Input voltage.....14.2 ± 1.0 Vdc
- Output voltage.....0-5 Vdc
- Error band.....± 3.5% FS or ± 259 psi

**PRESSURE TRANSDUCER**

**ITEM 215  
(CONT'D)**



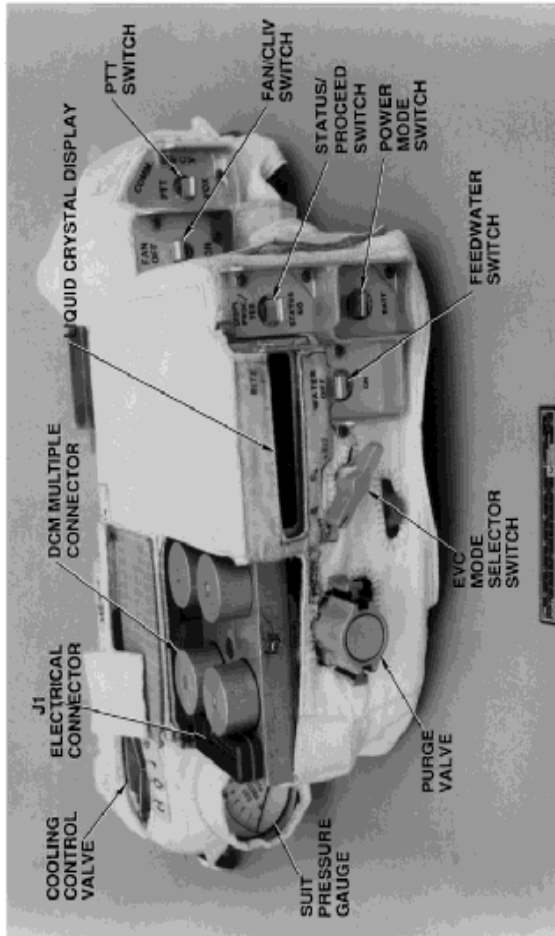
ITEM 215  
PRESSURE TRANSDUCER

(CONT'D)



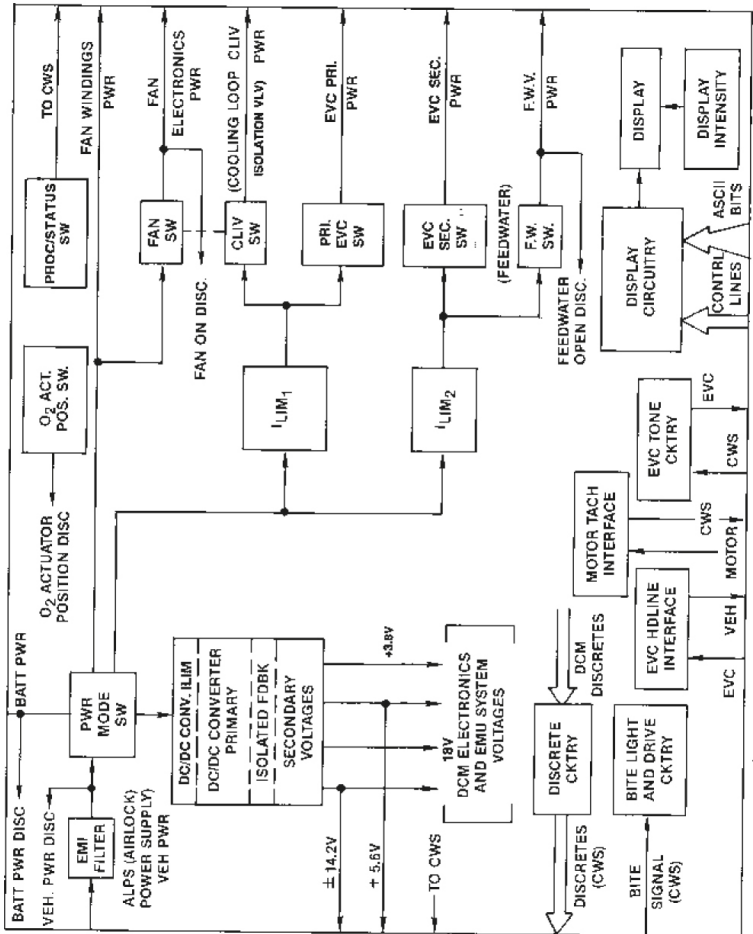
# ITEM 300 DISPLAY AND CONTROLS MODULE, AS VIEWED BY CREWPERSON

This CEI contains the EMU controls and displays the system status.



JG8353231cv

**ITEM 300**  
**(CONT'D)**



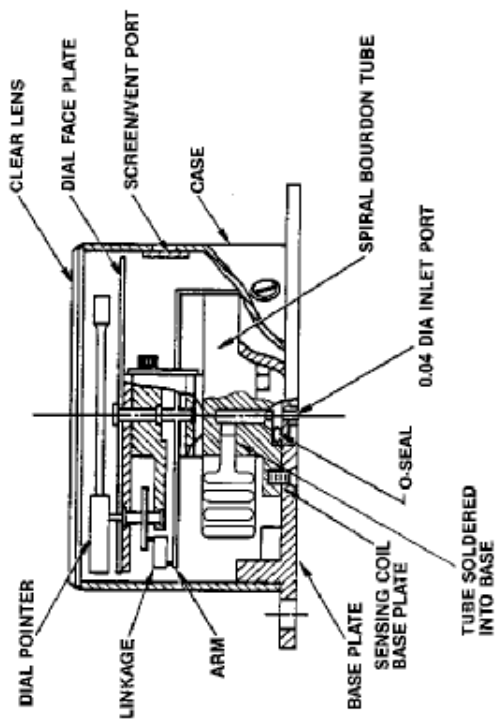
ITEM 311 SUIT PRESSURE GAGE

This gage displays the suit pressure relative to ambient and is a check of the I114 transducer.

- Pressure range.....0-5.5 psid
- Proof of pressure.....8.25 psid max
- Collapse pressure.....1.5 psid
- Leakage rate..... $2 \times 10^{-5}$  scc oxygen/sec. Max
- Accuracy..... $\pm 0.1$  psi from 3.0 to 5.0 psid  
..... $\pm 0.2$  psi over remainder of range

ITEM 311  
(CONT'D)

# SUIT PRESSURE GAGE



TOP VIEW

SIDE VIEW (SECTIONED)

JG8353229CV

G418

REV M

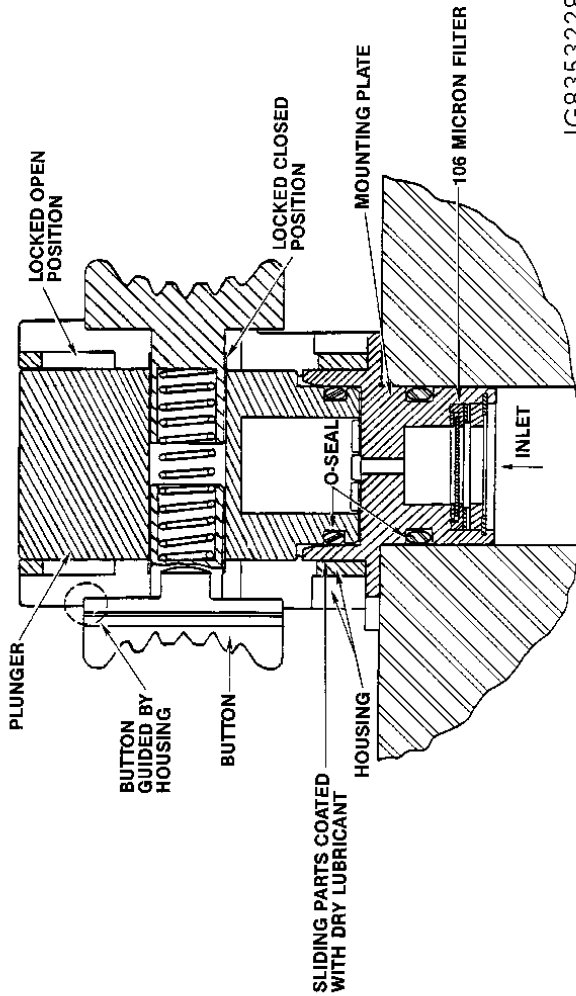
## ITEM 314 PURGE VALVE

Opening this valve provides a controlled opening from the suit to the environment. It is used to purge nitrogen from the suit prior to EVA and actuates the emergency system during EVA.

- **Flow rate:\***  
4.74 to 4.986 PPH dry O<sub>2</sub> with an inlet pressure of 3.45 psia, vacuum ambient and an inlet temperature of 60°F
- **Orifice Size:** 0.156 ± .001 inches
- **Detent lock:**  
Provided in both open and closed positions at 4.5 psig
- **Force to depress detent locks:** 1.0 – 4.0 lbs.
- **Force to open:** 3.0 lbs. max.
- **Force to close:** 5.0 lbs. max.
- **Leakage rate:**  
20 scc/hr O<sub>2</sub> max. at 4.7 ± 0.5 psid dumping into vacuum

\* Per memo ANAL 98-026 (3-4-98), flow at 3.62 psia and 1000 Btu/hr = 5.199 lb/hr of O<sub>2</sub>, H<sub>2</sub>O vapor and CO<sub>2</sub>. O<sub>2</sub> fraction of that flow = 5.01 lb/hr dry O<sub>2</sub>.

## DCM PURGE VALVE

ITEM 314  
(CONT'D)

JG8353228cv

Q-615

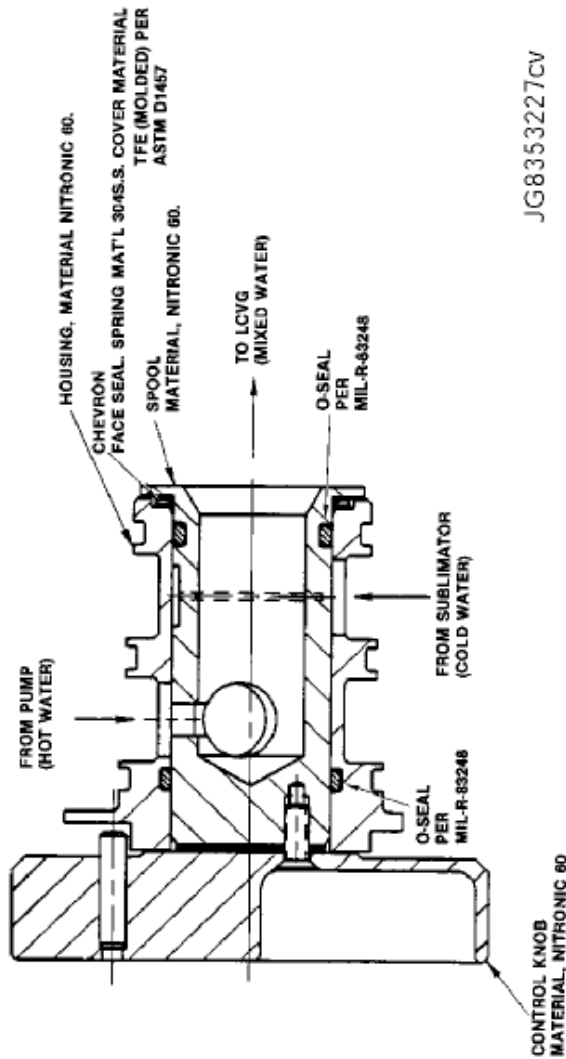
**ITEM 321 COOLING CONTROL VALVE**

Turning the valve handle allows the crewperson to control the amount of cooling to the suit by modulating the cooling loop flow to the sublimator. Below position "2", no flow is directed to the sublimator and flow to the LCVG decreases to zero when the "H" position is selected.

- Operating torque: 5-30 in. -oz
- Internal leakage: .533 lb/hr max (H position to LCG), 15.5 lb/hr max (C position to bypass port)
- External leakage: No visible leakage allowed
- Water temperature: 40-90°F
- Pressure drop at 70± 4°F:
  - "C" position (sublimator port to LCG port) 0.3 psid max
  - "2" position (bypass port to LCG port) 1.4 psid max
  - Positions 4-10 (bypass port to LCG port) 0.5 to 1.4 psid
- Flow rates:
  - Maximum cooling : 240 lbs H<sub>2</sub>O/hr (sublimator port)
  - Minimum cooling: 0 lbs/hr to LCG

ITEM 321  
(CONT'D)

## COOLING CONTROL VALVE



JG8353227cv

Q-514

COOLING CONTROL VALVE

ITEM 321  
(CONT'D)

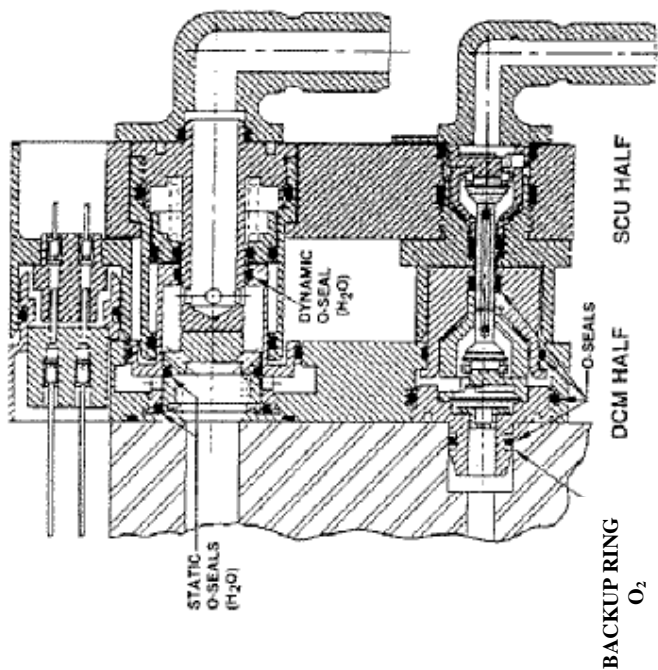


**ITEM 330 COMMON MULTIPLE CONNECTOR**

This item interfaces with the SCU and allows charging of the system and operation in the airlock. The circuits self-seal when the SCU is disconnected.

- Operating pressures:
  - Oxygen.....1050 psia max
  - Potable water.....8-20 psig
  - Cooling water.....20 psig
- Flow rates:
  - Oxygen.....5.0 lbs/hr min
  - Potable water.....50 lbs/hr min
  - Cooling water.....240 lbs/hr min
- Pressure drops:
  - Oxygen-45 psid max (at 5.0 lbs/hr or O<sub>2</sub> at 745 psia)
  - Potable water – 1.0 psid max (at 50 lbs H<sub>2</sub>O/hr at 17 psig inlet pressure)
  - Cooling water (at 240 lbs/hr at 15 psig and 50°F at inlet):
    - Inlet (P5-T5) – 0.9 psid max
    - Outlet (T6-P6) – 0.75 psid max
- Water spillage:
- 0.3 cc max pre-circuit per connect/disconnect cycle

## COMMON MULTIPLE CONNECTOR MATED

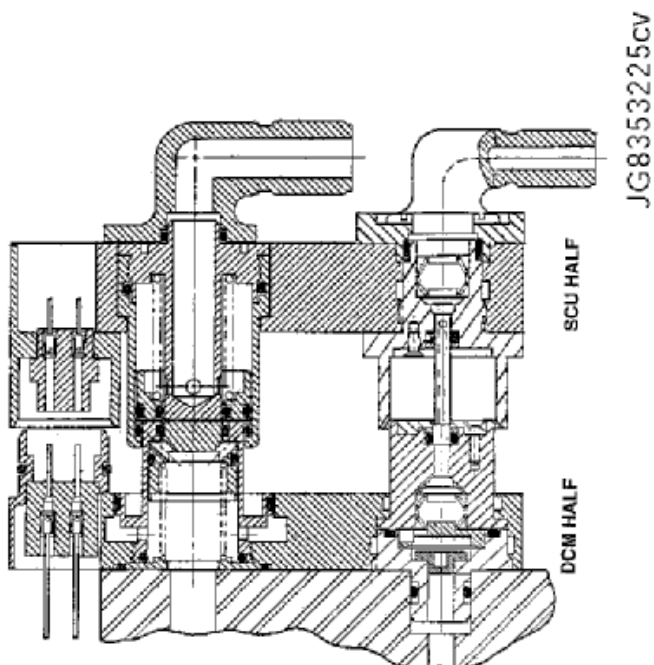
ITEM 330  
(CONT'D)

6013

JG8353226CV

**MULTIPLE CONNECTOR DISCONNECTED**

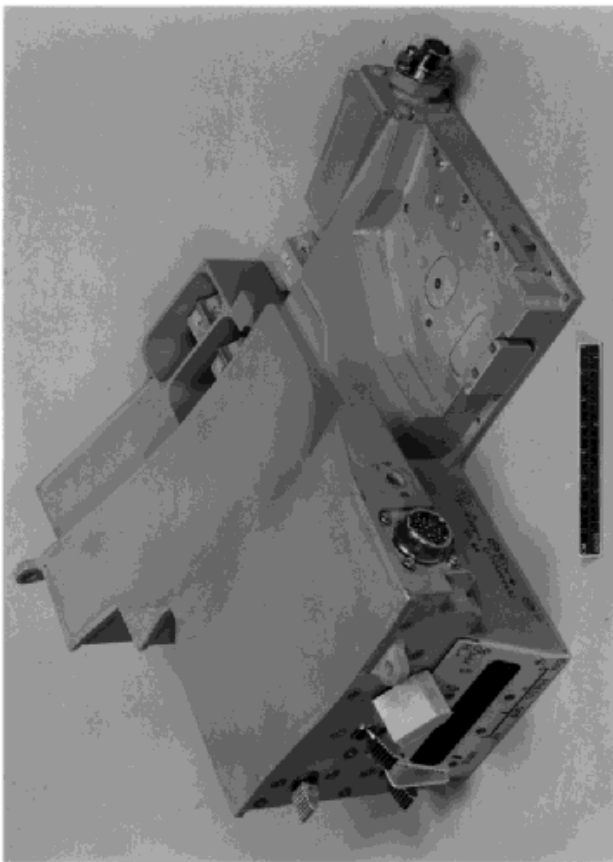
**ITEM 330  
(CONT'D)**



ITEM 350

**ELECTRONIC ASSEMBLY, HUT INTERFACE VIEW**

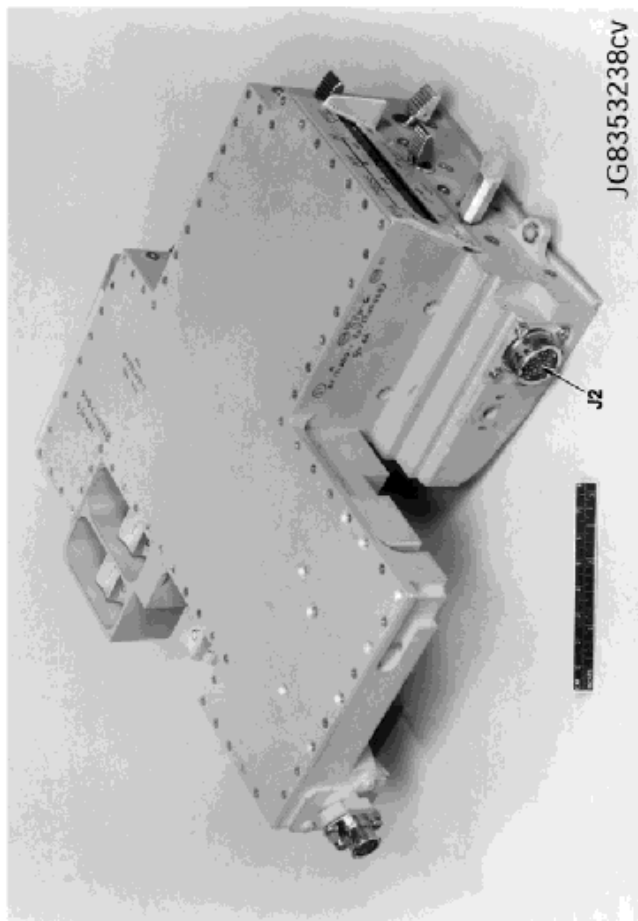
The DCM electronics are contained in this module.



JG8353224cv

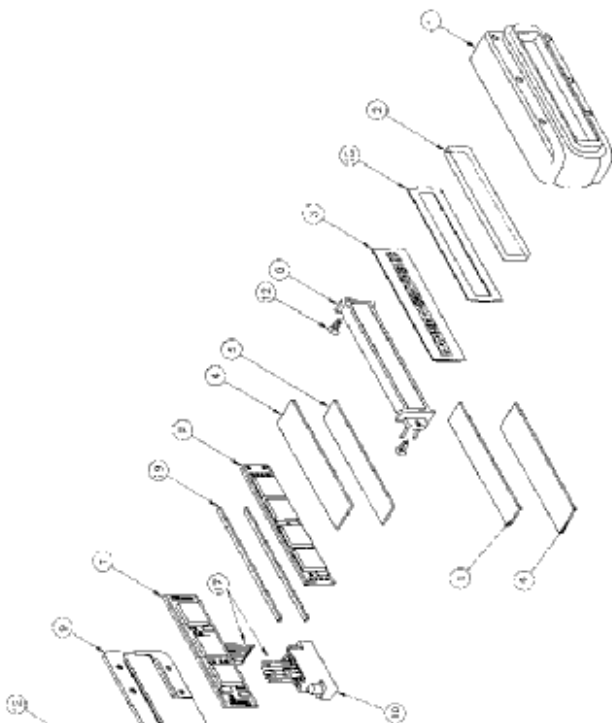
ELECTRONIC ASSEMBLY, EMU FRONT VIEW

ITEM 350  
(CONT'D)



# ITEM 351 REV. A

**LIQUID CRYSTAL DISPLAY MODULE**  
This module displays the system status to the Crewperson.



- 1 HOUSING, MODULE
- 2 COVER LEXAN INSERT
- 3 DISPLAY, LIQUID CRYSTAL
- 4 CONNECTOR, ELASTOMERIC LG
- 5 CONNECTOR, ELASTOMERIC SM
- 6 RETAINER ASSEMBLY
- 7 CERAMIC CIRCUIT BOARD ASSY LG
- 8 CERAMIC CIRCUIT BOARD ASSY SM
- 9 COVER, MODULE
- 10 CONNECTOR
- 11 INSERT, HELICAL .085-56 X 1 DIA
- 12 SCREW, 2-56 FLTHD SIS
- 13 EPOXY, THERMAL CONDUCTIVE
- 14 SOLDER, SN 63W RMA
- 15 TAPE, LACING
- 16 RTV
- 17 WIRE, STRANDED, 26 AWG
- 18 THERMAL LID
- 19 INTERBOARD SPACER
- 20 INSERT, HELICAL .085-56 X 2 DIA
- 21 PRIMER, SUPER KOROPON
- 22 ACTIVATOR, SUPER KOROPON
- 23 ACTIVATOR FOR THERMAL EPOXY

JG8353237CV

0-512

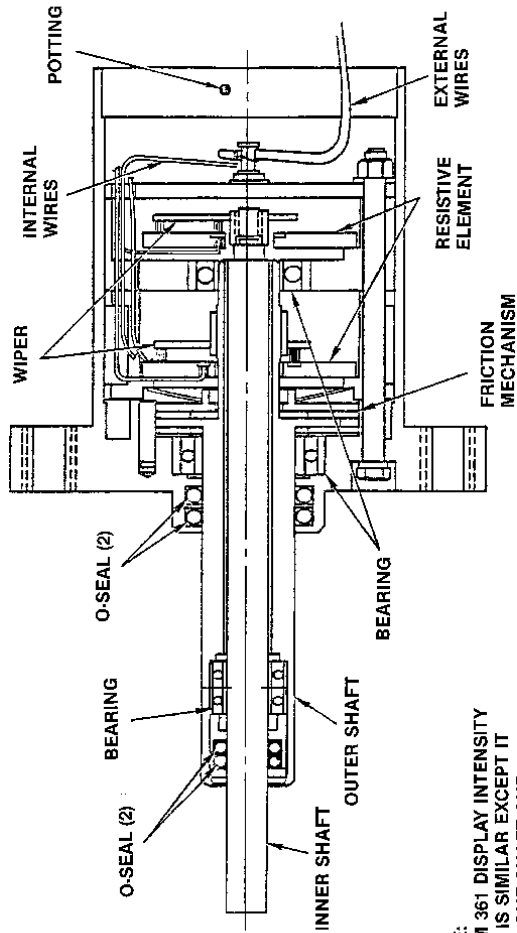
**ITEMS 360 AND 361 VOLUME CONTROL AND DISPLAY INTENSITY CONTROL**

These items control the display light intensity and the volume level of the radio.

- Element resistance.....10,000  $\pm$  1100 ohms
- Operating torque.....7.5  $\pm$  4.5 in.-oz.
- Shaft travel.....300  $\pm$  10 degrees

## ITEM 360

## VOLUME CONTROL POT



NOTE:  
ITEM 361 DISPLAY INTENSITY  
POT IS SIMILAR EXCEPT IT  
HAS ONE SHAFT AND  
RESISTANCE/WIPER

JG8353236cv

G-511

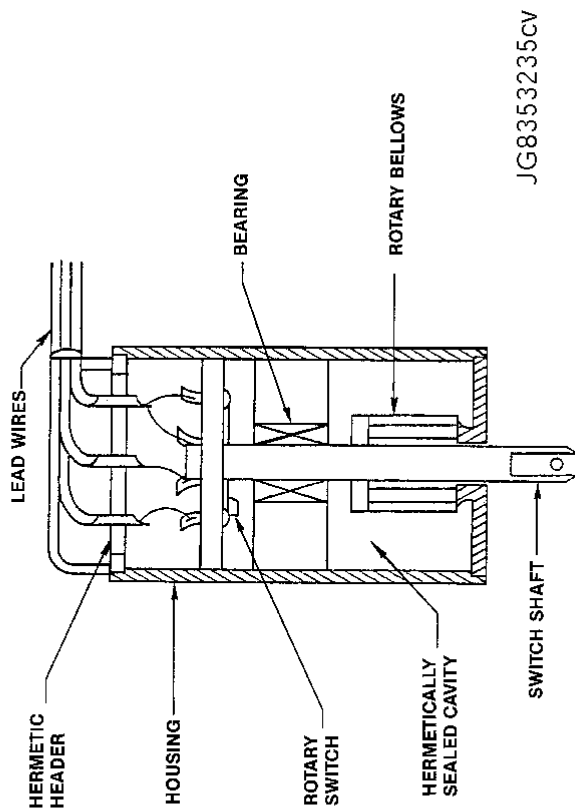
ITEM 362      EVC MODE SELECTOR SWITCH

While retaining the name “EVC Mode Selector Switch,” I-362 controls the 4 SSER Mode positions shown on the DCM TMG in Figure 2.1.4. The 4 modes are HL (hardline), PRI (primary radio), ALT (secondary radio) and OFF (SSER unpowered).

- Switch.....2 poles, four position
- Voltage rating.....28 VDC
- Current rating.....1.0 ampere resistive maximum
- Operating torque.....55 ± 20 in.-oz. each direction

ITEM 362  
(CONT'D)

EVC MODE SELECTOR SWITCH



G-510

**ITEM 364 POWER MODE SELECTOR SWITCH**

**Selector switch allows battery or SCU power selection.**

**Switch type**

- **Triple pole, double throw toggle**

**Current rating**

- **10 amps resistive, 5 amps inductive, two poles**
- **5 amps resistive, 3 amps inductive, one pole**

**Operating force**

- **$4 \pm 2$  lbs (measured 0.5 inches from mounting flange)**

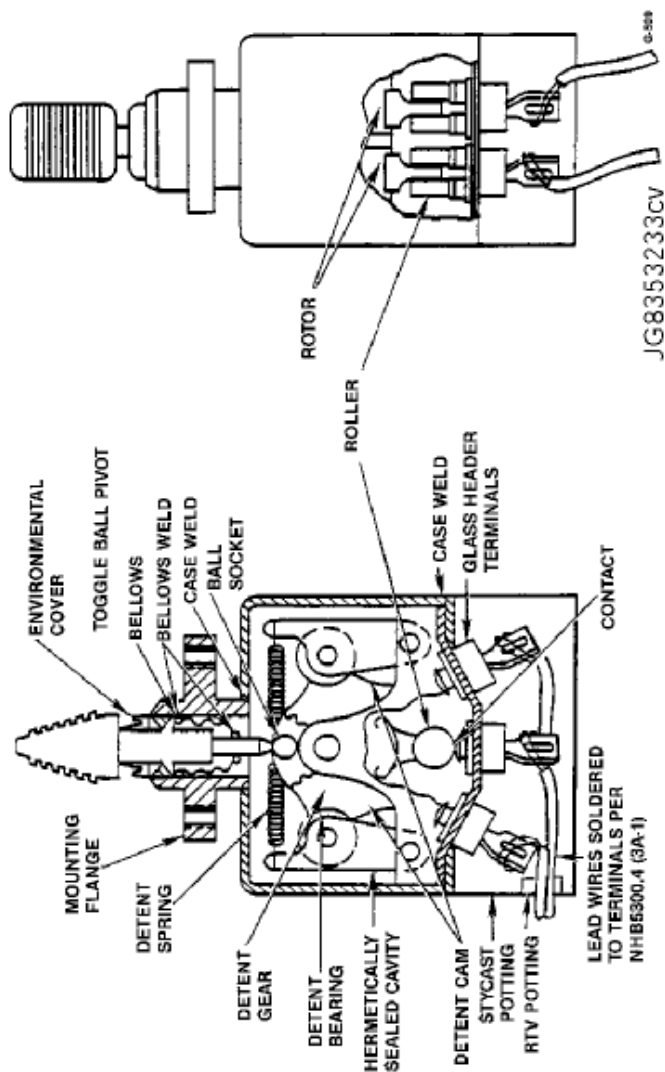
## ITEM 365, 366, 367 AND 368 DCM SWITCHES

These switches control the radio, the Fan/CLIV, the Feedwater and the DCM display.

### Switch type

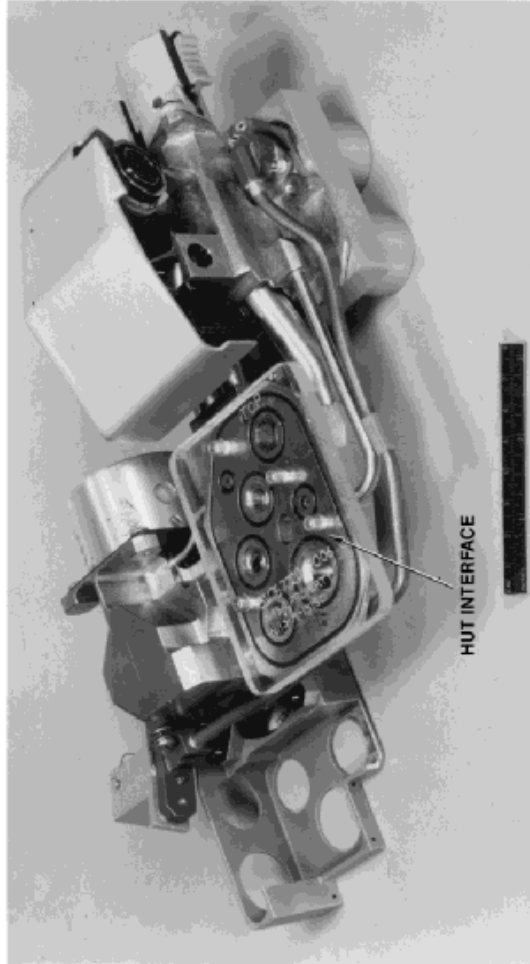
- Item 365 – Push-to-Talk Switch; single pole, double throw; maintained on-center off-momentary on
- Item 366 – Fan/CLIV Switch; double pole, double throw toggle
- Item 367 – Feedwater Valve Switch; single pole, double throw toggle switch; on-off
- Item 368 – CWS Proceed/Status Switch; single pole, double throw toggle switch; momentary on-off-momentary on
- Current rating (Resistive)
  - Item 365 – 0.5 amp max
  - Item 366 – 1.0 amp max
  - Item 367 – 1.0 amp max
  - Item 368 – 0.5 amp max
- Operating force.....4 ± 2 lbs measured 0.5 inches from mounting surface

## ITEMS 364, 365, 366, 367 AND 368 DCM SWITCHES (CONT'D)



**ITEM 385****OXYGEN, WATER MANIFOLD ASSEMBLY**

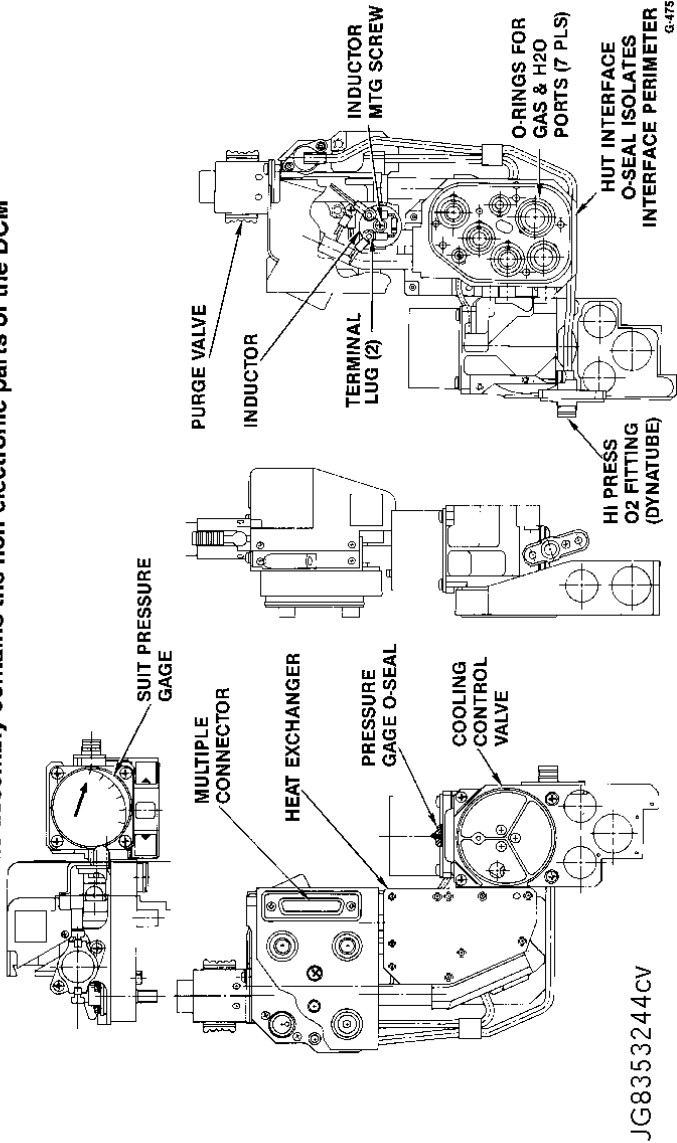
This assembly contains the non-electronic parts of the DCM. It allows purging of the suit, oxygen fill, water fill, water drain, cooling water flow and return, and vehicle power supply .



JG8353232CV

# ITEM 385 (CONT'D) O<sub>2</sub>/H<sub>2</sub>O MANIFOLD ASSEMBLY

This assembly contains the non-electronic parts of the DCM

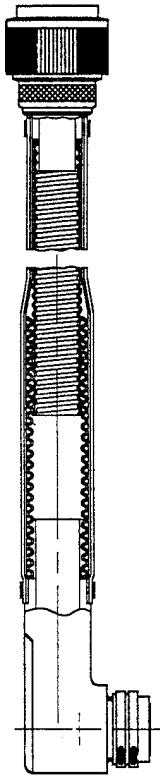


**ITEM 391 AND 392 PLSS JUMPER HARNESSES****Function:**

- **Item 391 – Electrical Power Jumper Harness**  
Connects between the DCM and ORU Item 151 Electrical Power Harness to allow on-orbit replacement (ORU) of the PLSS, HUT, or DCM from the Short EMU.
- **Item 392 – Electrical Signal Jumper Harness**  
Connects between the DCM and ORU Item 152 Electrical Signal Harness to allow on-orbit replacement (ORU) of the PLSS, HUT, or DCM from the Short EMU.

ITEM 391/392

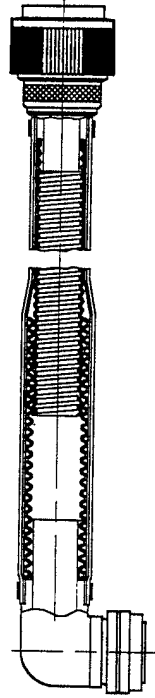
JUMPER HARNESSES



PLSS END

DCM END

391 JUMPER HARNESS

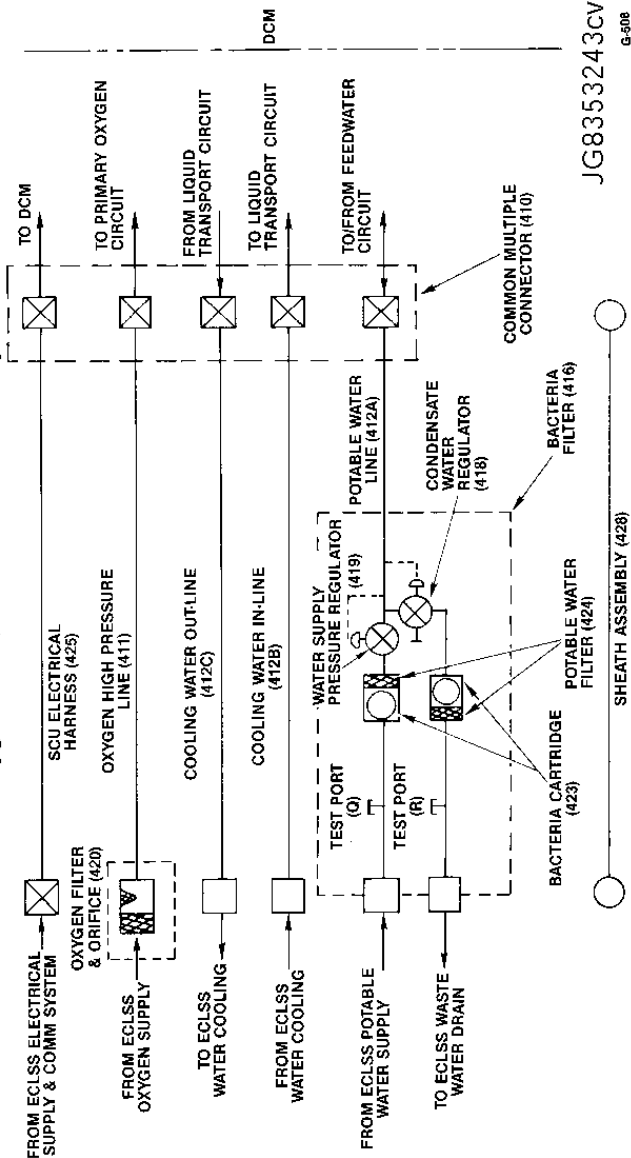


392 JUMPER HARNESS

## ITEM 400

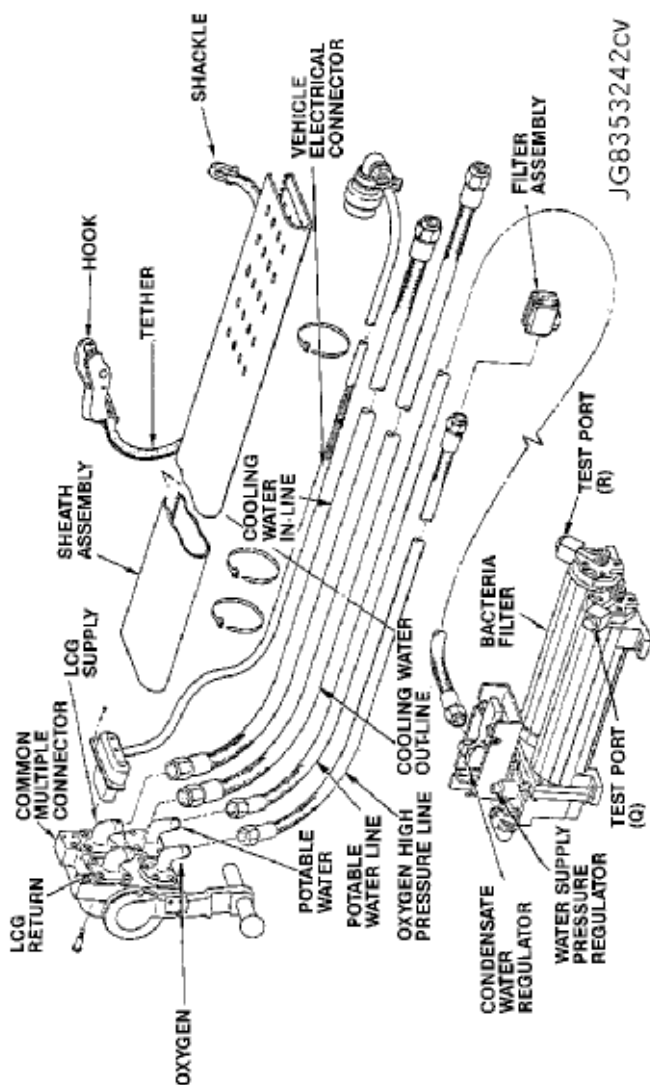
## SERVICE &amp; COOLING UMBILICAL

The SCU supplies the PLSS with electrical power, communications, oxygen, waste water drainage and water cooling from the orbiter during pre- and post-EVA operations. It also supplies the EMU with recharge of the oxygen tanks, water tanks and battery.



JG8353243CV  
G-508

## SCU EXPLODED VIEW

ITEM 400  
(CONT'D)

JG8353242CV

9-533

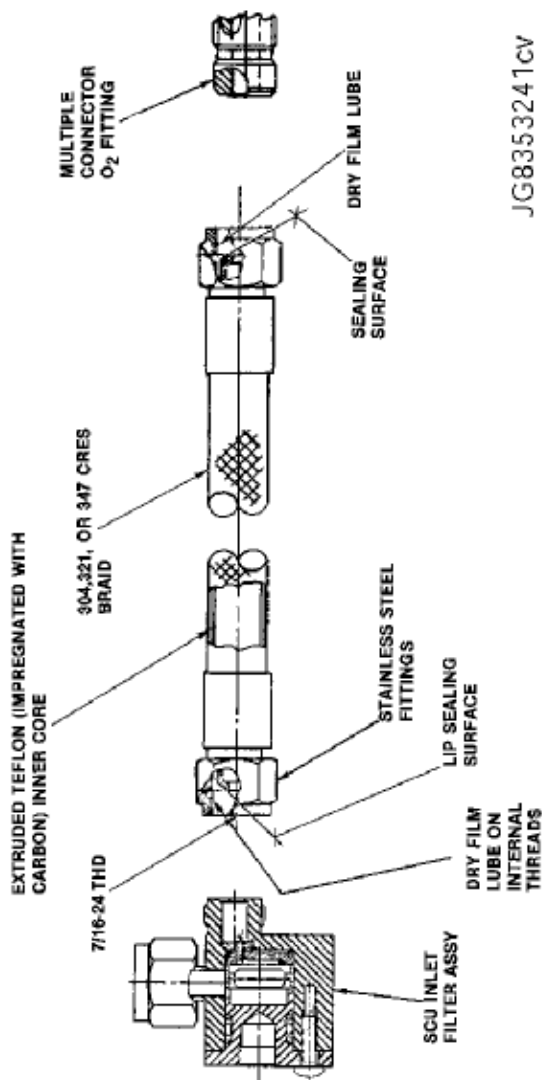
**ITEM 410**

See ITEM 330 for more information

**ITEM 411**

**OXYGEN HIGH PRESSURE LINE**

This line carries oxygen from the Vehicle to the EMU



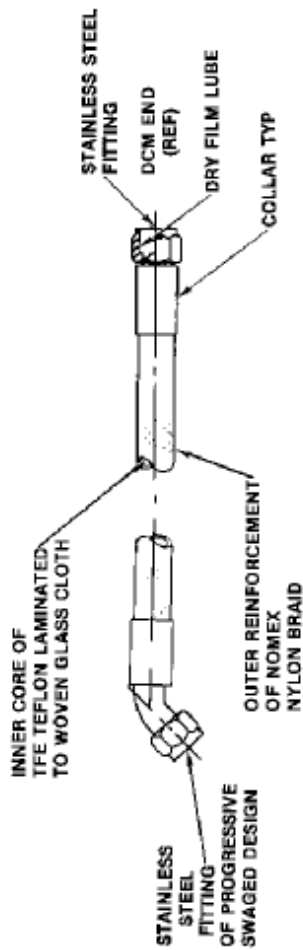
JG8353241cv

Q.887

**ITEM 412A**

**POTABLE WATER LINE**

This line carries potable water from the vehicle to the EMU.



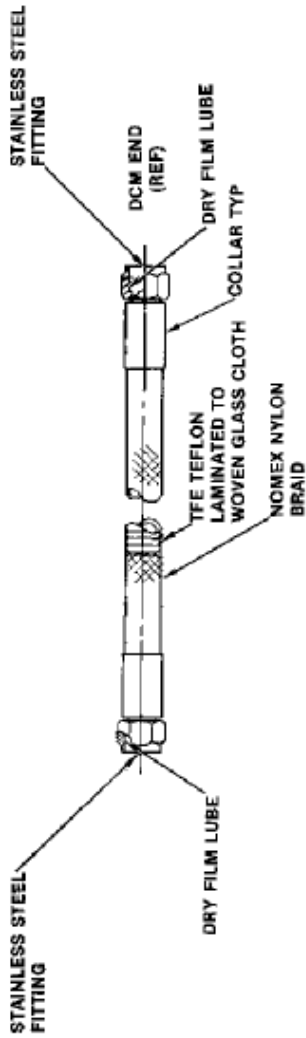
JG8353240CV

Q 504

**REV M**

# ITEM 412B AND 412C COOL WATER LINES

These lines carry cooling water between the Vehicle and the EMU



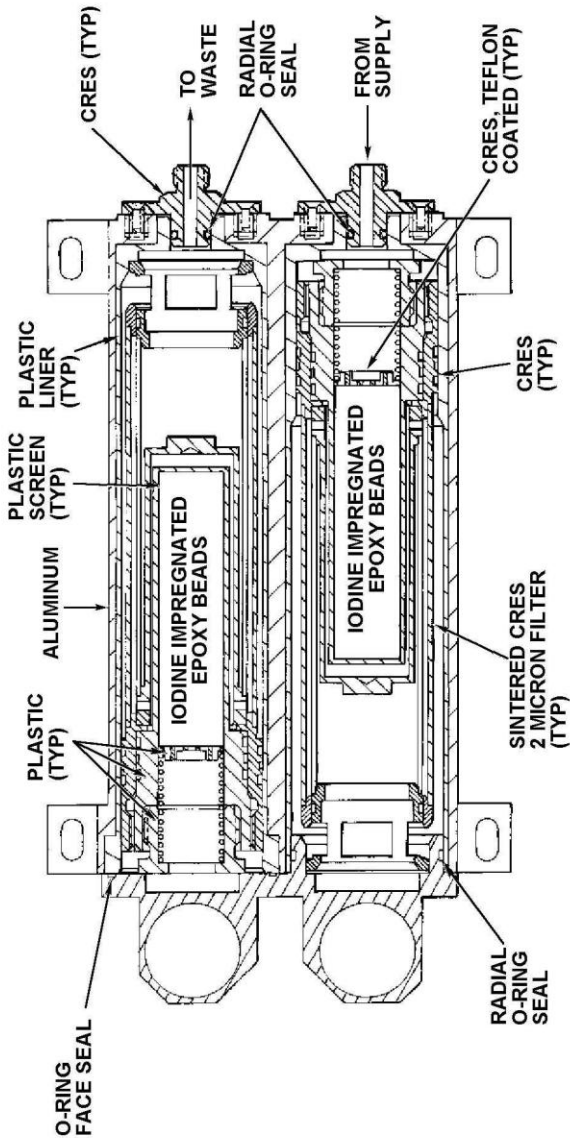
JG8353239cv

G 806

REV M

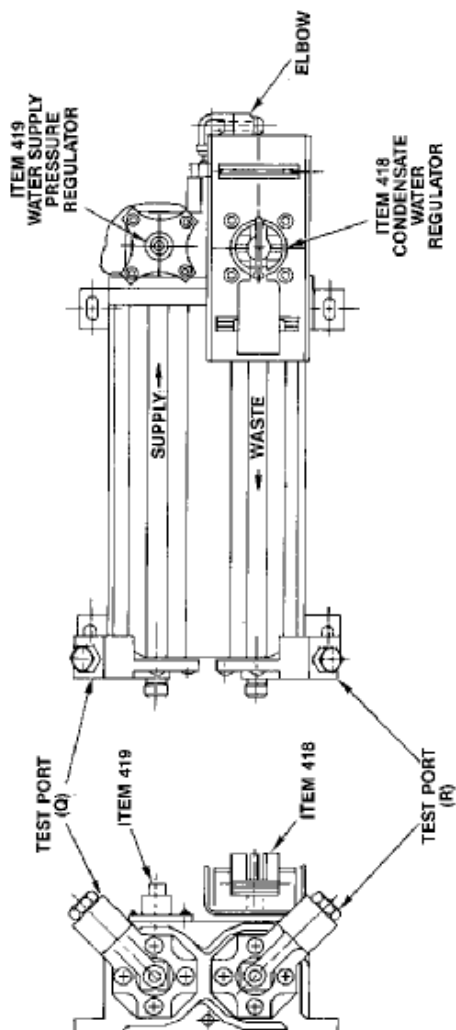
**ITEM 416****BACTERIA FILTER**

Prevents bacteria from the EMU from entering the Vehicle  
potable water supply and prevents bacteria from the Vehicle  
waste system from entering the EMU



10807007.m8

## BACTERIA FILTER

ITEM 416  
(CONT'D)

JG8353249cv

6-654

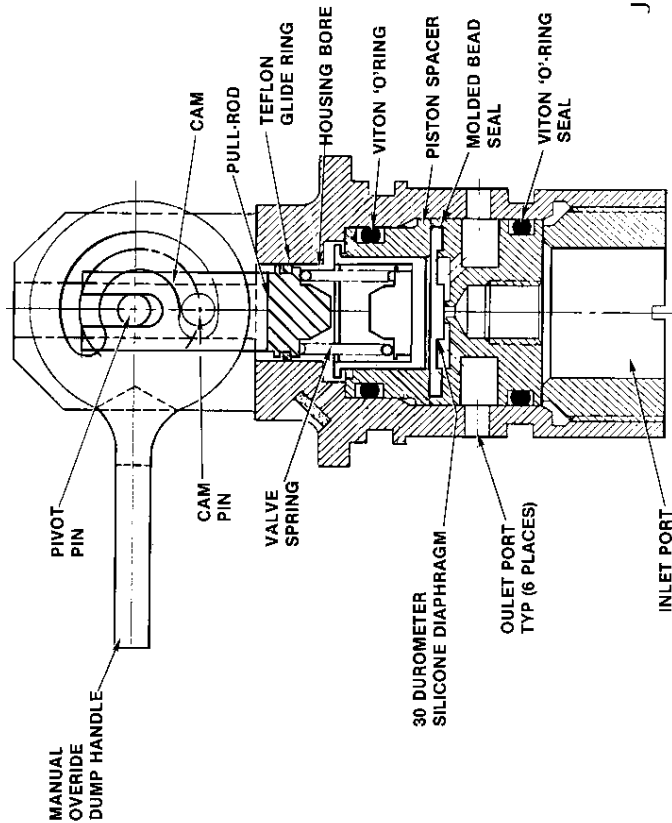
**ITEM 418      CONDENSATE WATER REGULATOR**

Allows the water tanks to be emptied to the vehicle waste system.

- “Manual Open” mode
  - Pressure drop..... 3.6 psid max. at 30-35 PPH max. flow
  - Crack/Reseat..... 4.9 psig max
- “Regulate” mode – This function is no longer utilized
  - Maintain upstream pressure..... $16.5 \pm 0.5$  psid over condensate flow range of 10 cc/hr to 1.0 lb/hr
  - Internal leakage .....10 cc/hr max

ITEM 418  
(CONT'D)

# SCU CONDENSATE WATER REGULATOR



JG8353200cv

G-584

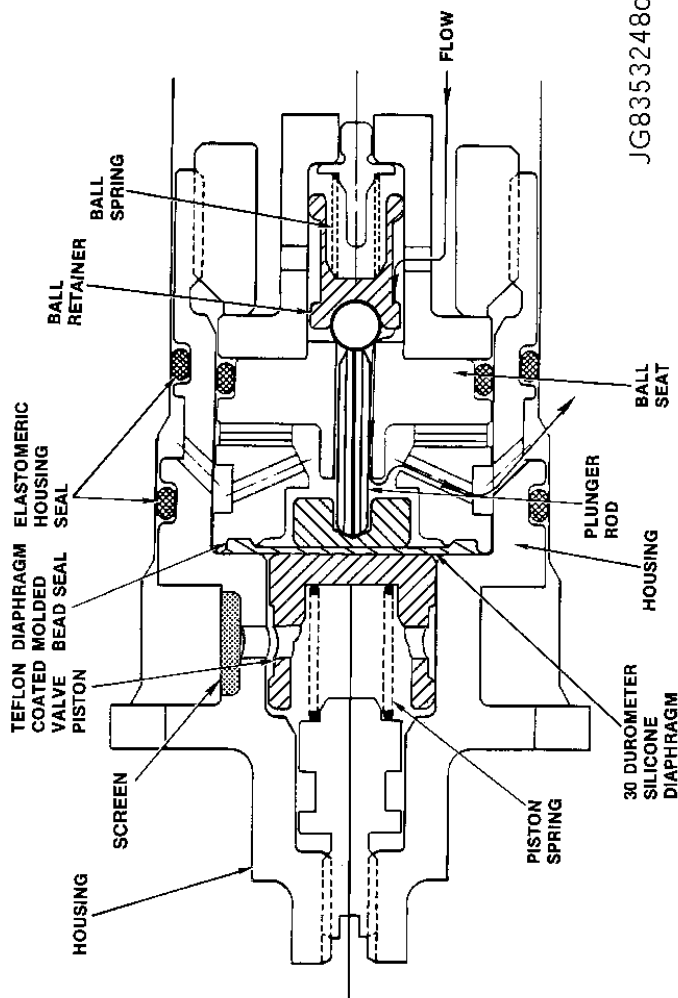
**ITEM 419 SCU WATER SUPPLY PRESSURE REGULATOR**

**Prevents the EMU water tanks from being overpressurized when filling.**

- **Inlet pressure.....12.5 to 25 psig above cabin ambient**
- **Regulation pressure.....7 to 15 psig above airlock ambient (0 – 14.9 psia)**
- **Flow rate.....10 cc/hr to 30 lbs/hr of water**

## ITEM 419 SCU WATER SUPPLY PRESSURE REGULATOR

(CONT'D)



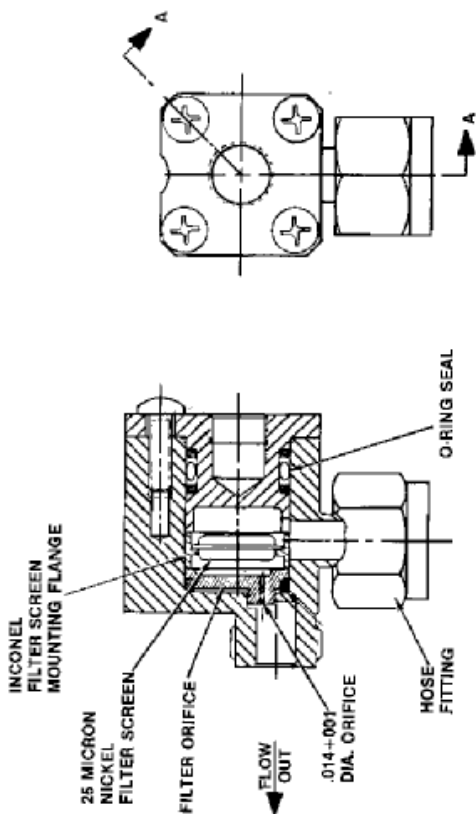
JG8353248CV

G-452

# ITEM 420

## SCU INLET FILTER ASSY

Filters oxygen supply and controls the rate of pressurization of the SCU.



SECTION A-A

JG8353247CV

G-452

## Item 423 Bacteria Cartridge

**Provides iodine ions to prevent bio fouling in the EMU feed water system**

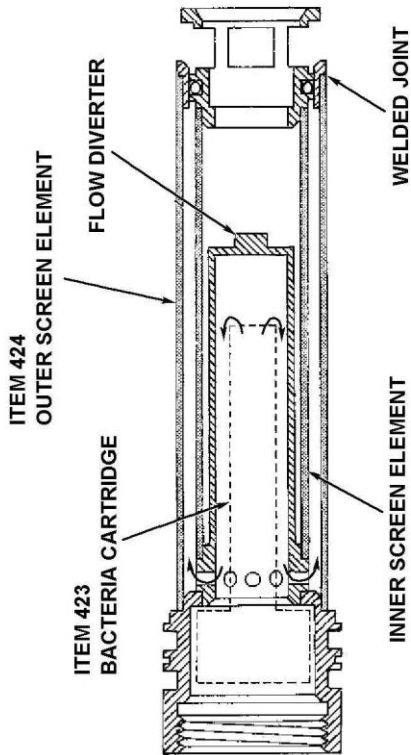
- **Iodine Concentration (nominally)..... 0.5-4.0 ppm (ref.)**
- **Pressure Drop.....0.95 psi max**

**Life Limit.....36 EVAs**

## Item 424 Water Filter

## Provides filtration of EMU resupply feedwater

- |                                     |   |
|-------------------------------------|---|
| • <b>Pressure Drop for Assembly</b> |   |
| <b>New.....</b>                     | <b>0.15 psid max</b>                              |
| <b>At End of Life</b>               |   |
| <b>Fill Side.....</b>               | <b>1.65 psid max</b>                              |
| <b>Drain Side .....</b>             | <b>2.45 psid max @ 30 pph H<sub>2</sub>O Flow</b> |
| <b>Life Limit.....</b>              | <b>36 EVAs</b>                                    |

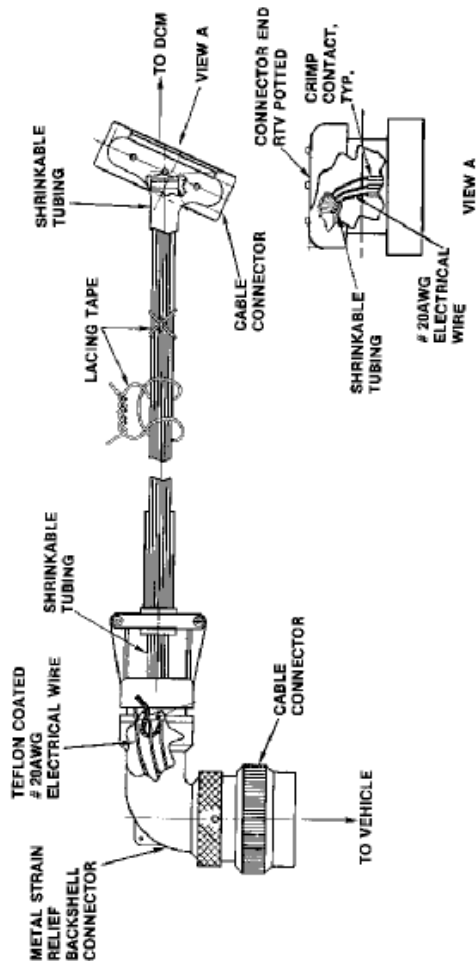
**ITEM 423, 424****POTABLE WATER FILTER  
AND BACTERIA CARTRIDGE**  
The replaceable element of the Item 416 Bacteria Filter

10607006.r1b.8

# ITEM 425

## SCU ELECTRICAL HARNESS ASSEMBLY

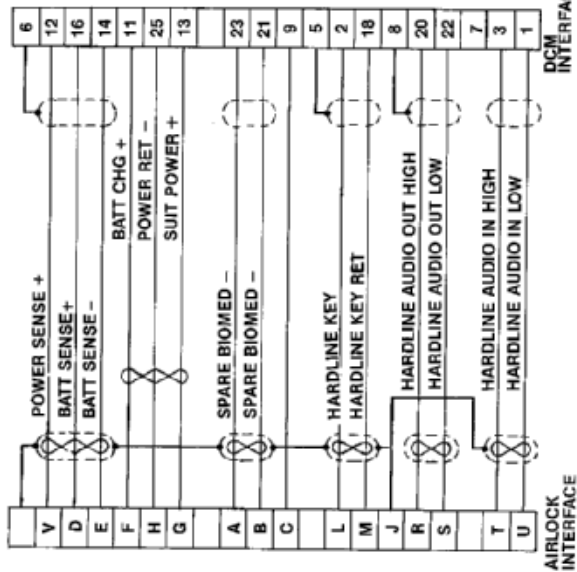
Transports Vehicle Electrical Power to the EMU for operation or battery recharge.



JG8353245cv G-464

ITEM 425  
(CONT'D)

SCU ELECTRICAL HARNESS ASSEMBLY



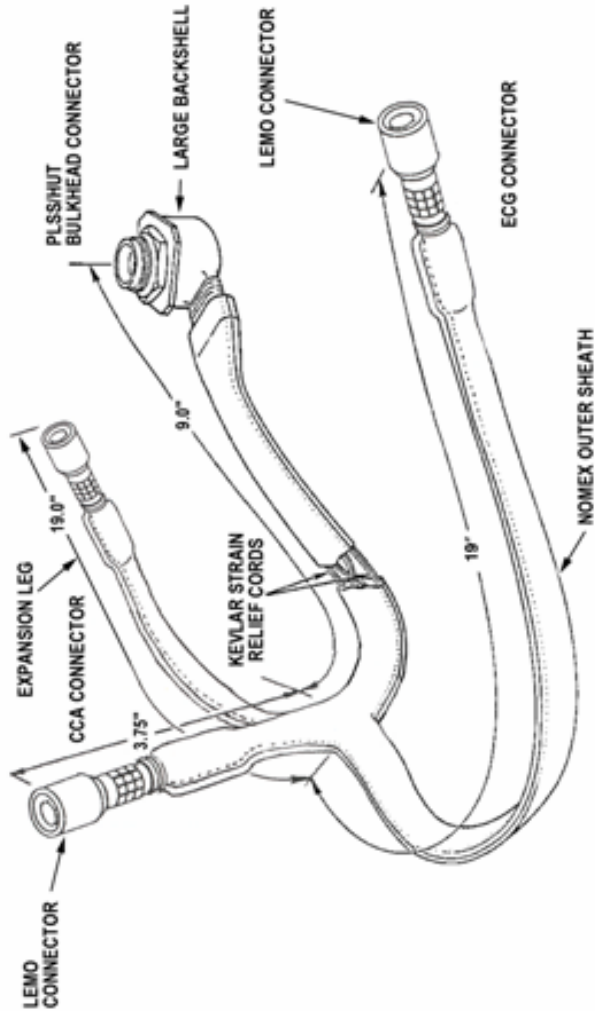
JG8353199CV

G-445

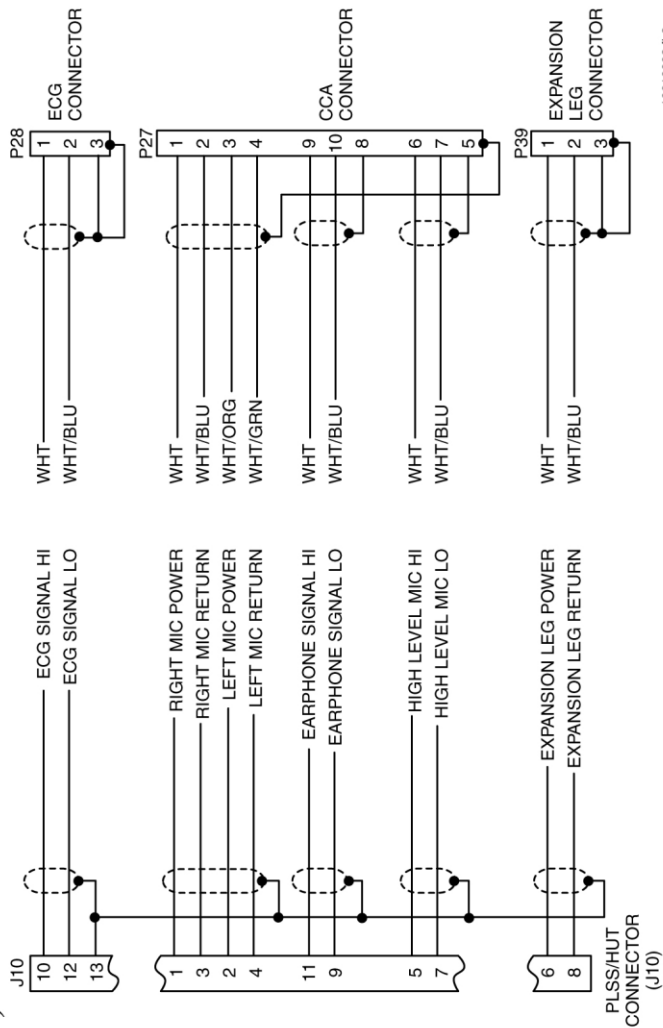
**ITEM 440  
(CONT'D)**

**EMU ELECTRICAL HARNESS (EEH)**

The updated EEH provides interconnecting wiring between the CCA, OBS or ECG wiring, expansion leg and PLSS via a pass-through connection on the HUT.



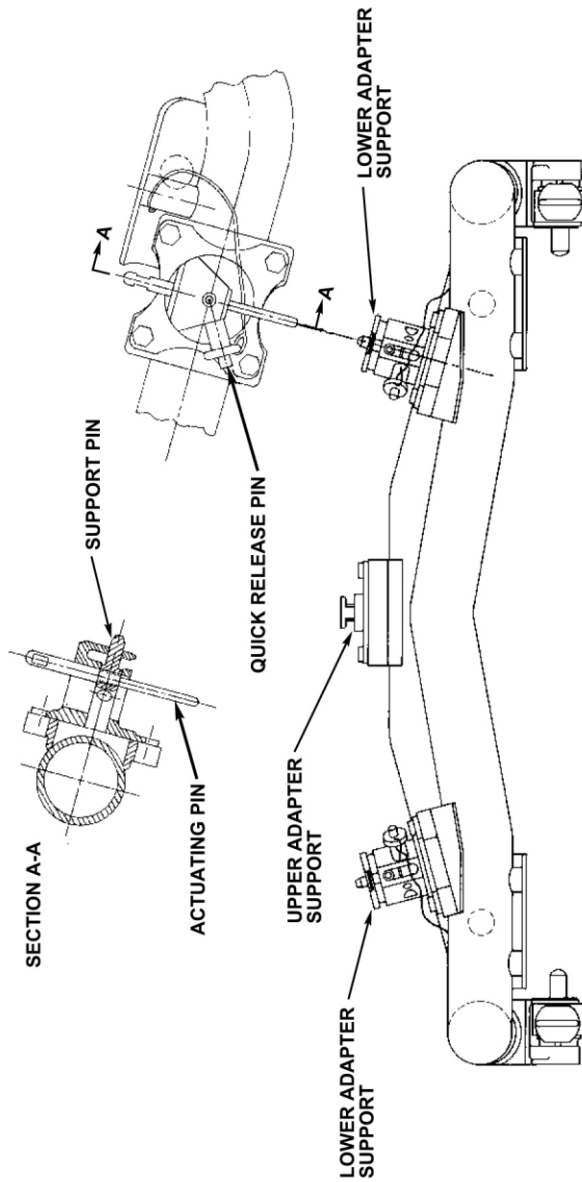
# **ITEM 440      UPDATED EMU ELECTRICAL HARNESS SCHEMATIC** **(CONT'D)**



10610002.hb

**ITEM 470****AIRLOCK ADAPTER PLATE (AAP)**

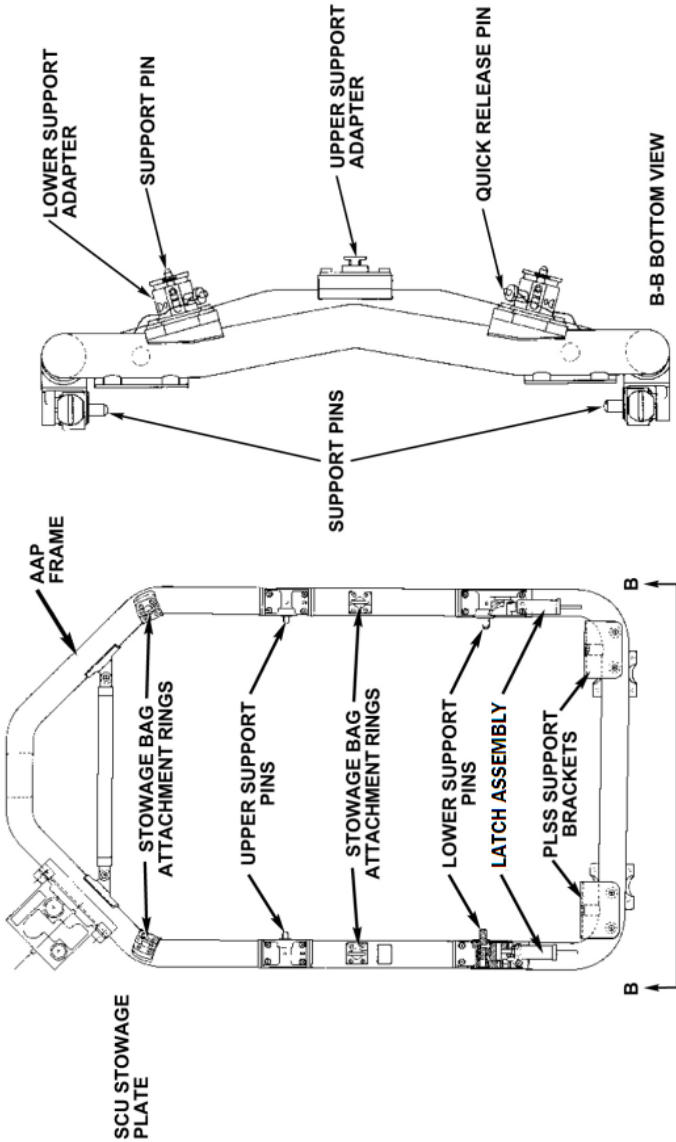
The AAP mounts to the Airlock Wall and is used to stow the EMU when not in use



11048005.flt7

ITEM 470  
(CONT'D)

AIRLOCK ADAPTER PLATE



11048004.rh7

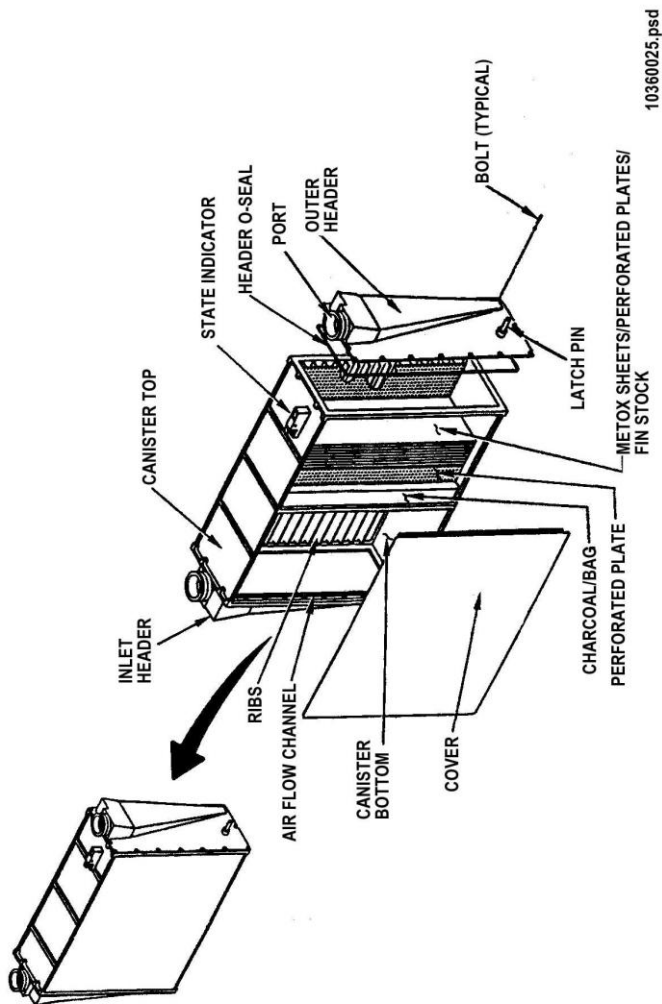
**ITEM 480 METOX CONTAMINATION CONTROL CARTRIDGE (CCC)**

**Filters and removes CO<sub>2</sub> and trace contaminants from the vent loop.  
Canister is regenerable on-orbit aboard ISS.**

- **Delta P..... 0.67 in. H<sub>2</sub>O beginning of life and  
0.90 in. H<sub>2</sub>O end of life at 9.9 lbs/hr  
O<sub>2</sub> (7.2 cfm) at 4.1 psia inlet pressure  
and 72°F inlet temperature**
- **Total weight.....32.0 lbs maximum**
- **Life.....8 hours at normal mission conditions (850 Btu/hr)  
55 absorption/regeneration cycles**

## METOX CONTAMINANT CONTROL CANISTER

ITEM 480



10360025.psd

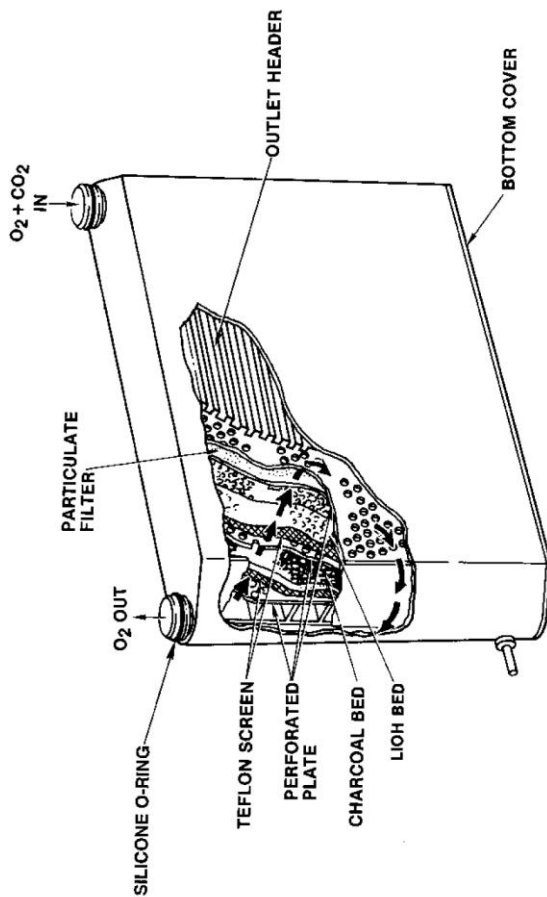
**ITEM 480    LiOH CONTAMINANT CONTROL CARTRIDGE (CCC)**

**Filters and removes CO<sub>2</sub> and trace contaminants from the vent loop.**

- **Delta P.....0.45 in. H<sub>2</sub>O max at 9.9 lbs/hr  
O<sub>2</sub> (7.2 cfm) at 4.1 psia inlet  
pressure and 72°F inlet temperature**
- **Charcoal weight.....0.121 - 0.286 lbs**
- **LiOH weight.....2.45 lbs minimum**
- **Total weight .....6.40 lbs maximum**
- **Life.....7.2 hrs at normal mission  
conditions**

# ITEM 480 LIOH CONTAMINANT CONTROL CARTRIDGE

ITEM 480



REV M

10360007.psd

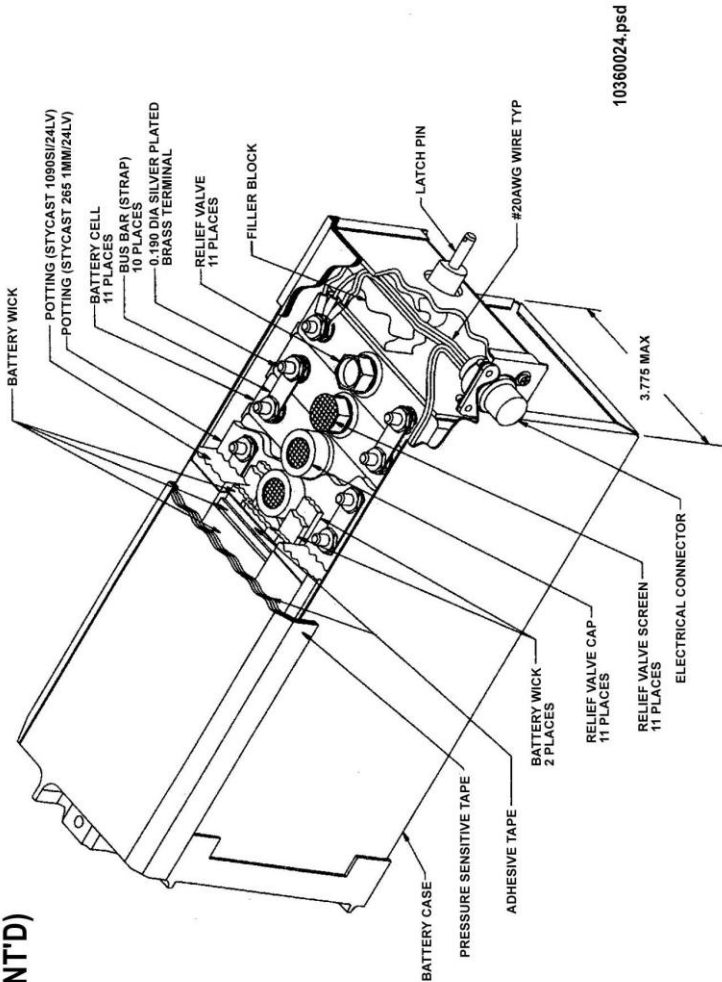
ITEM 490    EMU BATTERY – 2000 SERIES

Supplies power during EVA.

- Power (each cycle).....26.6 amp-hours
- Rechargeable.....12 cycles (319.2 amp-hours)
- Output voltage (nominal).....16.8 volts
- Discharge profile.....3.8 amps for 7 hours
- Weight.....14.7 lbs. max.
- Wet life.....300 days

**ITEM 490  
(CONT'D)**

**BATTERY - 2000 SERIES**

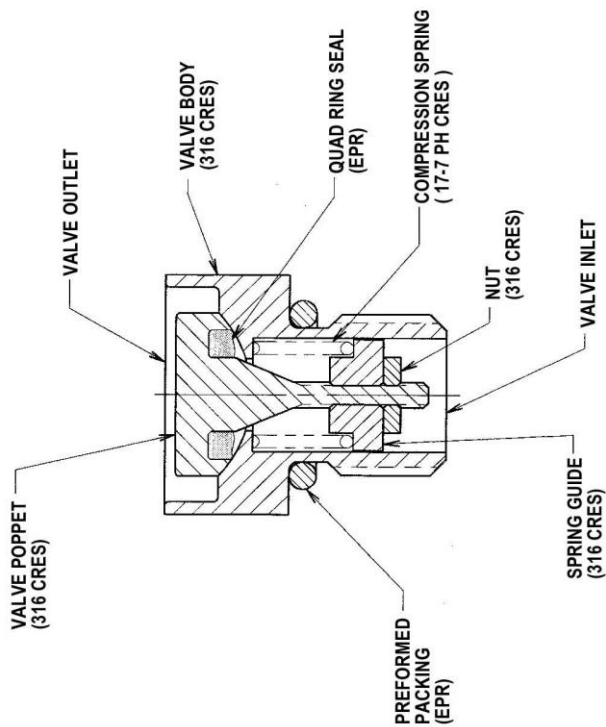


10360024.psd

**ITEM 490  
(CONT'D)**

**BATTERY RELIEF VALVE - 2000 SERIES**

Prevents battery cells from overpressurization.



REV M

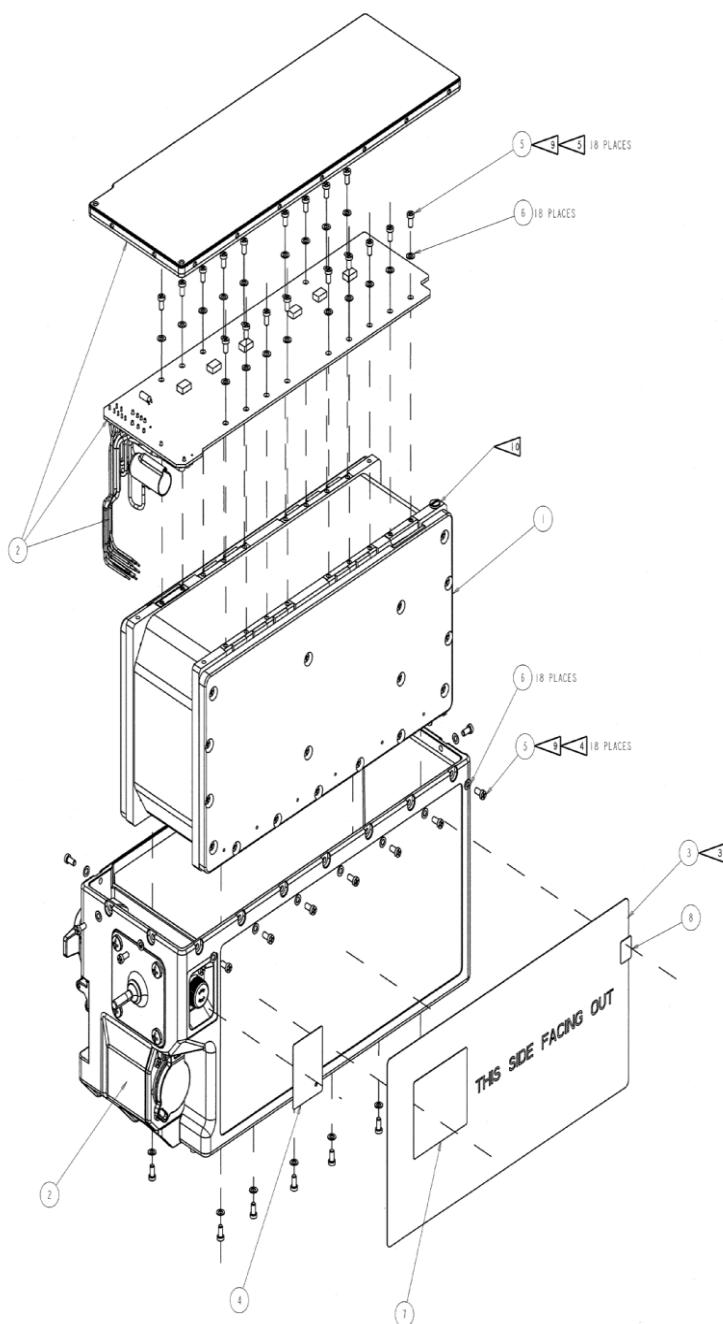
10360026.psd

**ITEM 490    EMU BATTERY – 3000 SERIES LONG LIFE BATTERY (LLB)**  
**Supplies power during EVA.**

- **Power (each cycle).....26.6 amp-hours**
- **Rechargeable.....50 cycles**
- **Life.....5 years**
- **Charged Life.....600 days**
- **Nominal Discharge Profile**
  - **3.8 amps for 7 hours**
  - **Start of discharge @ t = 0 hours.....20.2 to 20.6 volts**
  - **End of Discharge @ t = 7 hours.....≤ 17.5 volts**
  - **Voltage @ 30 minutes remaining before LLB discharges to 16.0 volts.....17.9 volts**
- **Weight.....15.5 lbs**

REV P

# ITEM 490 3000 SERIES LONG LIFE BATTERY



Publicly released per JSC-E-DAA-TN55224

2-295B

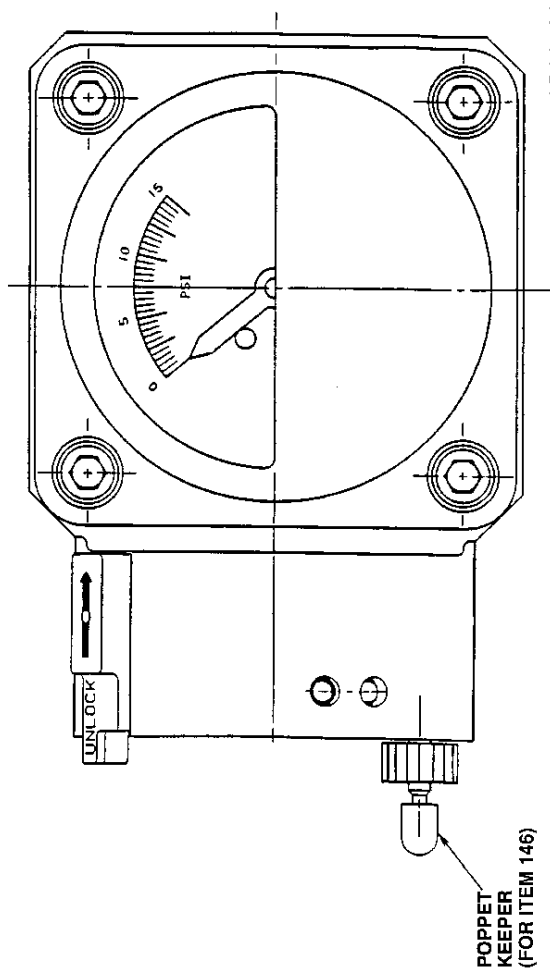
Subject to the EAR and restrictions on cover page: ECCN: 9E515.a

**ITEM 491      BENDS TREATMENT ADAPTER**

**Converts the EMU into a hyperbaric chamber for treatment of the bends by replacing function of I-146 Relief Valve and I-311 Suit Pressure Gauge**

- Normal operating pressure..... 7.5-8.0 psig
- Proof Pressure..... 13.2 psig
- Burst Pressure..... 17.6 psig
- Minimum dry O<sub>2</sub> flow.....7.57 pph
- Max. pressure across relief valve.....8.45 psid
- Max. operating suit pressure.....8.8 psig

## BENDS TREATMENT ADAPTER

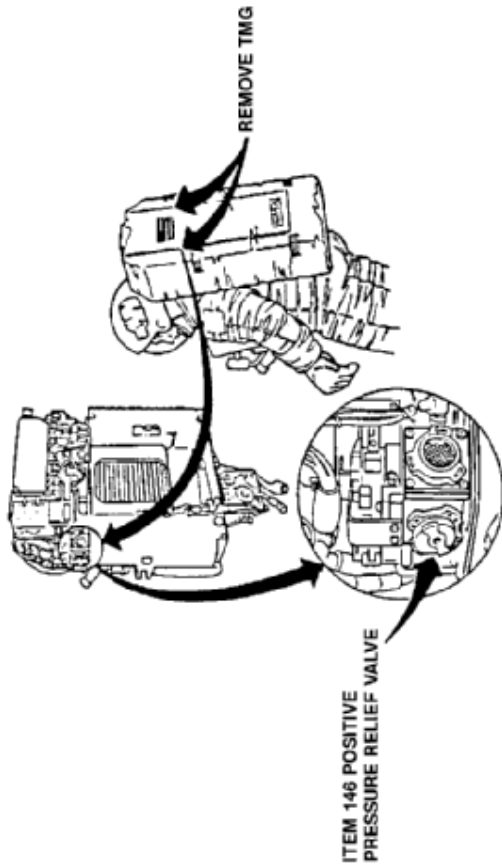
ITEM 491  
(CONT'D)

JG8353211cv

G-466

**ITEM 491  
(CONT'D)****BENDS TREATMENT ADAPTER**

The BTA is installed over the manually opened Item 146.  
The Poppet Keeper opens and holds open the Item 146.

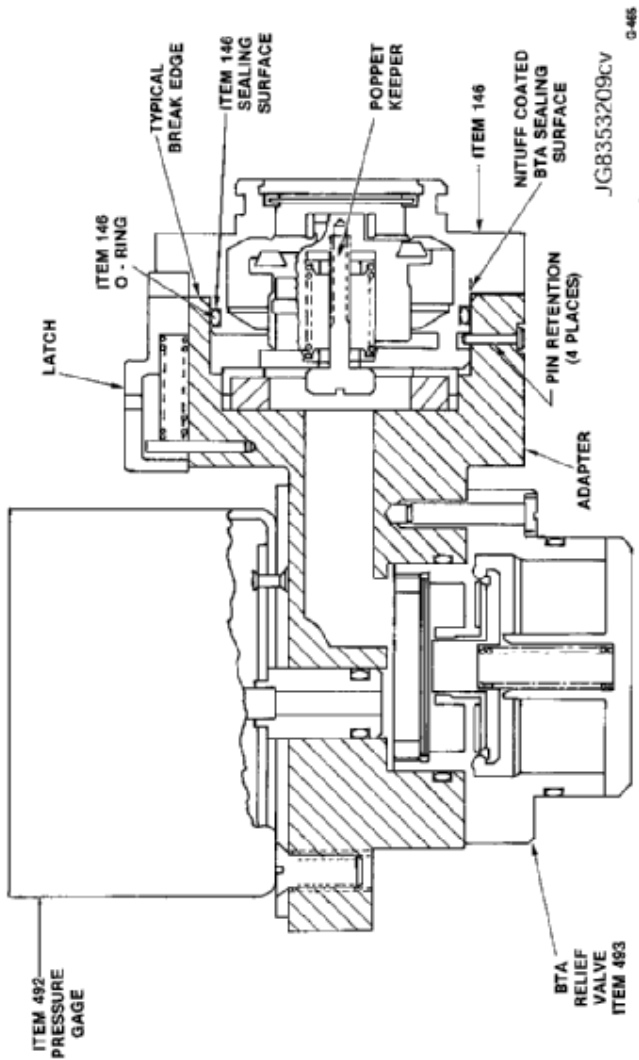


JG8353210cv

0-407

# ITEM 491 (CONT'D)

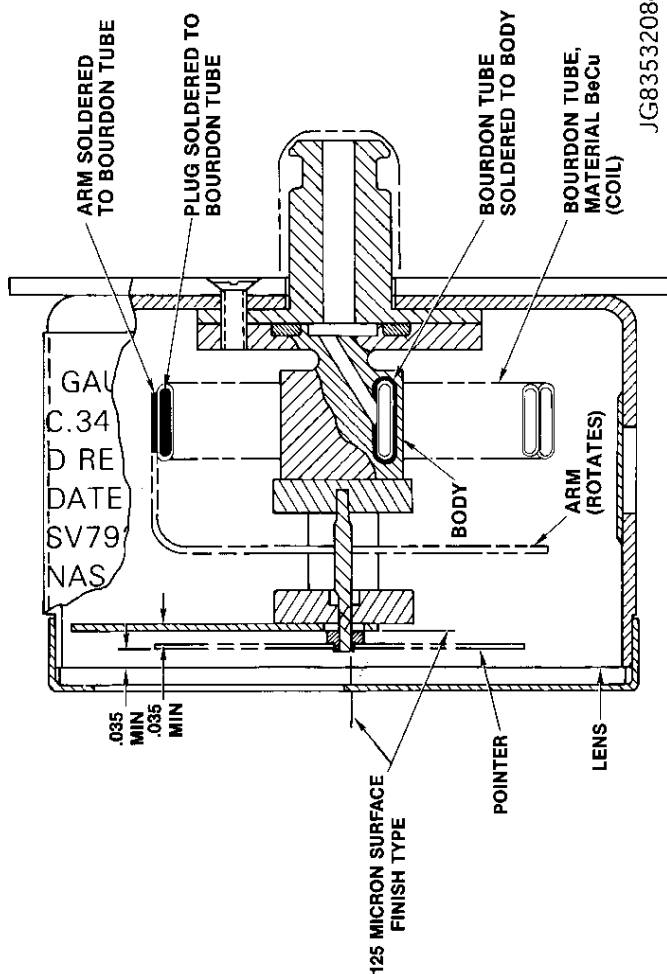
## BENDS TREATMENT ADAPTER INSTALLATION



ITEM 492

# BTA PRESSURE GAGE

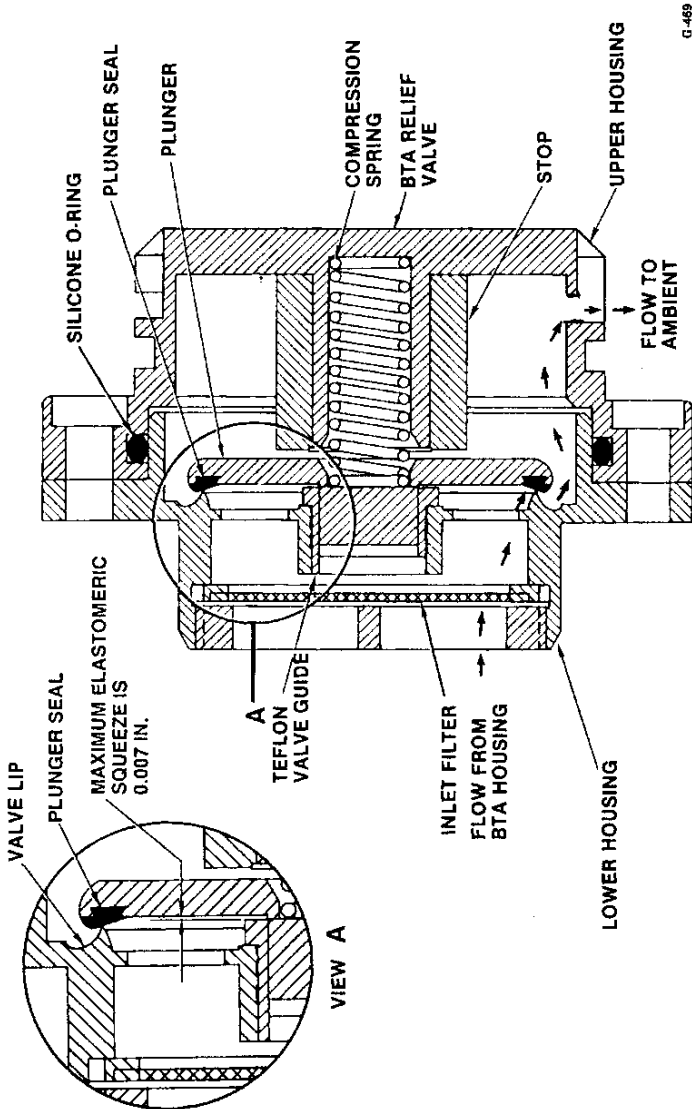
Displays suit pressure during bends operation.



G-468

## ITEM 493

## BTA RELIEF VALVE



G-469

JG8353207cv

**ITEM 495      SOP CHECKOUT FIXTURE (SCOF)**

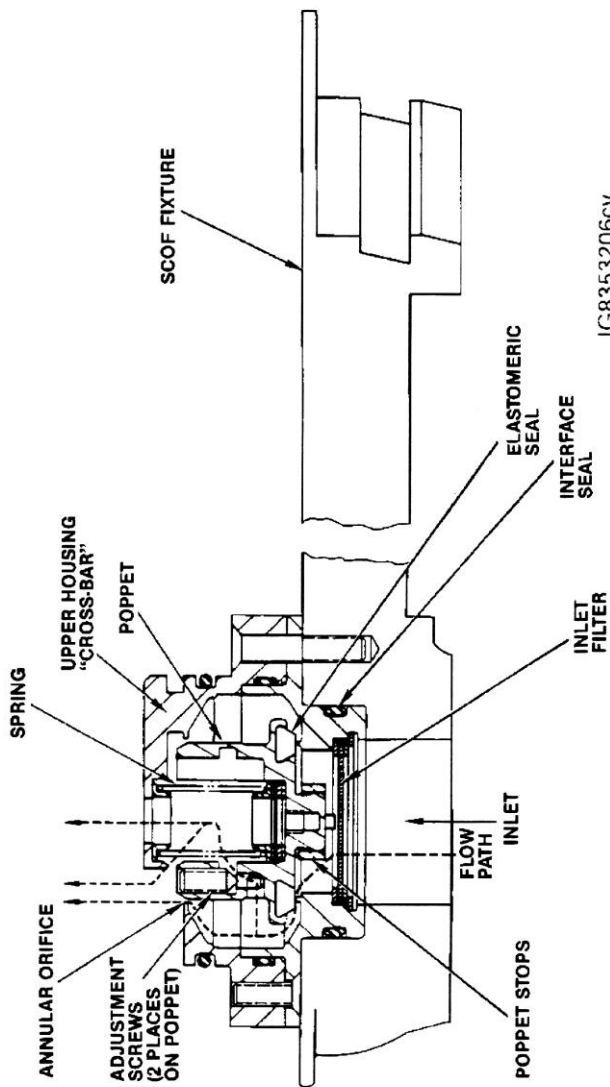
**Attaches to the neck ring and seals the vent loop to allow the SOP to be checked without excessive oxygen loss to the ambient. Provides over pressure protection during checkout.**

- **Flow Rate**  
     **(at 5.5 psid and downstream**  
     **ambient pressure of 10.2 psia)..... 7.49 PPH O<sub>2</sub> minimum**
- **Crack/Reseat..... 4.75 – 4.9 psid minimum**
- **Weight..... 1.2 lbs. maximum**
- **Pressure**
  - **Normal operating..... 5.5 psid**
  - **Proof..... 8.25 psid**
  - **Burst..... 11.0 psid**
- **Leakage..... 1.07 scc/min O<sub>2</sub> maximum**  
     **at 4.5 psid above ambient**

ITEM 495

# SECONDARY OXYGEN PACK CHECKOUT FIXTURE

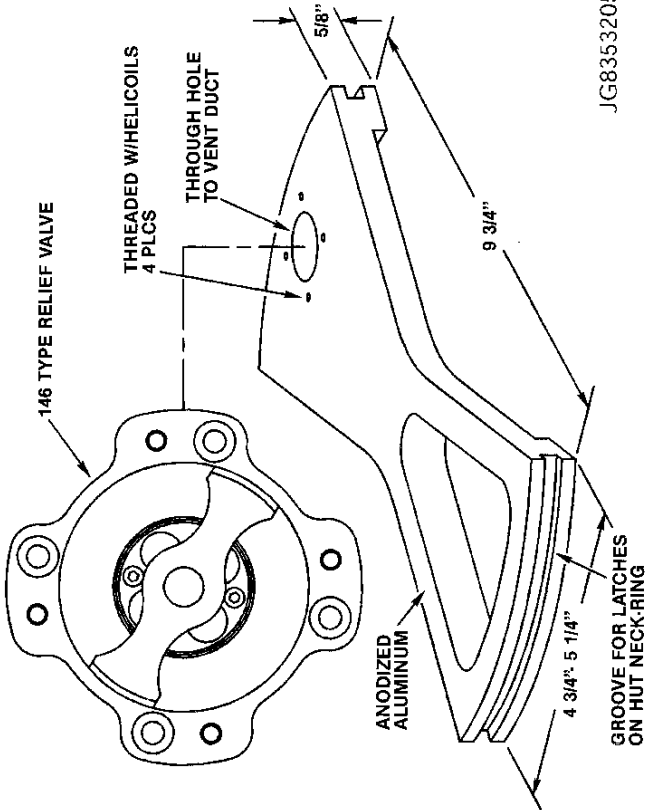
(SHOWN WITHOUT RELIEF VALVE COVER)



JG8353206cv

SOP CHECKOUT FIXTURE (SCOF)

ITEM 495  
(CONT'D)



JG8353205CV

**ITEM 498 ISS EMU UMBILICAL (IEU)**

- The IEU supplies the PLSS with electrical power, communications, oxygen, waste water drainage and water cooling from the ISS AirLock during pre and post EVA operations. It also supplies the EMU with recharge of the primary oxygen tanks and water tanks. In the event of external contamination of the EMU, the IEU can be used to provide power, O<sub>2</sub>, and cooling during “Bake Out”.
- Cooling water lines
  - Pressure drop.....2.1 psid @ 240 lbs/hr
  - Operating pressure.....28.1 psig max
  - Inlet filter.....100 µm
- Water fill/drain line
  - Pressure drop.....1.1 psid @ 30 lbs/hr
  - Operating pressure.....17 psig max
- Oxygen line pressure drop.....17 psig max
  - Inlet filter.....25 µm
- Size ..... Fully extended 252 inches
- Weight.....30 lbs max

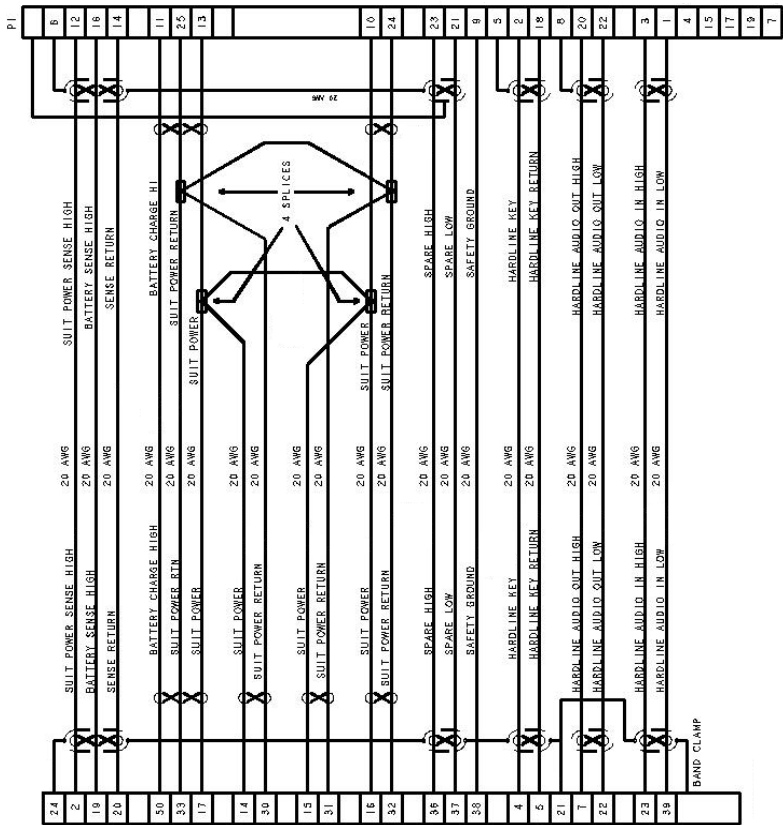
**ITEM 498 ISS EMU UMBILICAL (IEU) ELECTRICAL SCHEMATIC (CONT'D)**



ITEM 498  
(CONT'D)

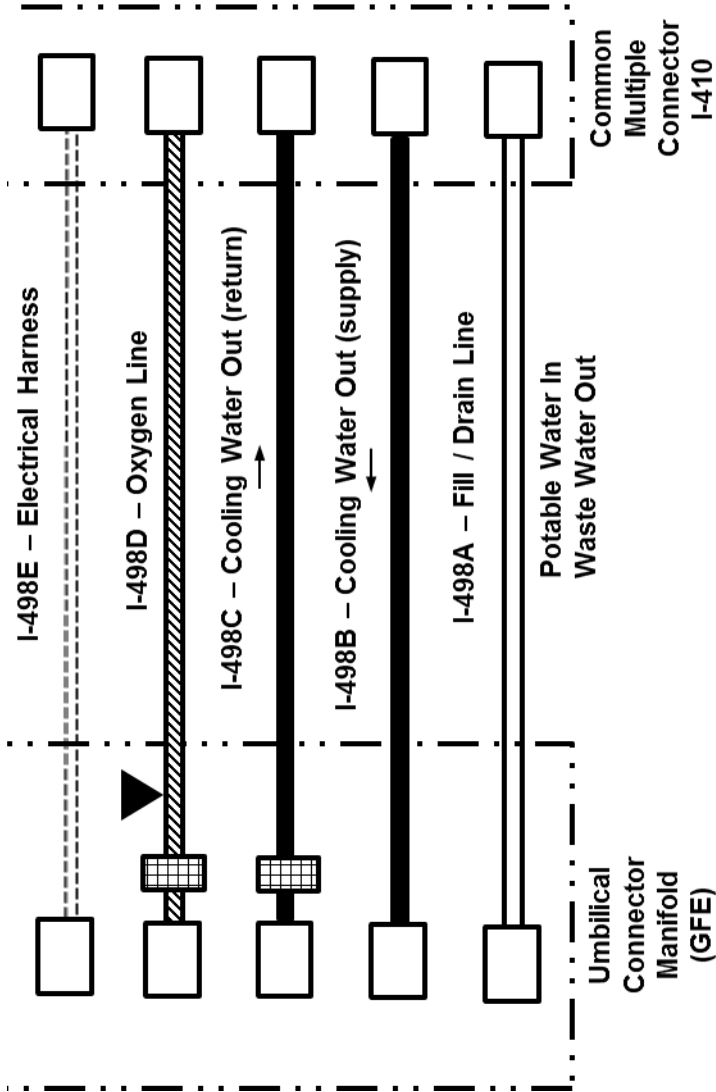
ISS EMU UMBILICAL (IEU) ELECTRICAL SCHEMATIC

REV N



WIRING DIAGRAM

ITEM 498 ISS EMU UMBILICAL (IEU) ELECTRICAL SCHEMATIC (CONT'D)



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# **SECTION 3.1**

## **ENHANCED SSA REQUIREMENTS**

### **3.1 ENHANCED SSA REQUIREMENTS**

The EMU mobility definitions and typical SSA cross section are as defined in Section 15.1.

Figure 1.8 summarizes the allowable leakage for each of the Enhanced suit's CEIs. The leakage is defined for both space and atmospheric pressure.

A summary of the Enhanced SSA mass properties is shown in Figure 1.10.

Enhanced SSA sizing requirements are summarized in Section 1.6.

# **SECTION 3.2**

## **COMMUNICATIONS CARRIER ASSEMBLY (CCA)**

### **3.2.1 COMMUNICATION CARRIER ASSEMBLY (CCA)**

The CCA serves to ensure that the headset, microphone and associated cables remain securely and comfortably positioned during EVA (Figures 3.2.1 and 3.2.2). It is comprised of the skull cap, absorption strap, ear seals and neck or chin straps. The Government Furnished Equipment (GFE) electronics are placed in the skull cap, and the chin or neck straps provide for personal comfort and prevent the entire assembly from shifting during normal operations.

### **3.2.2 CCA COMPONENTS**

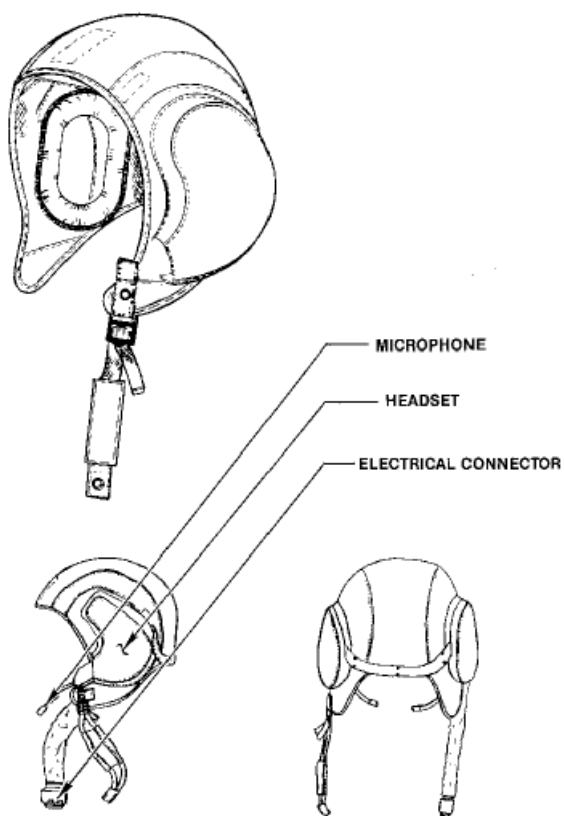
The skull cap consists of two (right/left) Teflon gussets with pockets for electronic interfacing, pull-the-dot fasteners for chin or neck strap attachment, and Velcro pile for ear seal interface. The Teflon pockets have nylon zippers to facilitate electronic installation of the Crew Communication Electronics Module (CCEM).

The two gussets are joined across the top span with nylon/spandex cloth to ensure a conformal fit. Three pieces of Velcro pile are attached to the front underside of this cloth to attach the optional absorption strap.

The crewmember option absorption strap is constructed of urethane foam and a Teflon felt backing. Velcro hook is attached to the Teflon felt for attachment to the skull cap. Regardless of crewmember preference, the fit of the CCA is not affected by the absence or presence of the absorption strap.

The chin strap components include a chin cup, nylon webbings, two pull-the-dot fasteners and an adjustable buckle. The chin cup is made of Teflon cloth with a Teflon felt liner for crewmember comfort.

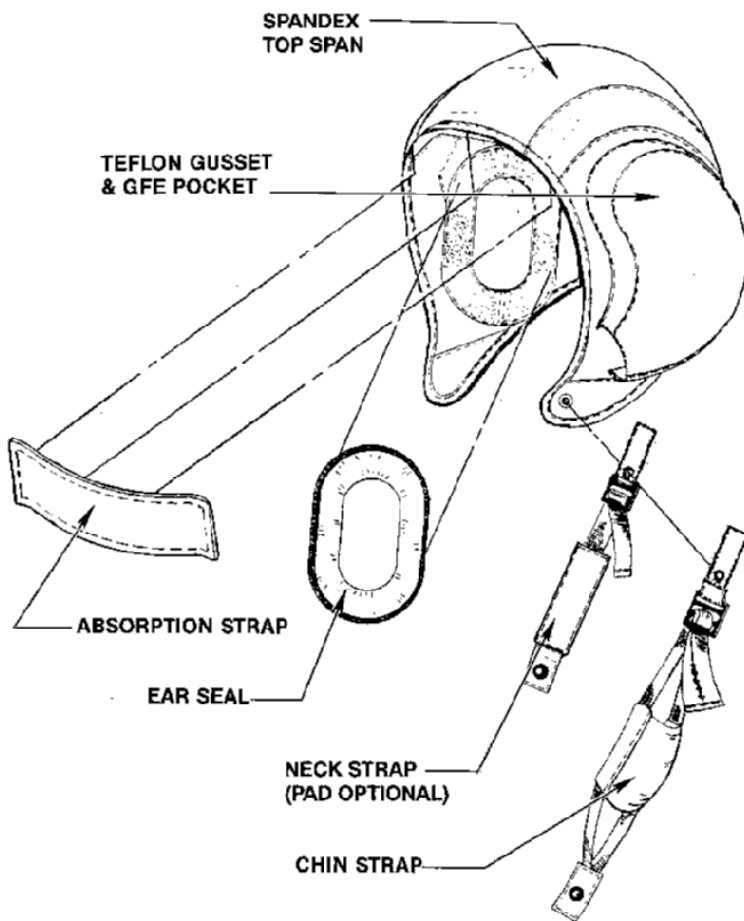
**FIGURE 3.2.1 COMMUNICATION CARRIER  
ASSEMBLY (CCA)**



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FIGURE 3.2.2 CCA COMPONENTS



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The neck strap is a crewmember option which may be substituted for the chin strap according to individual preference. The neck strap attaches to the skullcap at the same points as the chin strap. Pull-the-dot fasteners are installed into Teflon cloth strips and a nylon webbing spans between the two. The strap is sized by the use of an adjustment buckle. The neck pad, also a crewmember option, is constructed from a Teflon felt pad covered with Teflon cloth and slides freely over the neck strap webbing for a custom fit.

The ear seal is a form fitted cup used to channel communications directly into the crewmember's ear. The assembly consists of Latex foam surrounded by a leather cover. One side of the doughnut shaped assembly is covered with black Velcro hook for attachment to the skullcap behind the Teflon communications pockets.

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# **SECTION 3.3**

## **HARD UPPER TORSO (HUT)**

### 3.3.1 PLANAR HARD UPPER TORSO

The Planar HUT provides the structural mounting interface for the Primary Life Support System (PLSS), Display and Controls Module (DCM), Helmet, Arms, Lower Torso Assembly (LTA), and the EMU Electrical Harness (EEH). It also provides pressure containment for this portion of the body and fluid passages from the PLSS to the DCM and to the Liquid Cooling and Ventilation Garment (LCVG).

The Planar Hard Upper Torso (HUT) Assembly consists of four major subassemblies: The Hard Torso Shell (HTS), the Helmet-Suit Disconnect, the HUT-side Body Seal Closure (BSC), the Water Line and Vent Tube Assembly (WLVTa), and the HUT Thermal Micrometeoroid Garment (TMG). Some improvements of the Planar HUT over the Pivoted HUT include: Reduced failure modes due to the elimination of the shoulder Bellows/Gimbals, increased interior volume by reducing the size of water/gas transport tubes, decreased weight, and improved PLSS mounting boss/brackets to replace the stud/bracket/nut on the HUT-PLSS interface.

The main component of the Planar HUT is the HTS. The HTS consists of a rigid fiberglass shell (Figure 3.3.1.1) and two fixed metal retainers that act as the HUT-Arm interface. The HTS also contains the PLSS-HUT and PLSS-DCM mounting pads and mounting brackets and the EMU electrical harness (EEH) brackets. Assembled onto this unit are the HUT-side of the Helmet-Suit Disconnect, the HUT-side of the Body Seal Closure (BSC), the Waterline and Vent Tube Assembly, the Harness Pad and the Shoulder Harness Straps.

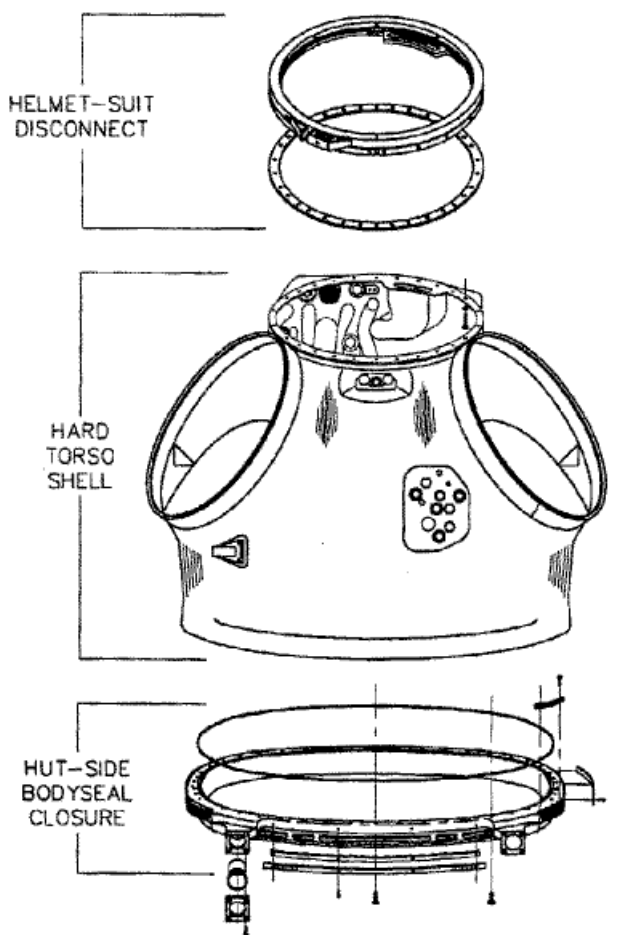
The Helmet-Suit Disconnect consists of the disconnect itself, the Helmet Vent Pad, and the Shoulder Harness Brackets. The Helmet-Suit Disconnect is installed onto the Neckring of the HTS with a silicone seal to retain pressure.

The HUT-side BSC is constructed of metal and is attached to the bottom flange of the HTS with screws and uses an "O" ring to act as a pressure seal. Through the BSC Mounts, the HUT provides an interface to the Mini-Work Station and the Modified Mini-Work Station.

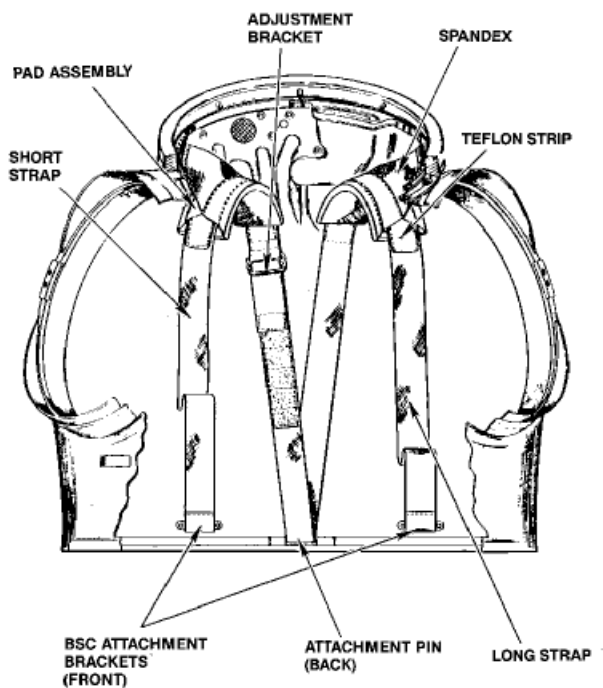
The Water Line Vent Tube Assembly mounts to the HTS interior and interfaces with the LCVG. The WLVTAs supplies cooling water to circulate through the LCVG and provides for exhaust of SSA vent air.

The TMG covers the outside surface of the HUT and provides thermal protection and protection from micrometeoroids. The TMG has long sleeves that also cover the upper arms. The SEMU Power Harness is routed through the sleeves and body of the TMG. The TMG also provides for routing and coverage of the O<sub>2</sub> line and actuator cable and the 391 and 392 electrical jumper harnesses.

A Shoulder Harness (Figure 3.3.1.2), much like a pair of suspenders, is a crewmember option and supports the weight of the EMU on the crewmember's shoulders during 1-G unpressurized activity and tends to stabilize the crewmember in the suit during 0-G pressurized conditions. The Shoulder Harness has two main parts: the Straps and the Pads. The straps are used to adjust and position the pads which act to distribute the load on the shoulders for optimum positioning of the HUT.

**FIGURE 3.3.1.1 PLANAR HARD UPPER TORSO**

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**FIGURE 3.3.1.2      SHOULDER HARNESS**

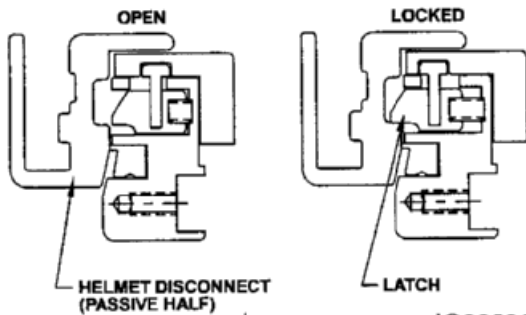
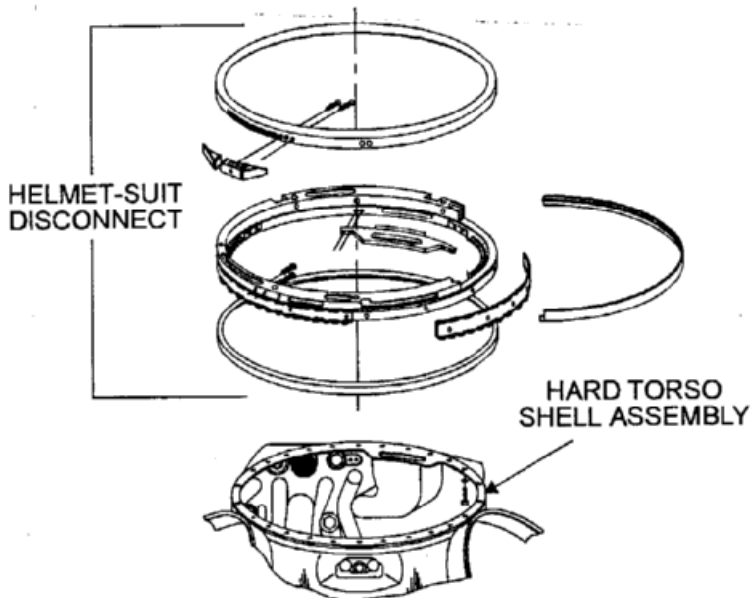
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### 3.3.1.1 HELMET TO PLANAR HUT INTERFACE

The connection of the Helmet to the Planar HUT is provided by a quick disconnect ring (Figure 3.3.1.3). The active half (the portion that contains the moving parts – cams, levers, pins, etc.) is attached to the HUT Neck Ring Flange. The passive half (the portion with no moving parts) is attached to the bottom of the Helmet. The operation of the active half of the quick disconnect is controlled by a locking handle that is located on the outside of the disconnect ring just right of center. The handle has three positions: Open, Engage, and Locked. These positions refer to the status of the locking ring cam, which controls the in and out position of the latching pins. Movement of the handle moves the cam and in turn, the latch pins.

The latch pins extend out of the ring in the Locked and Engage positions and are forced to retract in the Open position. A spring forces the handle to return to the Engage position when it is released from the Open position. This is a safety feature that assures that if a Helmet is properly mated to the Planar HUT it will be captured by the latch pins and will not inadvertently become detached.

**FIGURE 3.3.1.3 HELMET TO PLANAR HUT  
INTERFACE**

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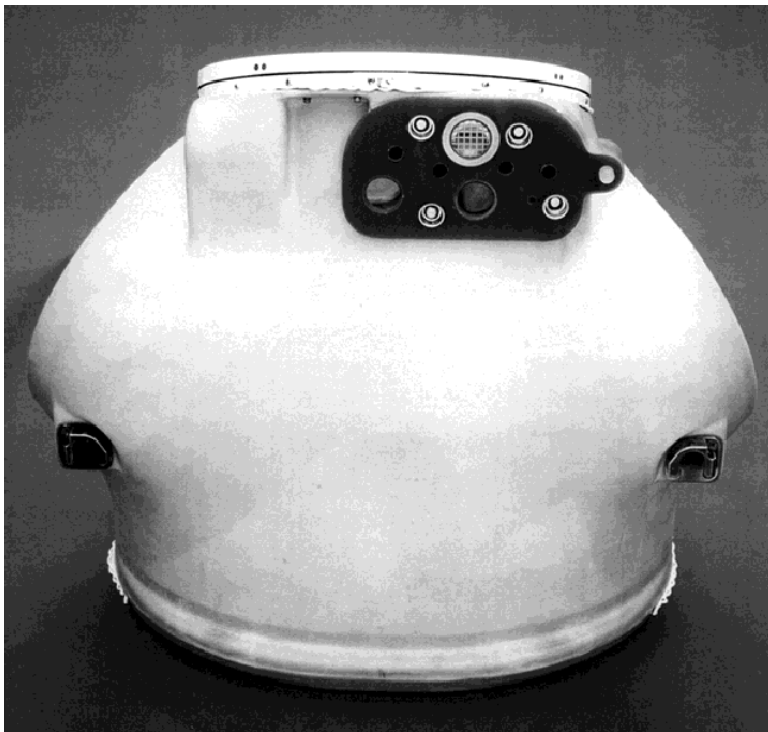
### **3.3.1.2 PLSS TO PLANAR HUT INTERFACE**

The PLSS is attached to the back of the Planar HUT at three points (Figures 3.3.1.4 and 3.3.1.5). There are two studs located on the lower right and left rear sides of the HTS and a PLSS/HUT interface pad at the rear of the Helmet-Suit Disconnect, right of center. To attach a Planar HUT and PLSS, the PLSS is laid on its back and the HUT is lowered onto the PLSS while aligning the two studs with their respective slots in the PLSS and sliding the HUT until the four bypass plate alignment features mate with their respective HUT pad counterbores. The rear vent pad screws are installed from the inside of the HUT. These screws are torqued in sequence to assure the "O" rings in the PLSS seal properly against the flat surface of the HUT pad.

### **3.3.1.3 DCM TO PLANAR HUT INTERFACE**

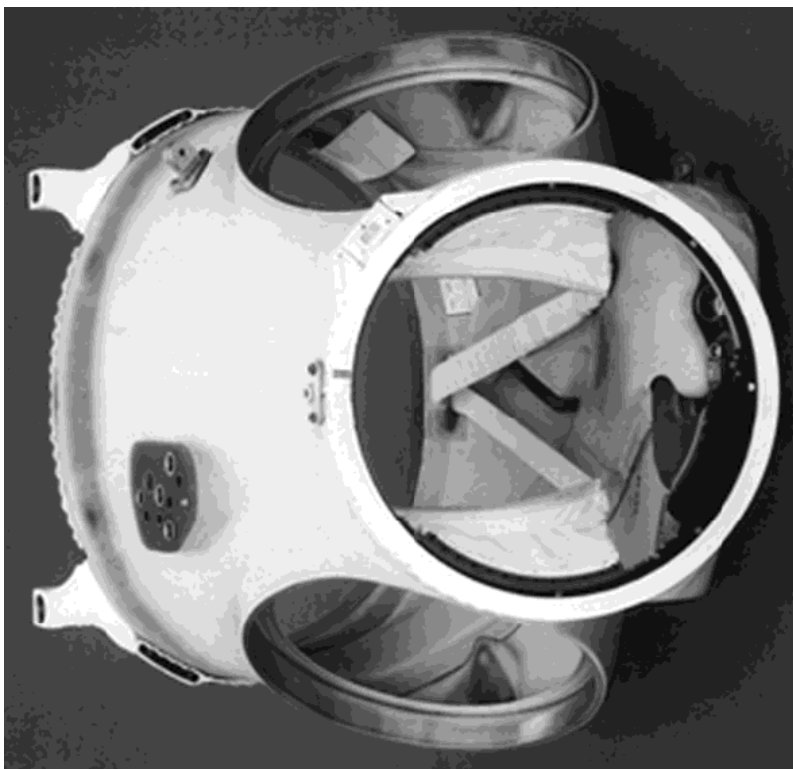
Three points, the DCM pad, the upper DCM mounting boss, and the lower DCM mounting boss, provide the attachment feature for the DCM to the HUT (Figure 3.3.1.6). Two alignment pins protruding from the DCM pad on the HUT mate with holes in the DCM when the two are properly mated to assure alignment of the pneumatic and hydraulic tubes and ducts. Screws are installed from inside the HUT and are tightened in a cross torque pattern to assure "O" rings in the DCM will seal against the flat face of the DCM pad on the HUT.

**FIGURE 3.3.1.4 PLSS TO PLANAR HUT  
INTERFACE**



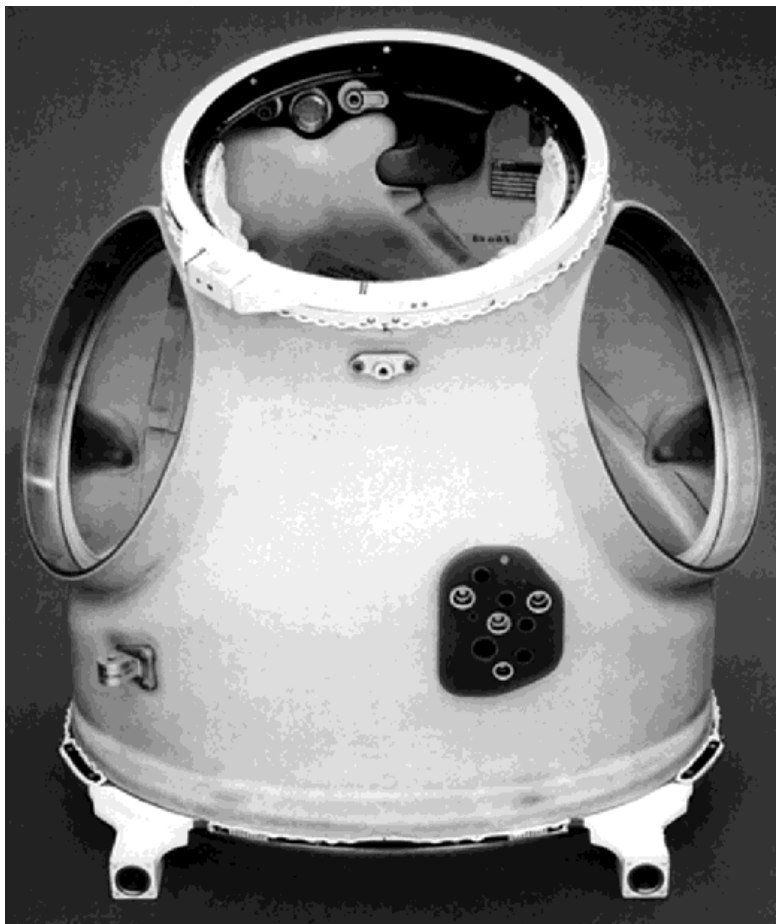
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**FIGURE 3.3.1.5 PLSS TO PLANAR HUT INTERFACE**



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**FIGURE 3.3.1.6 DCM TO PLANAR HUT INTERFACE**



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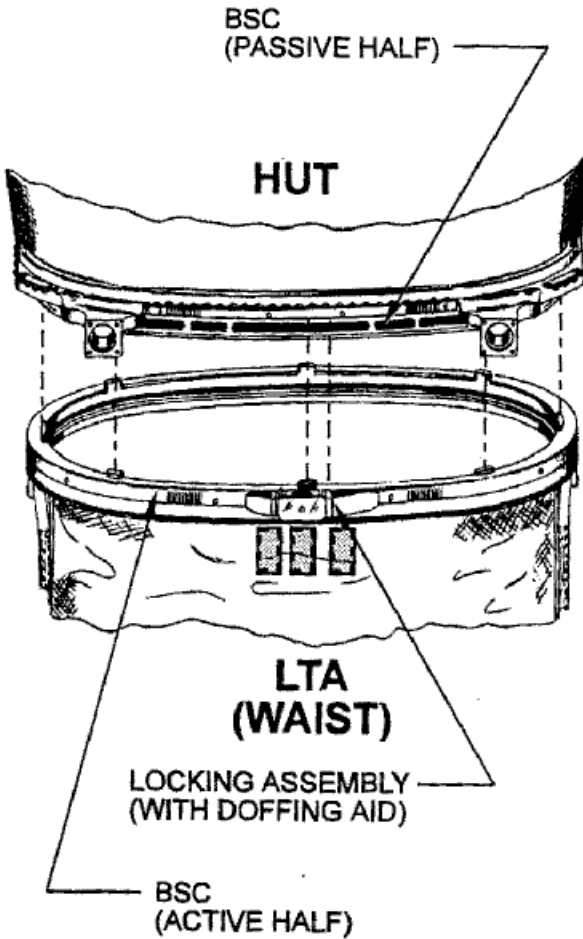
### **3.3.1.4 EMU ELECTRICAL HARNESS (EEH) TO PLANAR HUT INTERFACE**

A hole in the fiberglass shell located over and to the rear of the left shoulder is provided to allow installation of the EEH connector. The bulk-head type connector is installed from inside the HUT by aligning the flat on the connector with the flat on the "D" hole and pushing the connector through. A flange with an "O" ring at the base of the thread seals against the fiberglass shell as the lockwasher and attachment nut are installed. The electrical Harness coming from the EEH connector is routed over the left Scye Bearing opening under the shoulder Harness webbing and over to the front center of the HUT. The harness is secured to the fiberglass shell by tying it to harness clips with lacing cord.

### **3.3.1.5 ENHANCED LOWER TORSO ASSEMBLY (LTA) TO PLANAR HUT INTERFACE**

The LTA to HUT interface is accomplished using the Body Seal Closure (BSC) as shown in Figure 3.3.1.7. The BSC is a two-part quick disconnect similar to the Helmet to HUT Disconnect. The passive portion is attached to the Waist flange of the HUT fiberglass shell and the active portion is attached to the LTA using the LTA Donning Handles. Capture of the BSC halves is obtained by latch pins that are controlled by cams operated by a locking handle. The locking handle is located on the front middle part of the LTA half of the Disconnect and has three positions: Lock, Engage and Open. The operation of the locking handle is similar to the Helmet Disconnect except unlocking is aided by a retractable doffing aid lever.

**FIGURE 3.3.1.7 LOWER TORSO ASSEMBLY  
(LTA) TO HUT INTERFACE**



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### **3.3.1.6 ENHANCED ARM TO PLANAR HUT INTERFACE**

This interface is accomplished by inserting the Arm through a fixed metal retainer in the HUT (Figure 3.3.1.8). The insertion is made from inside the HUT such that the Arms are drawn through the arm openings extending to the outside of the HUT. In this manner, plug and manloads tend to hold the arms in place without the need for heavy structural attachment hardware.

A Dual Seal Scye Bearing is used in the Arm Assembly. The Scye Bearing mounts to the softgoods flange of the Upper Arm (Figure 3.3.1.9). The arm is secured to the HUT by insertion of the Scye Bearing into the HUT retainer. The Scye Bearing sets against a lip on the inside surface of the metal retainer.

A retention ring retains the scye bearing assembly in the HUT by overlapping three lips on the retention ring with matching lips on the HUT side retainer. This is accomplished by twisting the retention ring open into position such that the lip on one end of the ring overlaps the locking lip on the HUT side retainer. With the retention ring seated in this manner, the ring is secured by a cap screw.

### **3.3.1.7 DISPOSABLE IN-SUIT DRINK BAG (DIDB) TO PLANAR HUT INTERFACE**

The DIDB fits into a restraint bag. The restraint bag is attached to the interior of the Planar HUT by attaching Velcro on the bag to DIDB and IDB Velcro on the inside front of the HUT.

**FIGURE 3.3.1.8 ENHANCED UPPER ARM TO HUT INTERFACE**

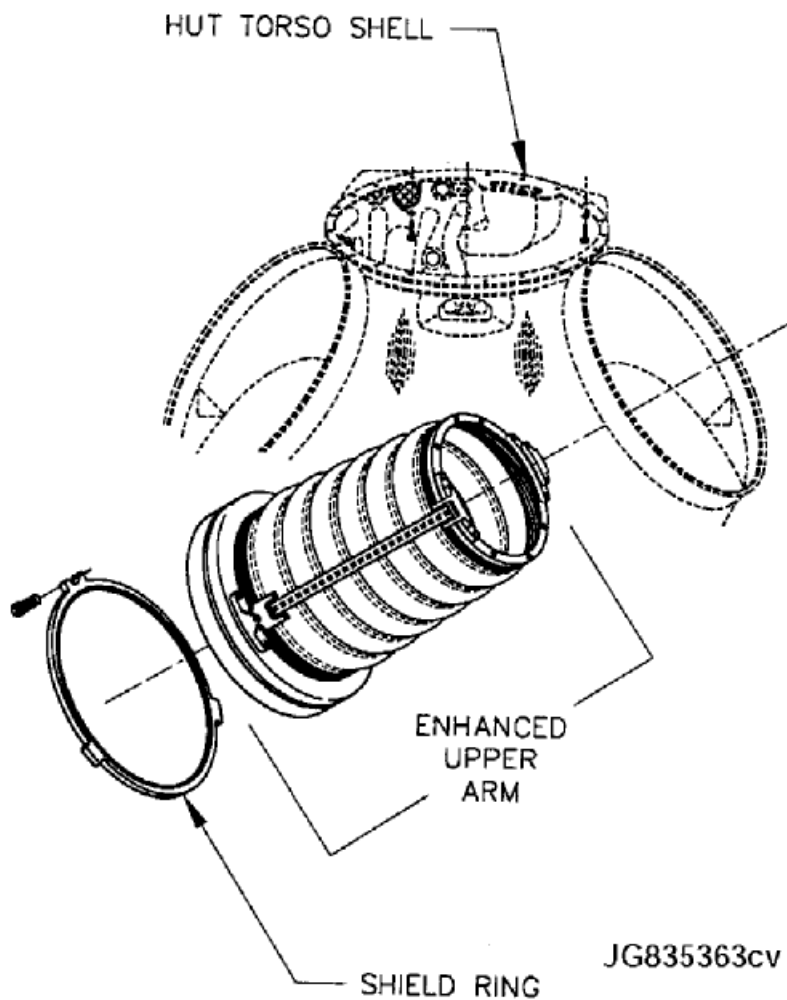
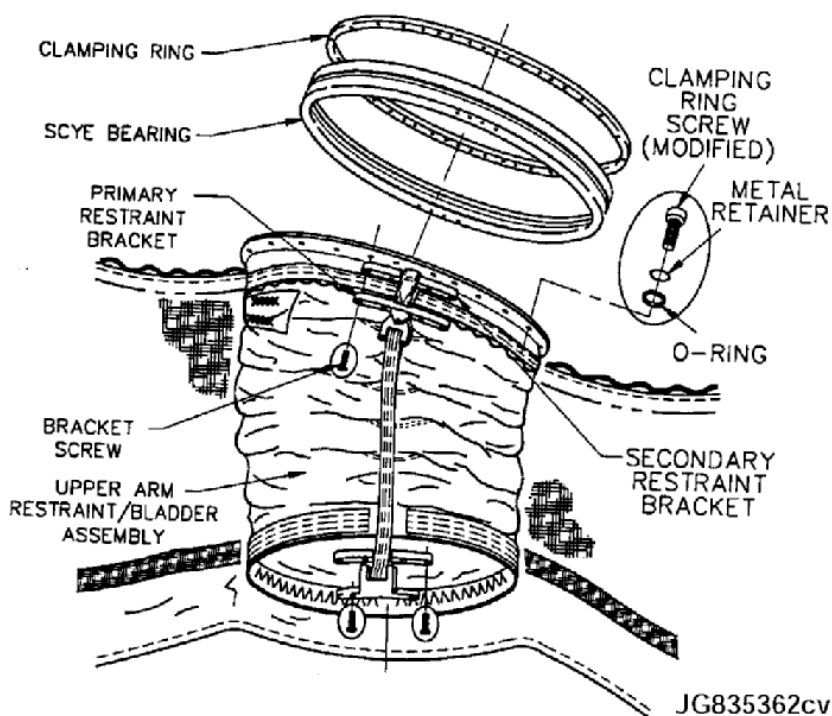


FIGURE 3.3.1.9 SCYE BEARING INSTALLATION



### **3.3.1.8 LIQUID COOLING AND VENTILATION GARMENT (LCVG) TO PLANAR HUT INTERFACE**

The interface between the LCVG and the HUT is accomplished by mating the two halves of the Multiple Water Connector (MWC) quick disconnect. Mating the two halves of the MWC joins the LCVG water inlet and outlet tubes and the oxygen return duct of the LCVG to the HUT WLVTAs. This provides a water and vent flow path between the MWC and the water and vent openings at the back of the HUT (Figures 3.3.2.16 and 3.3.2.17). The WLVTAs, comprised of several major parts, has the Torso Vent Duct in the center bounded by one water line on each side. These are held together within a Harness Assembly.

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## **SECTION 3.4**

# **REMOTE POWERED HEATED GLOVE (RPHG) ARM ASSEMBLY**

### **3.4 REMOTE POWERED HEATED GLOVE (RPHG) ARM ASSEMBLY**

The RPHG Arm Assembly (Figure 3.4.1) consists of three (3) major components; the Upper Arm Assembly, the Sizing Ring, and the Lower Arm Assembly. The RPHG Arm Assembly incorporates in-flight sizing provisions and a power harness.

The RPHG Upper Arm consists of an Upper Arm Restraint/Bladder Assembly, a Dual Seal Scye Bearing and a Dual Seal Arm Bearing with disconnect capabilities. The RPHG Upper Arm Assembly allows shoulder rotation and mobility.

The Sizing Ring provides for a 0.5-inch arm length adjustment and inserts between the Upper Arm Assembly and the Lower Arm Assembly. The Sizing Ring incorporates quick disconnect capabilities.

The RPHG Lower Arm consists of a Lower Arm Restraint/Bladder Assembly, an Arm Fabric Attachment Ring, an EMU Power Harness and a Lower Arm TMG. The Lower Arm Assembly allows elbow flexion and rotation. The suit side wrist disconnect is attached to the lower arm.

The Upper and Lower Arms are joined by the Dual Seal Arm Bearing, which features a threaded metal quick disconnect and enables the upper and lower arms to be separated by crewmembers. The entire Arm Assembly interfaces with the Planar HUT at the Scye opening.

The Thermal Micrometeoroid Garment (TMG) provides thermal protection. The Upper Arm TMG, an integral part of the HUT TMG, incorporates a portion of the EMU Power Harness Assembly. The Lower Arm TMG allows access to the adjustable Lower Arm Brackets and thermally protects the Lower Arm portion of the EMU Power Harness. Attachment of the Lower Arm TMG is

accomplished with looptape/lacing cord at the fabric attachment ring and Velcro hook/pile at the wrist disconnect.

The EMU Power Harness provides power to heaters in the glove to ensure crewmember finger/hand comfort. Sections of the EMU Power Harness are connected via 'plug in' connectors located at each end of the Lower Arm.

### **3.4.1 BLADDER ASSEMBLY**

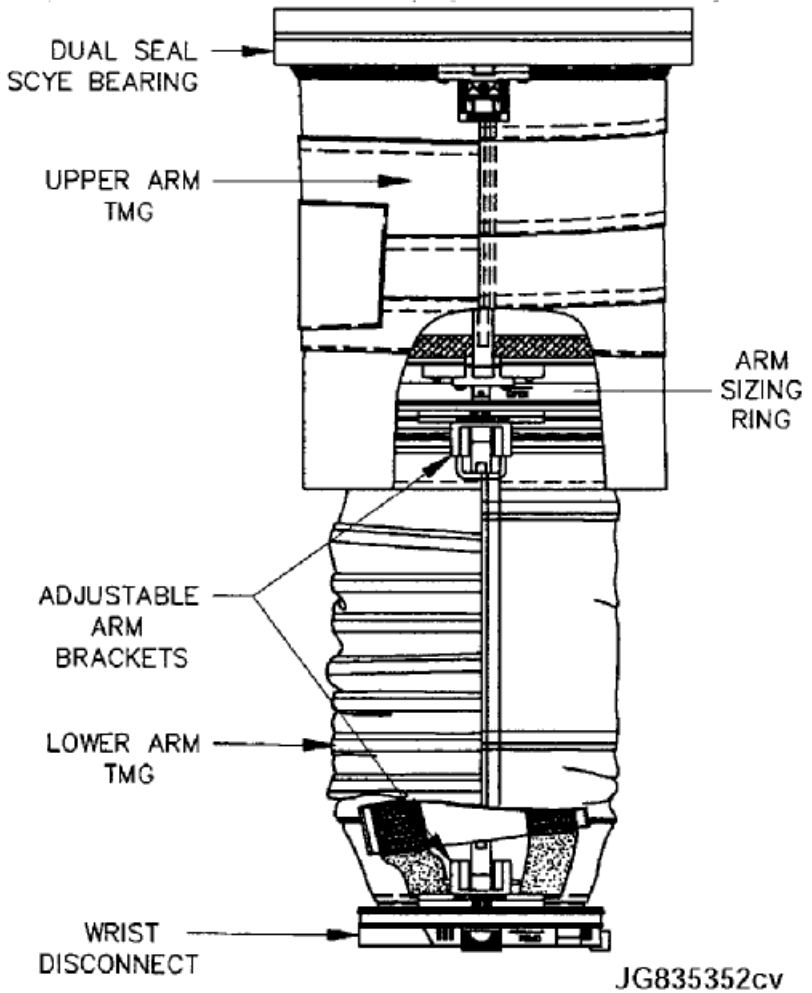
The pressure integrity of the RPHG Arm Assembly is maintained by the Bladder Assembly. The bladder Assembly on the RPHG Arm was redesigned to reduce torque and "bunching" in the convolutes.

### **3.4.2 RESTRAINT ASSEMBLY**

The Arm Restraint Assembly (Figure 3.4.2) serves to manage the pressure loads on the Arm Bladder during suit operation. The restraint is constructed from a plain weave polyester fabric. The axial restraint webbings are constructed from a high strength, low elongation material in order to reduce the amount of stretch or "growth" that occurs when the article is pressurized.

Circumferential loads are held by the restraint fabric. Axial loads are managed by the Axial Restraint Webbings. Redundancy is incorporated in the axial restraints by the use of both a primary and secondary restraint webbing. The secondary is capable of assuming the total axial load in the event the primary were to fail.

FIGURE 3.4.1 RPHG ARM ASSEMBLY



### **3.4.3 GLOVE TO RPHG ARM INTERFACE**

Interface of the Glove to the Arm is accomplished via Wrist Disconnects (Figure 3.4.3). These are metal couplings attached to both the wrist flange of the Arm and the Glove which serve to mechanically couple and lock the two together. The Glove side of the Dual Seal Wrist Disconnect uses an "O" ring at the flange to provide a pressure seal. The suit-side of the Wrist disconnect also uses an "O" ring at the flange mount, but also incorporates a static lip seal in the hardware to ensure suit pressure integrity. Dual and redundant locks, installed on the suit-side disconnect, serve to lock the Glove to the Arm and prevent inadvertent disengagement. The outer rim of the disconnect locking ring is marked to show OPEN and LOCK positions and rotates to engage one or the other. Arrows are also engraved below the labeling to indicate direction of actuation. Operation of the disconnect/connect mechanism consists of depressing the locking button, raising the redundant latches and rotating the locking ring to engage or disengage the Glove.

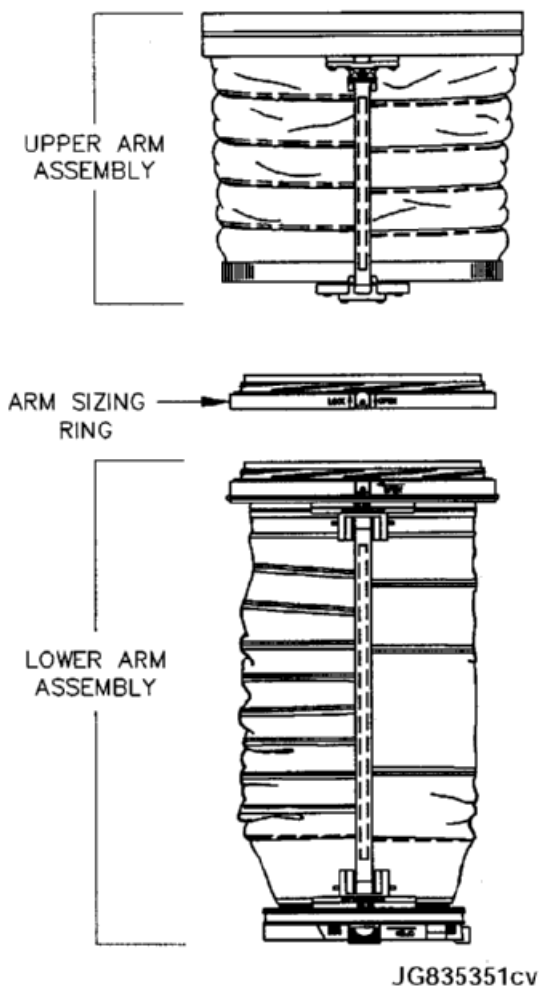
### **3.4.4 LOWER ARM TO UPPER ARM INTERFACE**

The interface of the Lower Arm Assembly and Upper Arm Assembly is accomplished via the arm bearing (Figure 3.4.4). Pressure is maintained in the bearing with two lip seals to offer redundancy. Torque has been reduced both by the use of composite spacers between the steel balls in the bearing and by the use of a light weight lubricant. The Lower Arm is attached to the arm bearing by a threaded Fabric Attachment Ring or Sizing Ring. The Fabric Attachment Ring attaches to the Lower Arm through the use of a clamping ring and screws. Upper Arm axial restraint brackets are attached to the arm bearing via clamping ring screws. The Lower arm axial restraint brackets are attached directly to the Fabric Attachment Ring which in turn threads onto the arm bearing inner race.

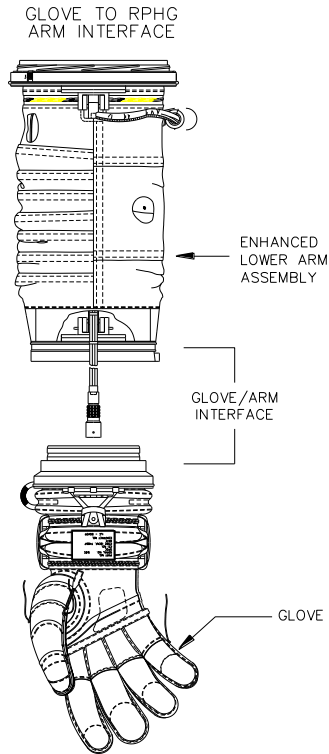
### **3.4.5 SIZING THE RPHG LOWER ARM ASSEMBLY**

The RPHG Lower Arm Assembly uses adjustable arm brackets as well as a metal Arm Sizing Ring for sizing. These items are designed to allow crewmembers to perform sizing tasks on-orbit. There are four adjustable arm brackets, one at each end of both axial restraint lines. Each cam can adjust 0.25 in. for a total of 0.5 in. The Arm Sizing ring adds an additional 0.5 in. of length to the lower arm (Figure 3.4.5). The Arm Sizing Ring threads onto and locks to the Fabric Attachment Ring, which is then threaded onto the Dual Seal Arm Bearing.

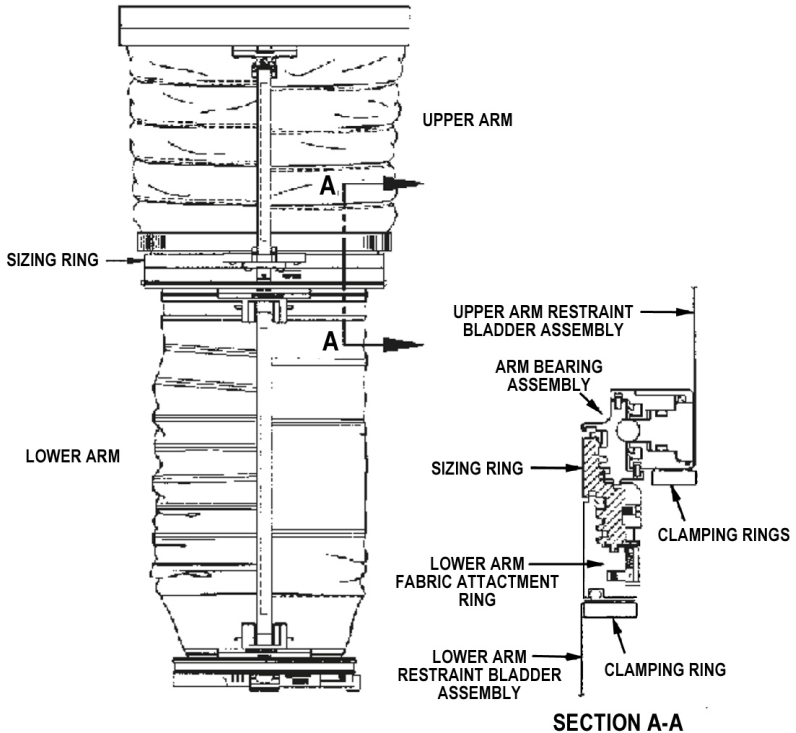
**FIGURE 3.4.2 RPHG ARM RESTRAINT  
ASSEMBLY**



**FIGURE 3.4.3 GLOVE TO RPHG ARM INTERFACE**

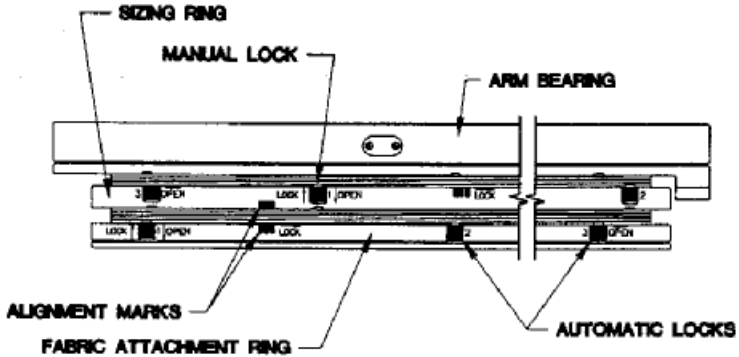


**FIGURE 3.4.4 ENHANCED LOWER ARM  
TO UPPER ARM**

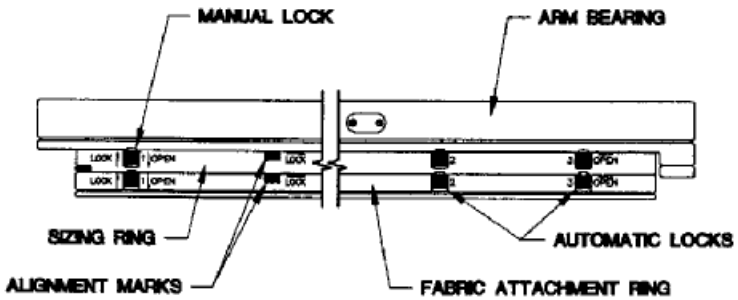


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**FIGURE 3.4.5 RPHG ARM FABRIC ATTACHMENT  
RING / SIZING RING INTERFACE**



**ENGAGE POSITION**



**LOCKED POSITION**

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# **SECTION 3.5**

## **ENHANCED LOWER TORSO ASSEMBLY (LTA)**

### 3.5 ENHANCED LOWER TORSO ASSEMBLY (LTA)

The Enhanced Lower Torso Assembly (Figure 3.5.1) consists of five major subassemblies: the Brief-Waist Assembly, the Leg Assembly, the Boot Assembly, the Thigh Sizing Ring, and the Leg Sizing Rings. The Enhanced LTA configuration includes adjustable leg restraint brackets incorporating 0.5 in. of length adjustment; a 0.5 in. thigh sizing ring, 0.5, 1.0, and 1.5 in. leg sizing rings, that provide overall length adjustment by as much as 3.0 in. Resizing and change-out of the enhanced components can be performed on-orbit.

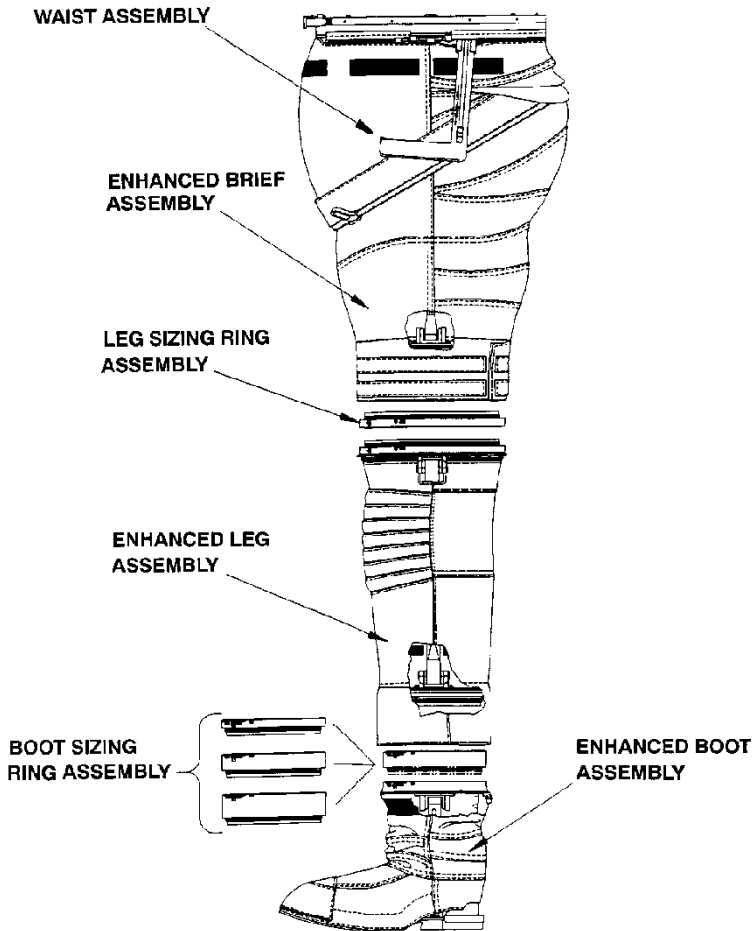
The fabric elements are joined by flange attachment to hardware, and in all cases, except at the BSC and the waist bearing, the attachment between elements is by a threaded metal quick disconnect which allows components to be interchanged easily. The LTA interfaces the Hard Upper Torso (HUT) via the BSC.

LTA thermal protection is provided by a Thermal Micrometeoroid Garment (TMG). The TMG sections fit over the waist, brief, leg and boot assemblies. They are secured to the LTA through the use of lacing cord/looptape attachments, zippers, and Velcro hook and pile.

The Brief-Waist Assembly consists of the Body Seal Closure (BSC), adjustable Waist Restraint/Bladder Assembly, a Dual Seal Waist Bearing, Brief Restraint/Bladder Assembly, and the Waist and Brief TMG Assemblies. The Brief-Waist Assembly includes the waist and hip joint and thigh fabric attachment rings.

The leg assembly consists of the Leg Restraint/Bladder Assembly and the TMG Assembly. The Leg Assembly includes an upper and lower Fabric Attachment Ring, adjustable leg restraint brackets incorporating 0.5 inch of length adjustment and primary/secondary axial restraint webbings. The Leg Assembly includes a knee joint.

**FIGURE 3.5.1      ENHANCED LOWER  
TORSO ASSEMBLY (LTA)**



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The Boot Assembly consists of the Boot Restraint/Bladder Assembly, the Boot Sole Stiffener, the Boot Heel Assembly, the Boot TMG Assembly, and the Boot Fabric Attachment Ring. The Boot Assembly contains the ankle joint.

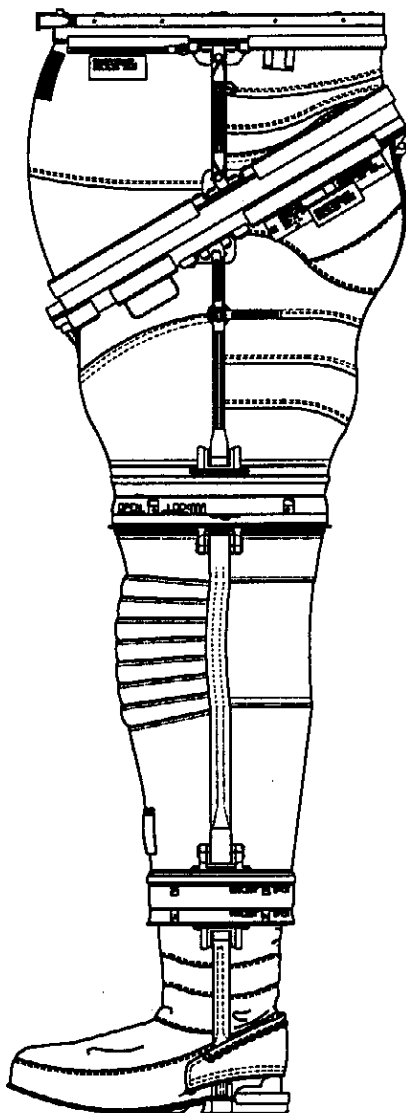
### **3.5.1 BLADDER ASSEMBLY**

Pressure integrity of the Enhanced Lower Torso Assembly is maintained via seals at all component disconnects and component bladder assemblies i.e. adjustable waist, brief, leg, and boot.

### **3.5.2 RESTRAINT ASSEMBLY**

The LTA Restraint Assembly (Figure 3.5.2) serves to manage the circumferential loads of the LTA during normal suit operation. The restraint is constructed from polyester fabric. The Axial Restraint Webbing on the Enhanced LTA are constructed from a new, high strength, low elongation webbing. This webbing greatly reduces the amount of stretch or “growth” that occurs when the article is pressurized. The exception is the Boot Assembly, which uses polyester for Axial Restraint Webbing. The axial restraint loads are transferred in a contiguous loop from one side of the BSC to the other through the Waist, Brief, Leg, and Boot axial restraint lines. Redundancy is incorporated in the axial restraints by the use of both primary and secondary restraints. The primary restraint brackets, except for the crotch buckle and the brief-waist bearing interface, may be removed for inspection or replacement of Enhanced LTA components.

**FIGURE 3.5.2      ENHANCED LOWER TORSO  
RESTRAINT ASSEMBLY (LTA)**



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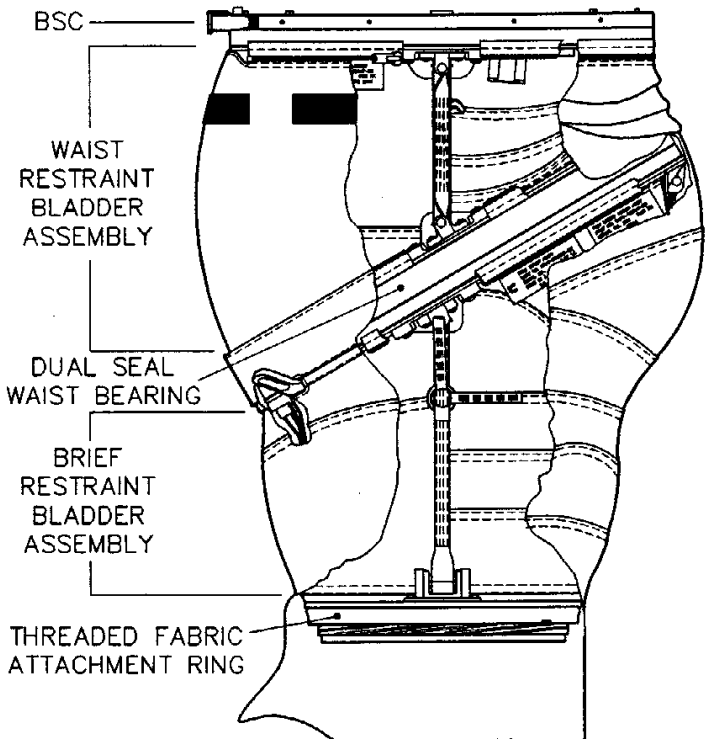
### 3.5.3 BRIEF-WAIST ASSEMBLY

The Brief-Waist Assembly (Figure 3.5.3) consists of a Body Seal Closure (LTA-half), fabric waist joint, dual seal waist bearing, thigh fabric joints, threaded fabric attachment rings at the thigh openings of the Brief, and Brief and Waist TMG assemblies. The Brief-Waist Assembly is the transition from the HUT to the Leg portion of the LTA. The Brief-Waist Assembly is the longest component of the LTA. There is 2.0 in. of adjustment available in one inch increments in the waist by removing the upper and/or lower primary restraint pins, repositioning the primary webbing and replacing the pin. There are two sizes of Waist Bearings that join the Brief-Waist Assembly. A 16.0 in. Waist Bearing is used on the Large Brief Assembly. An appropriately sized Waist Assembly is attached to the other side of either Waist Bearing.

### 3.5.4 LEG ASSEMBLY

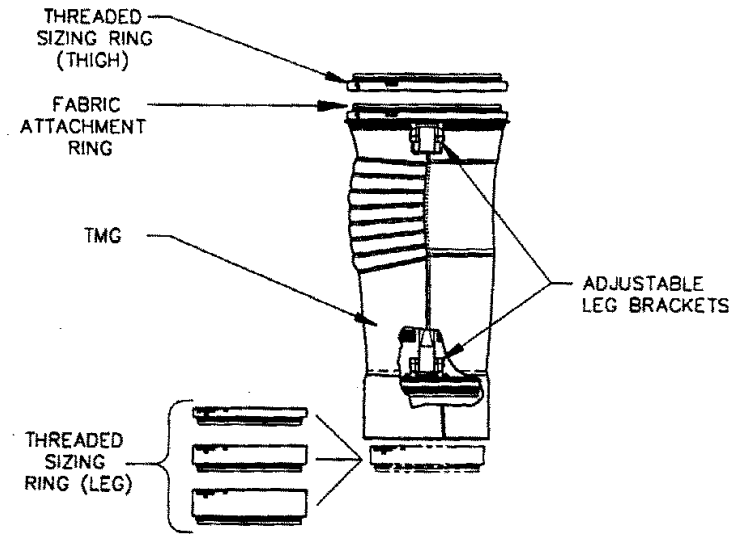
The Leg Assembly (Figure 3.5.4) consists of a single-axis unidirectional fabric joint, upper and lower threaded fabric attachment rings, adjustable leg brackets, and a TMG. The Leg Assembly provides for flexure of the knee joint while maintaining SSA pressure integrity and joint shape. Several sizes of Leg Assemblies allow for rapid resizing of the LTA. The Leg Assemblies come in five different lengths and are removed from the Brief Waist Assembly via the use of threaded Fabric Attachment Rings. The Leg Assemblies also incorporate leg adjustable brackets and metal Thigh and Leg Sizing Rings to achieve proper knee/convolute position. The possibilities include a 0.5 in. Thigh Sizing Ring and/or 0.5 in., 1.0 in., and 1.5 in. Leg Sizing Rings (sizes may not be combined).

**FIGURE 3.5.3      ENHANCED LTA BRIEF WAIST ASSEMBLY**



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**FIGURE 3.5.4      ENHANCED LTA LEG ASSEMBLY**



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### **3.5.5 BOOT ASSEMBLY**

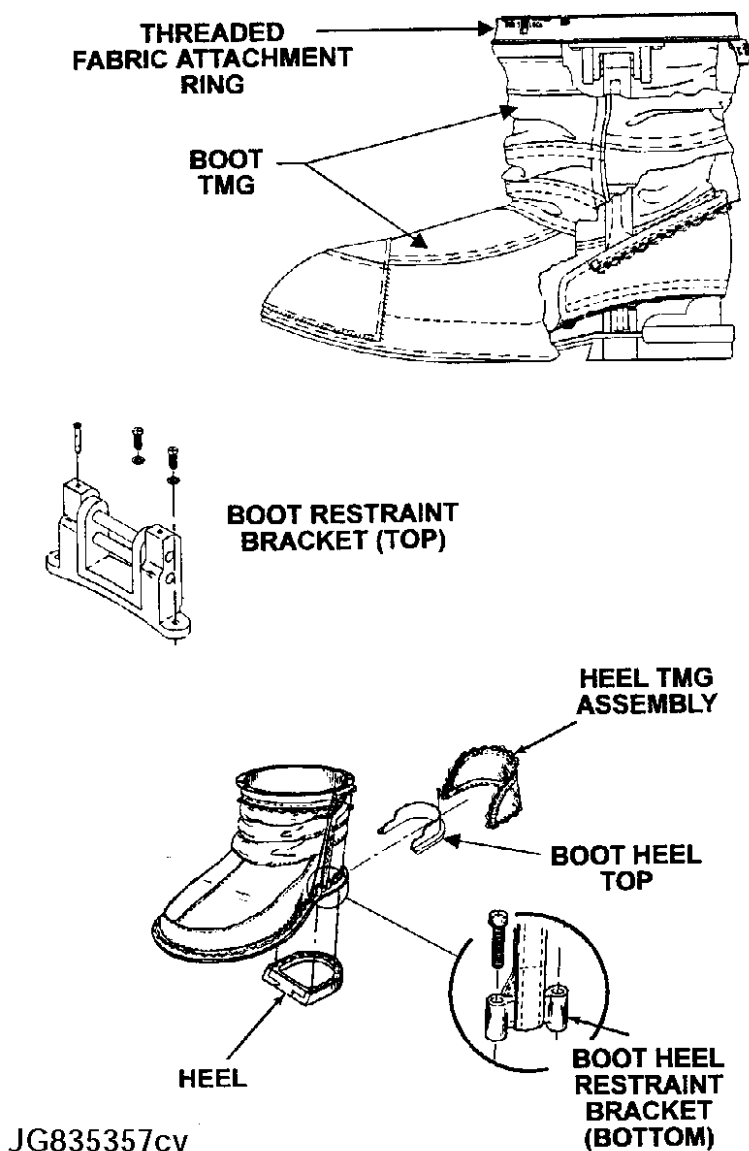
The Enhanced Boot (Figure 3.5.5) consists of a fabric ankle joint, fabric foot envelope, fiberglass sole stiffener, removable heel, threaded fabric attachment ring, and a TMG. The Boot Assembly provides for flexion and extension of the ankle joint while maintaining SSA pressure integrity and joint shape. Two sizes of boots and three sizes of Boot Sizing Inserts for each of them, allow for sizing adaptation to different sizes of crew foot size. The boot top fabric attachment ring is threaded to allow insertion of sizing rings between the Leg and the Boot.

### **3.5.6 BOOT SIZING INSERTS AND THERMAL SLIPPERS**

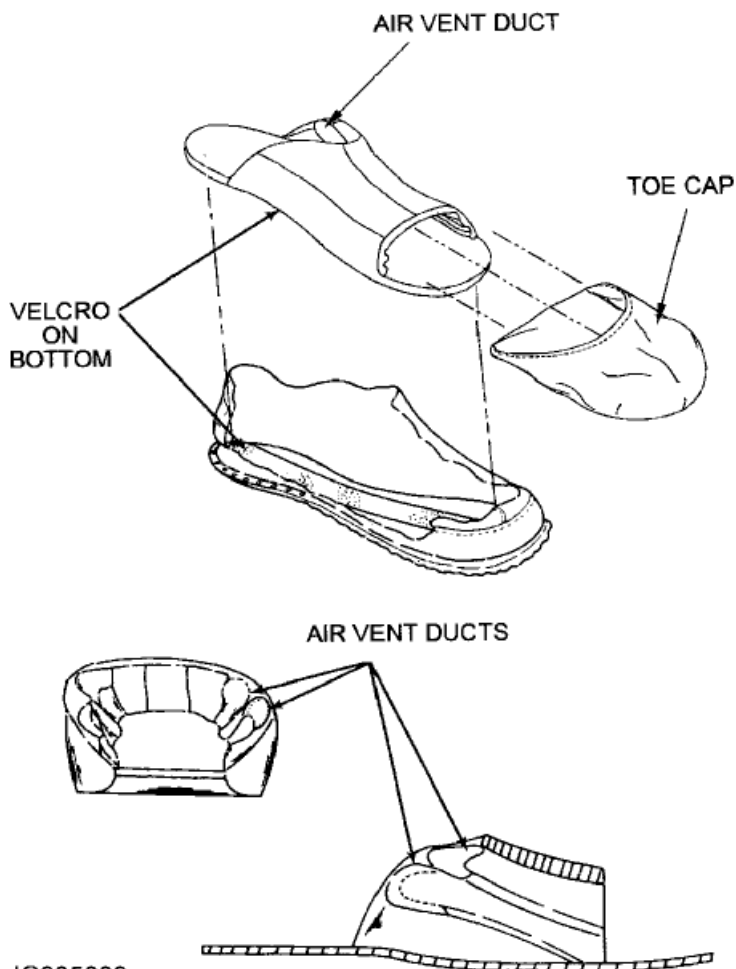
The Boot Sizing Insert (BSI) allows for sizing adaptation to different sizes of crew foot size. The BSI is installed into the Boot Assembly. The BSI is constructed from foam rubber and urethane coated nylon fabric. There are three sizes of foam Boot Sizing Inserts (BSI) available for the large and small boots. The available sizes are: Small/Small, Small/Medium, Small/Large for Small boots, and Large/Small, Large/Medium, Large/Large for Large boots (Figure 3.5.6). In the event that a crewmember does not find the fit with a Boot Sizing Insert acceptable, the thermal slipper may be chosen (Figure 3.5.7). The thermal slipper provides for additional foot volume while maintaining thermal comfort in place of the Boot Sizing Insert.

### **3.5.7 TOE CAPS**

The Toe Cap was created to enclose the open, toe end of the BSI for enhanced thermal comfort. The toe cap is constructed from Rip-stop nylon polyester/nylon insulation and reinforced aluminized Mylar (Figure 3.5.6).

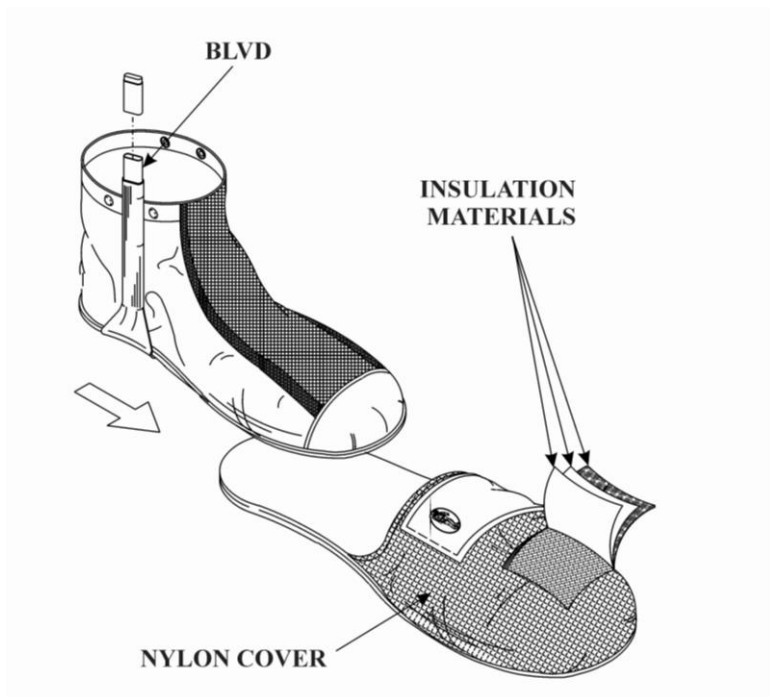
**FIGURE 3.5.5 ENHANCED LTA BOOT ASSEMBLY**

**FIGURE 3.5.6 BOOT SIZING INSERTS**



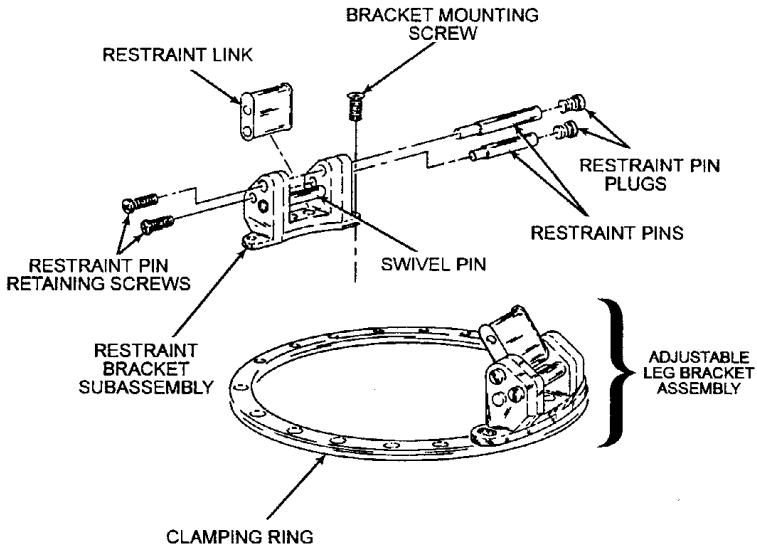
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**FIGURE 3.5.7 EMU THERMAL SLIPPER ASSEMBLY**



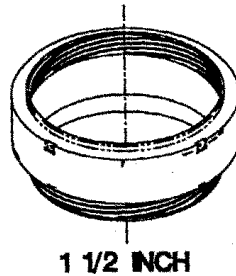
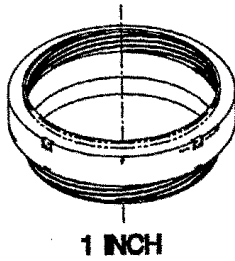
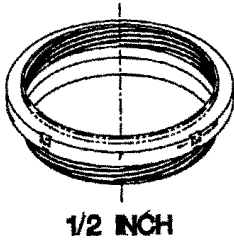
### **3.5.8 SIZING THE ENHANCED LOWER TORSO ASSEMBLY (LTA)**

The LTA can be sized with adjustable leg brackets and sizing rings (Figures 3.5.8, 3.5.9, 3.5.10 and 3.5.11). The leg assemblies contain brackets that can be adjusted in 0.5 in increments for a total of 1.0 in.. Crewmembers with long legs can be accommodated by adding a 0.5 in. Thigh Sizing Ring. The distance between the knee and the foot can also be adjusted with Leg Sizing Rings in 0.5 in. increments from 0.5 in., 1.0 in. and 1.5 in. rings. Using the Enhanced LTA sizing provisions (five lengths of Legs, 0.5 in. Adjustable Leg brackets, Thigh and Leg Sizing Rings) allows for optimum sizing of crewmembers and assures correct knee position within the knee joint.

**FIGURE 3.5.8 ENHANCED LTA ADJUSTABLE LEG BRACKET ASSEMBLY**

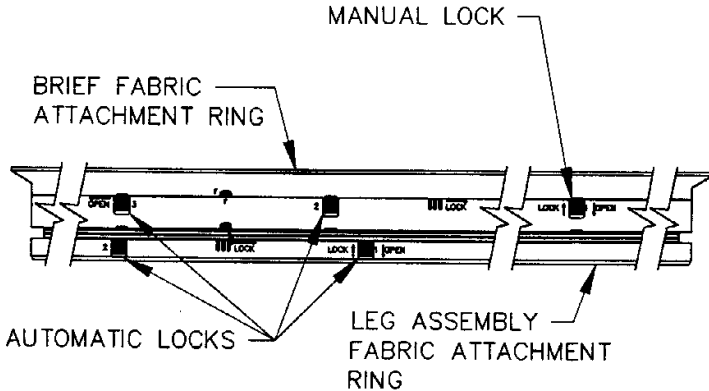
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**FIGURE 3.5.9      ENHANCED LTA LEG SIZING  
RINGS**

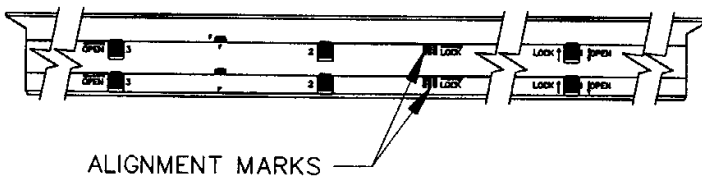


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**FIGURE 3.5.10      ENHANCED LTA FABRIC  
ATTACHMENT RING / SIZING  
RING INTERFACE**



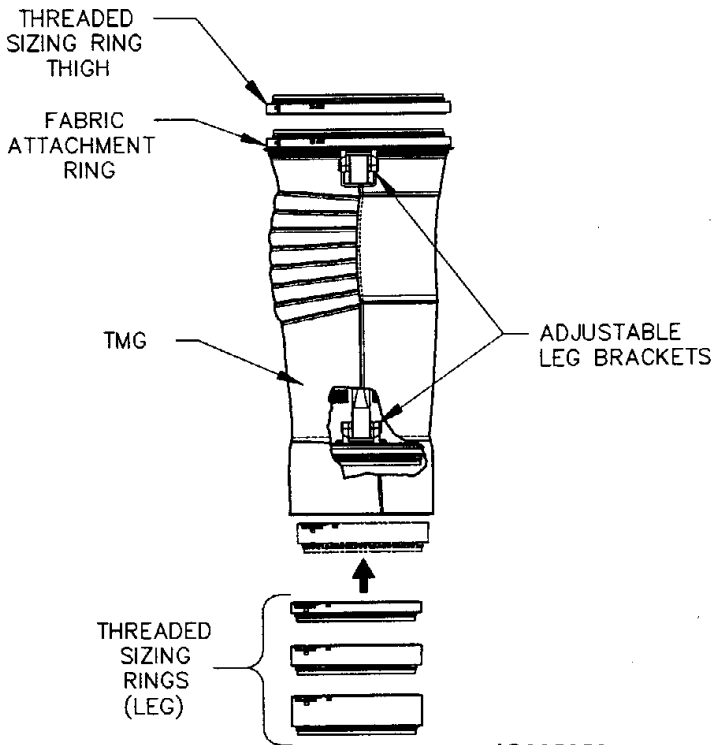
**ENGAGED POSITION**



**LOCKED POSITION**

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**FIGURE 3.5.11      ENHANCED LTA THIGH / LEG  
SIZING PROVISIONS**



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# **SECTION 3.6**

## **HELMET**

### 3.6 HELMET

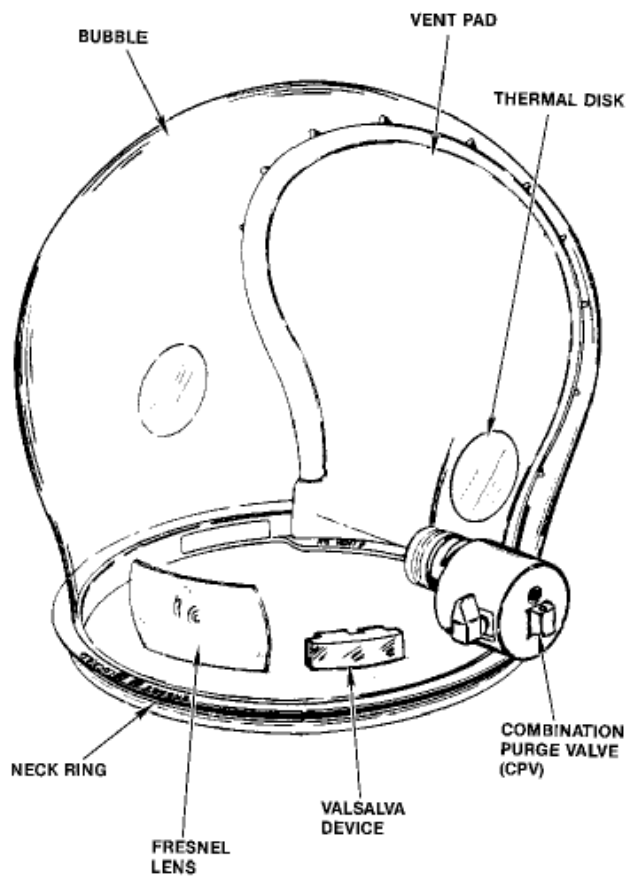
The Helmet (Figure 3.6.1) consists of a clear polycarbonate bubble, neck disconnect, ventilation pad and Combination Purge Valve (CPV). The Helmet provides visibility (Figure 3.6.2), pressure retention, impact protection and emergency purge capability for a crewmember using the SSA in an EVA configuration.

The Bubble, Neck Ring and Vent Pad are a permanent assembly while the CPV, attached to the left side of the Bubble with three screws, is removable.

The Neck Ring (Figure 3.6.3) provides for a quick disconnect of the Helmet from the HUT. The Vent Pad (Figure 3.6.4) mounted in the back of the Helmet, directs vent flow oxygen from the HUT inlet to the front areas of the Helmet Bubble. The CPV (Figure 3.6.5) provides the secondary suit purge capability. When being used as a secondary purge, the flow is regulated to  $2.5 \pm 0.4$  lb./hr of O<sub>2</sub> through a hard metal orifice sandwiched inside the Helmet between the mounting plate and silicone gasket. Leakage through the CPV in the closed position is prevented by an "O" ring. The Helmet is capable of being donned and doffed unassisted by the crewmember.

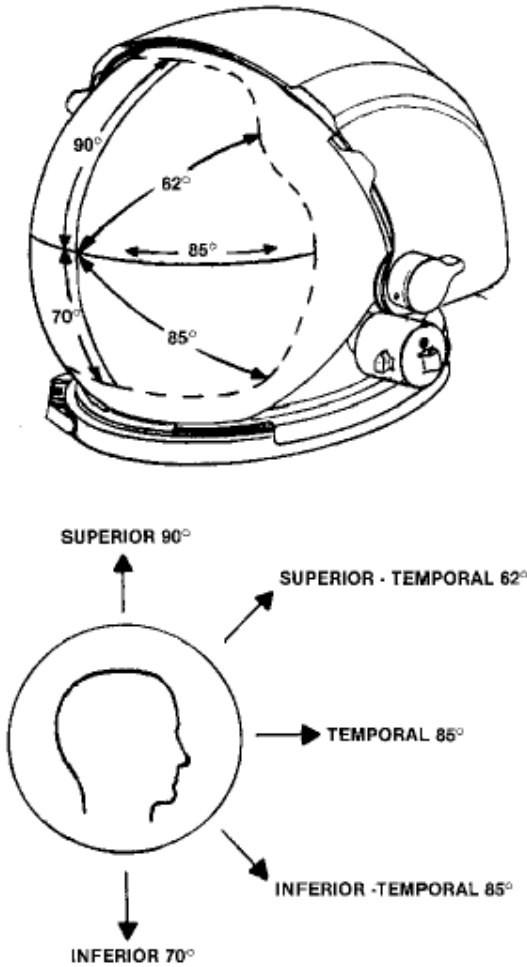
Although the Helmet is compatible with GFE eyeglasses, a Fresnel lens may be fitted as a crew option. A Fresnel lens, mounted to the lower front inside of the Helmet, improves DCM visibility for crewmembers with eyeglasses.

A Valsalva device may also be fitted as a crew option and is attached to the inside surface of the Helmet via pressure sensitive adhesive on the back of the Valsalva device.

**FIGURE 3.6.1      HELMET****JG8353277cv**

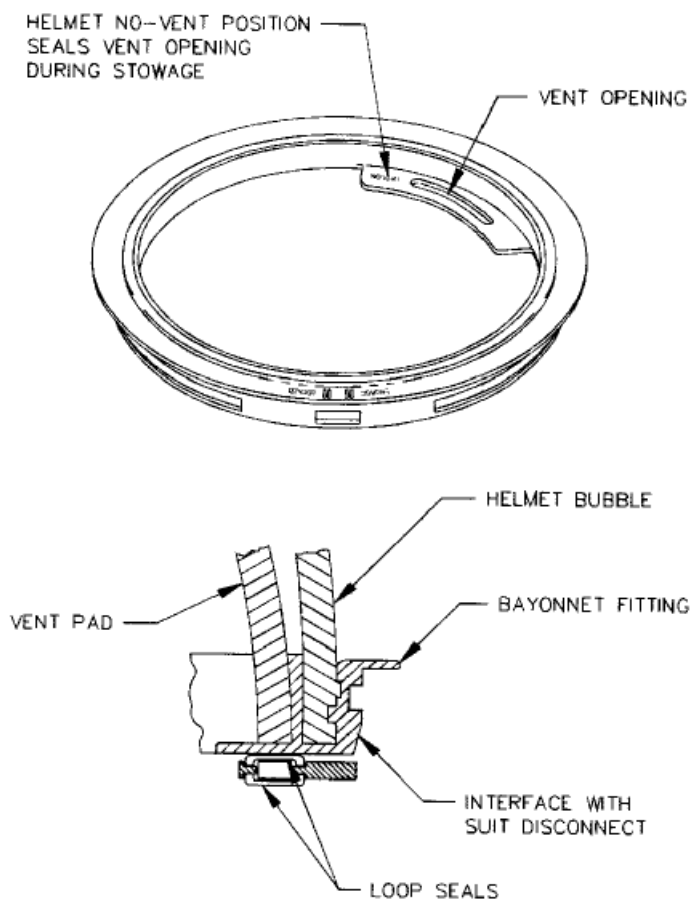
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**FIGURE 3.6.2      HELMET FIELD OF VISION  
(EVVA INSTALLED)**



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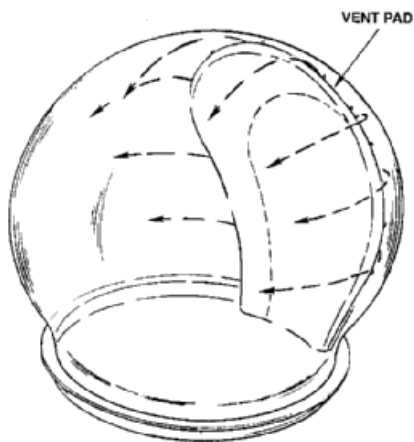
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**FIGURE 3.6.3      HELMET SUIT DISCONNECT**

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**FIGURE 3.6.4 VENT FLOW (IN HELMET)**

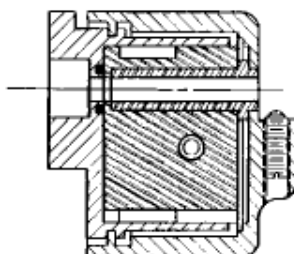
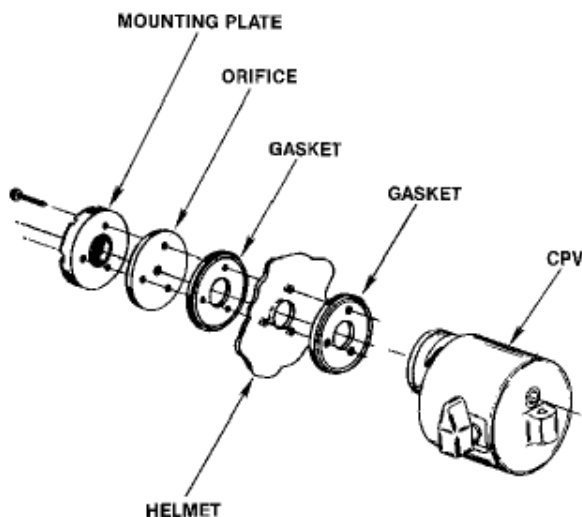
**FIGURE 3.5.4 VENT FLOW (IN HELMET)**



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**FIGURE 3.6.5 COMBINATION PURGE VALVE (CPV)**



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# **SECTION 3.7**

## **GLOVES**

### 3.7.1 PHASE VI GLOVES

The EMU Phase VI glove is the active interface between the crew member and the work being performed. While preserving a greater degree of nude hand mobility than previous glove designs, it provides a protective barrier against the natural environment, as well as work place hazards. The glove is equipped with a low torque disconnect. The Phase VI glove is comprised of the following basic components: Bladder, Restraint, TMG, Wrist Tether Strap and Wrist Disconnect.

The Phase VI glove build process starts with a casting of the crewperson's hands. A laserscan data file is obtained from the hand cast and is used to create the bladder dip form and restraint patterns. The end result of the process is an individualized, extremely accurate fitting glove that allows the user excellent mobility and task capability.

#### 3.7.1.1 BLADDER

The Phase VI glove bladder is made of urethane material and is designed to maintain pressure in the glove assembly, while not exaggerating the torque or limiting the range of the finger joints and wrist gimbals.

A Teflon liner (dual layer) provides abrasion protection to the bladder from the comfort glove, wristlet, or LCVG. One end of the Teflon liner is stitched to a strip of urethane, which is then bonded to the bladder using a urethane adhesive. The other end of the Teflon liner is sewn to a flange ring of urethane reinforced with double-coated bladder cloth. It is then attached by capturing the flange under the clamping ring at the glove disconnect.

The Phase VI glove bladder is considered a low easement bladder and as such, it has a very conformal fit with the CM's hands. This results in significantly less folding and bunching of the bladder within the restraint, producing a more comfortable and mobile glove.

The inside of the bladder is “flocked” with small cotton fibers to reduce Rucothane tack for ease of donning and doffing.

The Phase VI glove bladder is shown in Figure 3.7.1.1.

### **3.7.1.2 RESTRAINT**

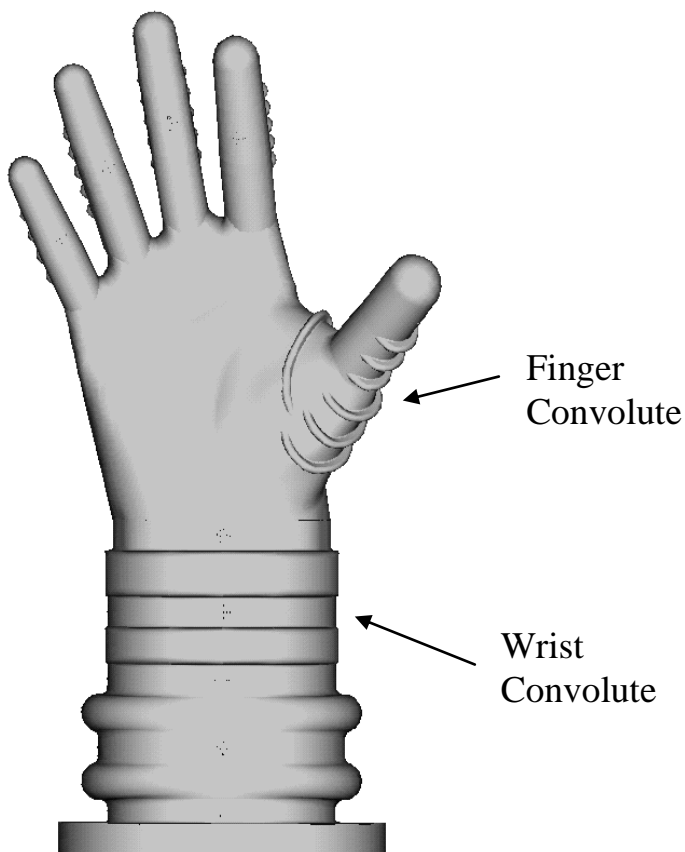
The restraint is the basic structural element of the Phase VI glove. Its purpose is to manage both pressure loads and man loads while permitting the joints to flex with low torque.

The Phase VI glove restraint is designed to meet Satellite Man Load (SML) requirements and has at least a 2.0 safety factor on ultimate loads. It is made of Dacron fabric of various weights. Restraint hand seams are turned to the exterior to minimize bladder abrasion (Figure 3.7.1.2).

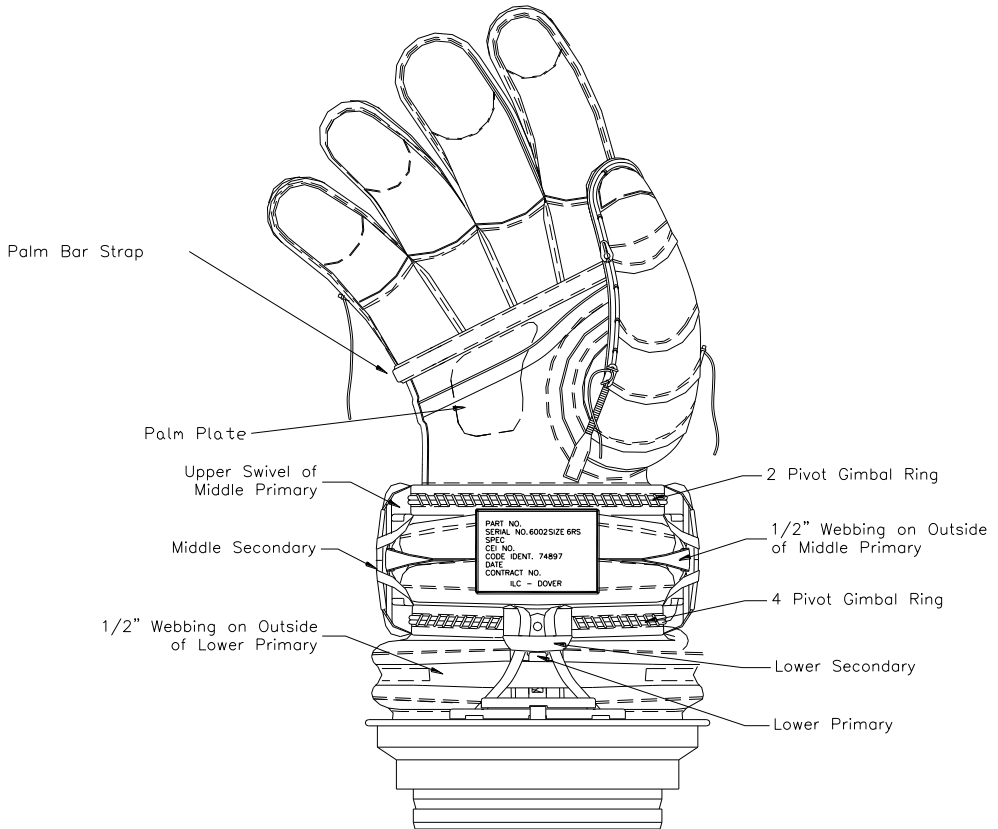
The fingers are made of front and back halves which are pleated and joined together by pinch seams. The seams form the primary axial restraint of the fingers while the pleats permit the desired range of finger flexing. Stitched to the interior of each finger are circumferential bladder anchor strips made of urethane coated fabric (Figure 3.7.1.3). These anchor strips are a means of semi-permanently attaching the bladder to the restraint. This ensures proper distribution of the bladder and also prevents the bladder from shifting as the hand enters or leaves the glove.

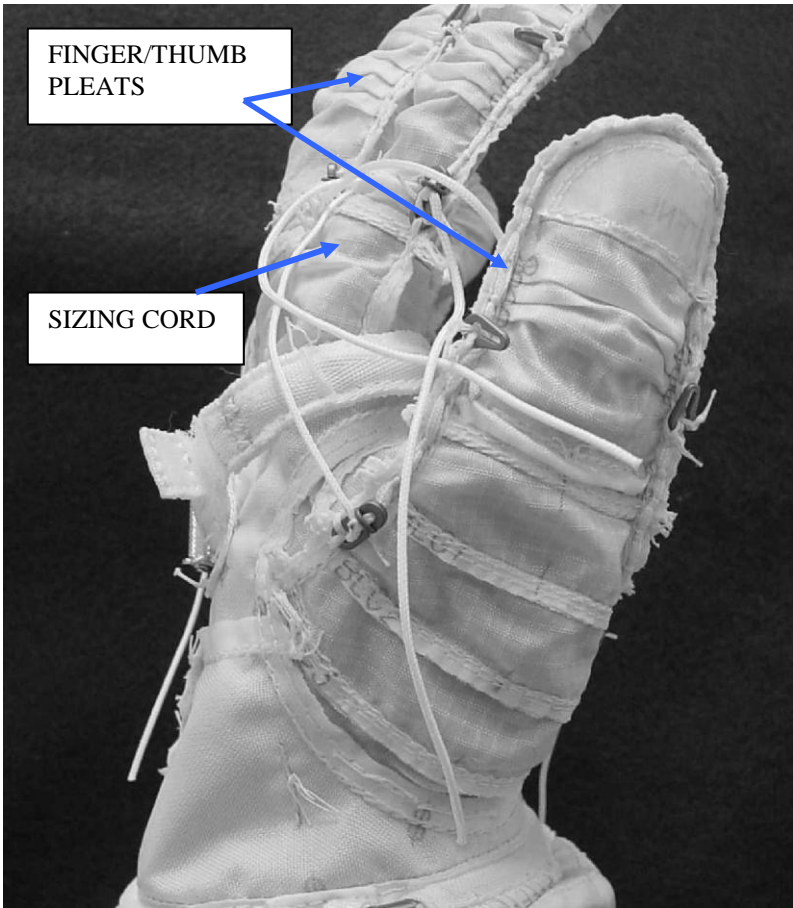
The palm and back of the restraint tie directly to the upper pivot gimbal ring. Two outboard gimbal swivels have the middle primary restraint lines attached to them. These restraints then attach to the outboard gimbal swivels of the lower gimbal ring.

**FIGURE 3.7.1.1      PHASE VI GLOVE BLADDER**



**FIGURE 3.7.1.2 PHASE VI GLOVE RESTRAINT SEAM.**



**FIGURE 3.7.1.3 PHASE VI GLOVE**

The lower pivot gimbal ring has one pivot on the palm side and one on the restraint's back side. The lower primary restraint lines attach at these locations and then terminate at the wrist disconnect.

Webbing reinforcements called valley bands are used at the small diameter of the convolutes to minimize bladder bulging between gimbal rings and between the lower gimbal ring and the glove disconnect. Bulging here would reduce mobility and increase wrist torque.

Secondary webbing restraints are also employed between the upper and lower gimbal rings and between the lower gimbal ring and the wrist disconnect. They are unloaded, unless their associated primary restraints fail. Both the lower primary and lower secondary webbing restraints are attached to the wrist disconnect via stainless steel brackets. The gimbal rings, webbing restraints, and restraint brackets all provide a structural path to withstand pressure and manloads.

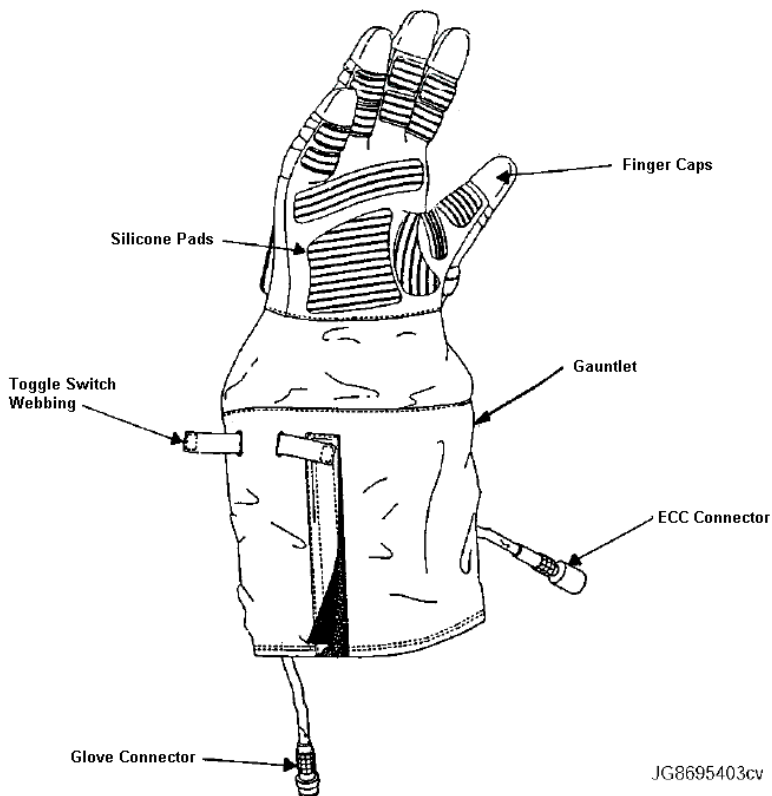
Finger and thumb lengths are adjustable via a lacing cord/terminator bracket system similar to that of the 4000 Series Glove design (Figure 3.7.1.5).

A fabric flange stitched to the restraint, the bladder flange, and the bladder liner flange are all bolted between a clamping ring and the wrist disconnect to provide a pressure seal.

### **3.7.1.3 THERMAL MICROMETEOROID GARMENT (TMG)**

A glove TMG must fulfill two somewhat mutually exclusive requirements: 1) provide maximum thermal insulation and protection from micrometeoroids, and (2) allow maximum mobility of crewmember's hands. The Phase VI glove TMG is shown in Figure 3.7.1.4.

**FIGURE 3.7.1.4 PHASE VI GLOVE TMG**



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The finger and thumbs of the TMG are formed of front and back halves, with the back halves being comprised of multi-layer insulation consisting of an outer layer of Teflon fabric over multiple layers of unreinforced aluminized Mylar, in between which is a non-woven Dacron spacer material to prevent thermal shorting of the aluminized layers. The innermost layer of the fingers is a nylon chiffon which acts as a protective buffer between the restraint and aluminized Mylar. This cross-section differs from the suit lay-up in the following aspects:

1. Aluminized mylar is unreinforced in fingers only.
2. Outer shell is Teflon fabric instead of orthofabric.
3. Inner layer or liner is a chiffon instead of neoprene coated ripstop.

These differences are all aimed at minimizing the negative effects of TMG bulk on overall glove mobility. The fingertips of the TMG are dipped in silicone rubber to aid dexterity.

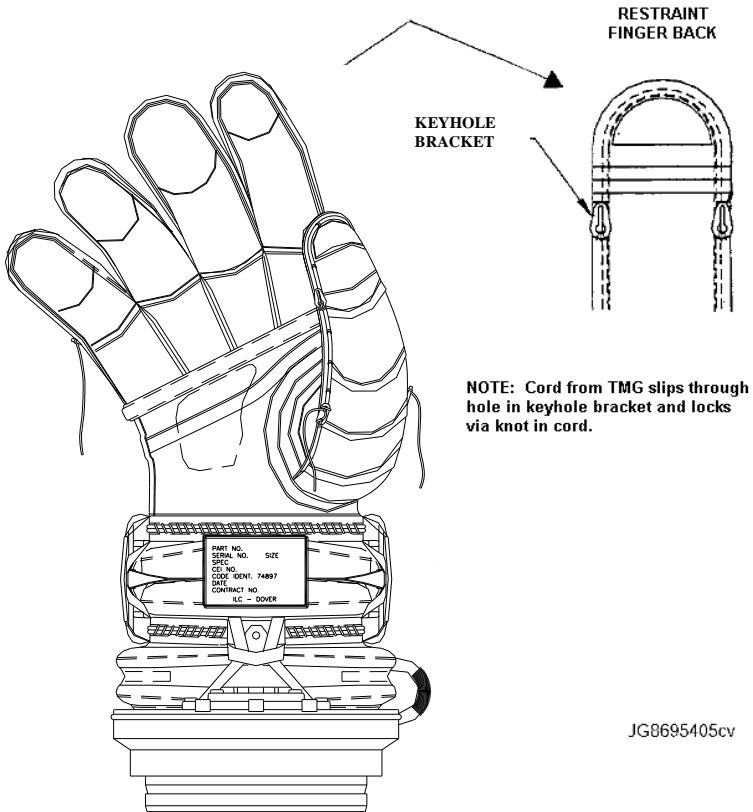
The fingertips of the TMG contain thermofoil heaters. These heaters are located approximately over each fingernail and provide additional thermal comfort on demand.

The Phase VI glove TMG is an Orbital Replacement Unit (ORU) and is expected to last six EVAs before it needs ground refurbishment. The TMG is attached to the restraint/bladder combination via lacing cords that lock into keyhole brackets on each side of the fingers and thumb. The TMG is also attached to the restraint/bladder with Velcro hook and pile that covers the area of the palm plate. The TMG is also attached by routing the palm bar restraint strap through slots on the TMG hand back. This keeps the crew's fingertips in close proximity to the TMG finger caps.

Removing the TMG is accomplished by releasing the palm bar strap and carefully demating the palm side Velcro attachment while inverting the TMG up to the keyhole brackets and pulling the TMG off the fingertips. Installation of the TMG is the opposite.

One significant improvement of the Phase VI over the previous glove TMG is in the material and fabrication method for the TMG palm. The base material for the previous TMG palm was a woven Nomex fabric, which was cut and sewn to the palm shape. The base material for the Phase VI glove palm is a Vectran knit which is stretched and compressed into the 3-D shape of the palm which is then maintained with a thin coating of silicone. This fabrication technique eliminates seams in the TMG palm and improves mobility. The palm is then coated with RTV 3145 for high cut and abrasion resistance and thermal protection. There are divisions in the silicone rubber coating to maximize mobility. A cut resistant layer of Turtleskin® material has also been added on the index finger and thumb (between the RTV and the Vectran) for resistance against sharp edges.

A cone shaped shroud referred to as the gauntlet is attached to the hand portion of the TMG. The gauntlet protects the wrist area of the restraint as well as the wrist disconnect from the ambient thermal environment. It also serves as a mounting location for the glove heater switch and LEMO quick disconnects for the glove heaters. The gauntlet serves as the mounting location for the EVA Cuff Checklist.

**FIGURE 3.7.1.5      PHASE VI GLOVE LESS TMG**

#### **3.7.1.4 WRIST TETHER STRAP**

The Wrist Tether Strap (not shown) retains small articles used during EVA in close proximity to the hands. It is not, and should not be considered, a safety tether. The wrist tether strap has a breaking force of 30-150 lb. static load to protect the crewmember and pressure suit integrity.

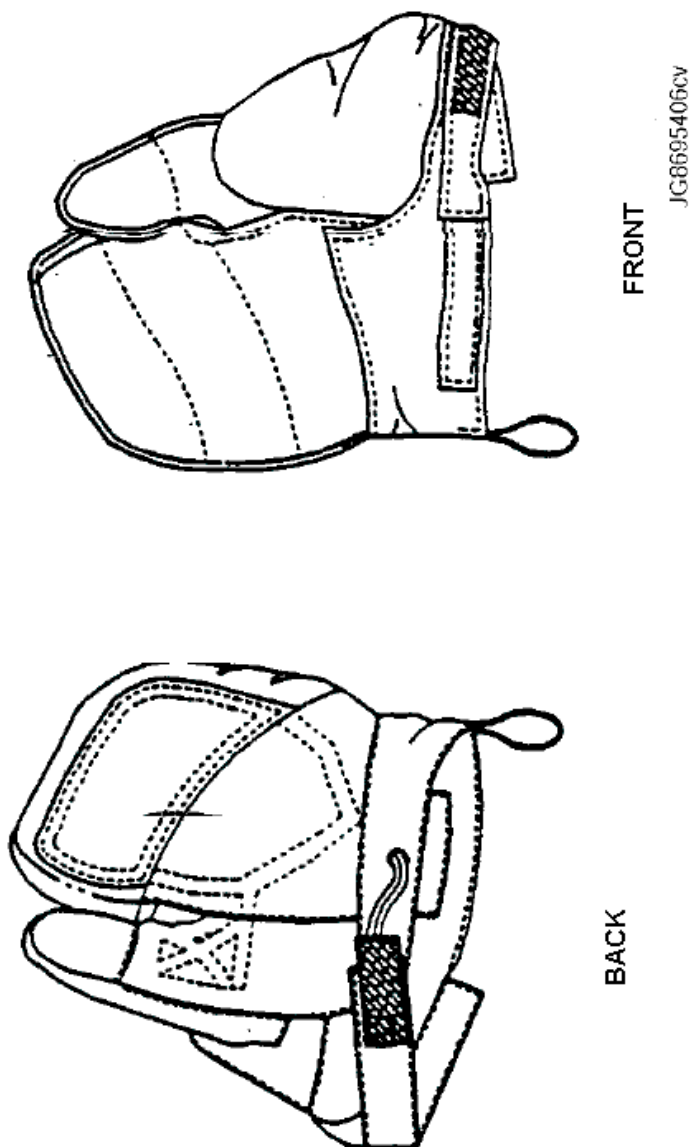
#### **3.7.1.5 ADJUSTABLE THERMAL MITTENS**

Adjustable Thermal Mittens (Figure 3.7.1.6) are provided as added protection for the crewmember operating in extreme temperature environments. The Adjustable Thermal Mittens can be quickly and easily donned and doffed. They are fabricated with a TMG-type construction (shell, insulation, and liner) and are sized to provide as close to a conformal fit as possible without creating excessive fabric bulk or sacrificing thermal protection.

#### **3.7.1.6 COMFORT GLOVE**

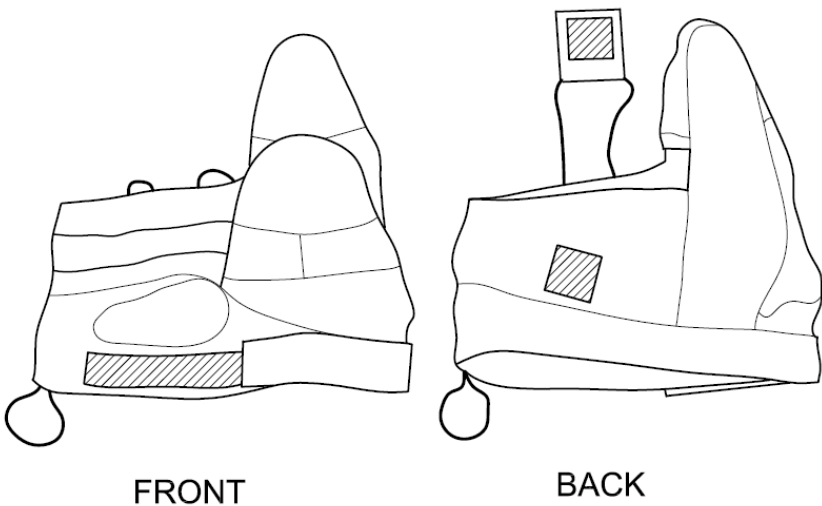
Comfort Gloves are provided as a crew option to those crewmembers who wish an added measure of comfort inside of the glove assembly. Crewmembers can choose from different types and sizes of Comfort Gloves depending on their preference. Comfort Gloves are worn under the EVA glove and aid EVA glove donning, doffing, wicking away perspiration and they provide some additional thermal protection. They also provide a comfortable layer of fabric against the hand during glove use.

**FIGURE 3.7.1.6      ADJUSTABLE THERMAL  
MITTENS**



**3.7.1.7****ADJUSTABLE PROTECTIVE MITTEN ASSEMBLY**

Adjustable Protective Mittens (Figure 3.7.1.7) are provided as added protection for the crewmember against cuts and abrasion. The Adjustable Protective Mittens can be quickly and easily donned and doffed when ground control or the crewmember deems it appropriate. They are fabricated with a cut resistant Vectran fabric with RTV pads on the front for grip and come in 2 sizes, Medium and Large. The mittens have several sizing cords that allow a more conformal fit to various gloves.



**FIGURE 3.7.1.7      ADJUSTABLE PROTECTIVE MITTENS**

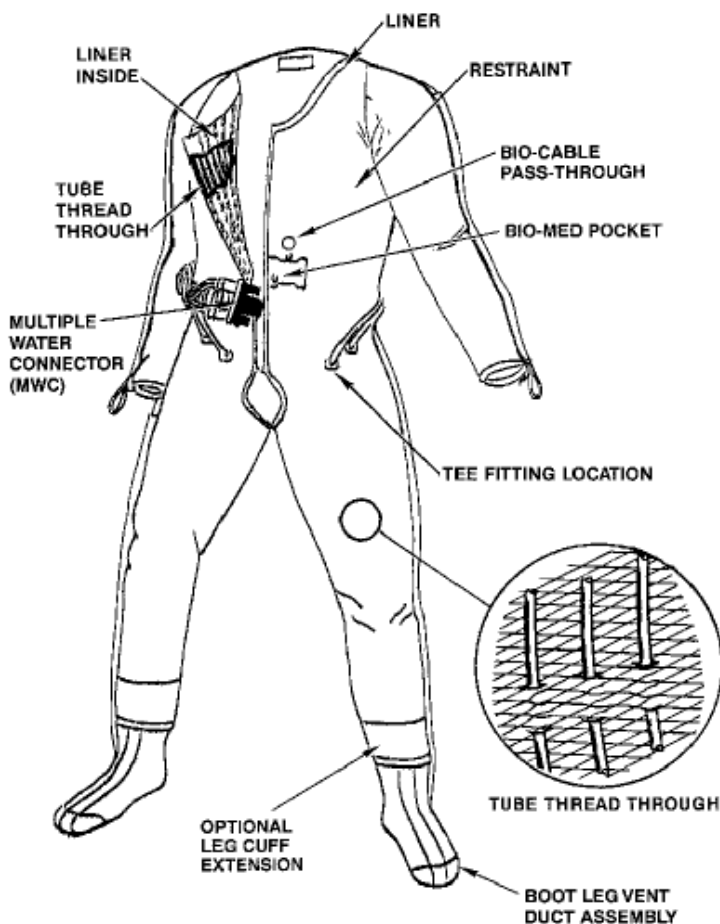
**SECTION 3.8**

**LIQUID COOLING AND  
VENTILATION  
GARMENT  
(LCVG)**

### 3.8 LIQUID COOLING AND VENT GARMENT (LCVG)

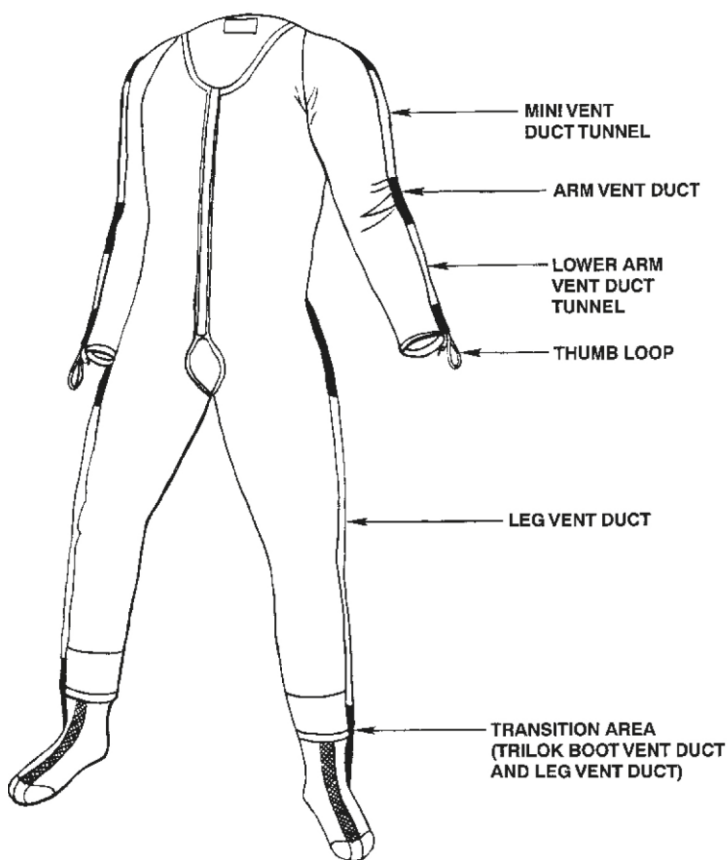
The Liquid Cooling Ventilation Garment (LCVG) Assembly (Figure 3.8.1) is a form-fitting, stretchable undergarment consisting of a Garment Assembly that covers the entire body to the neck, ankles and wrists and a Boot Leg Vent Duct (BLVD) assembly that covers the feet. The LCVG both cools and ventilates the crewmember using water and oxygen supplied by the PLSS. The water is chilled in the PLSS and enters the LCVG through the Multiple Water Connector (MWC). The chilled water removes excess metabolic heat as it circulates around the crewmember's entire body through a network of flexible tubing. Ventilation gas is drawn (by the PLSS) from the helmet down to the hands and feet where it is recirculated back to the PLSS through the LCVG by means of a vent system (Figures 3.8.2, 3.8.3 and 3.8.4).

The Garment Assembly consists of the LCVG Restraint Assembly, the Liner Assembly, the Vent Plenum Assembly and the Multiple Water Connector. The LCVG Restraint Assembly is made from a nylon/spandex mesh which supports the flexible water line tubing. The restraint fabric and tubing are held firmly against the crewmember's body. The LCVG Liner Assembly is made of light weight nylon/tricot material. The Liner assembly aids in donning and doffing and provides a comfort layer between the tubing and the crewmember's skin. The vent plenum assembly is composed of a plenum assembly which draws ventilation gas from the arm and leg ducts into the torso vent duct. The torso vent duct interfaces with the MWC.

**FIGURE 3.8.1 LCVG ASSEMBLY**

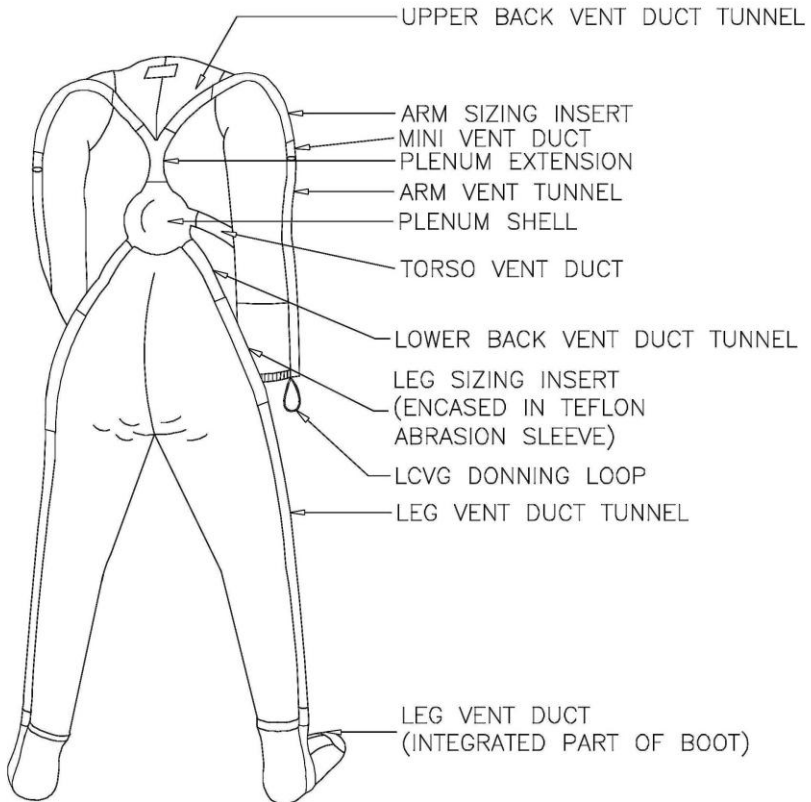
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**FIGURE 3.8.2 VENT SYSTEM (FRONT VIEW)**

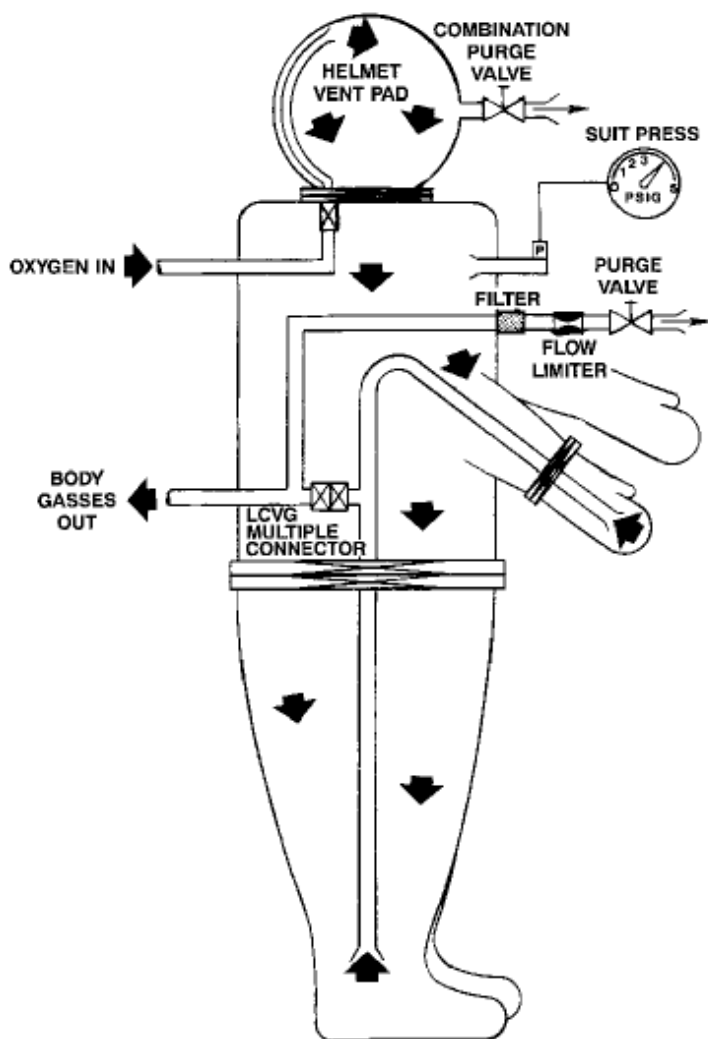


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**FIGURE 3.8.3 VENT SYSTEM (BACK VIEW)**



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**FIGURE 3.8.4 VENTILATION LOOP****JG8353318cv**

### **3.8.1 RESTRAINT ASSEMBLY**

The restraint assembly is the stretch outer fabric of the LCVG consisting of a nylon spandex blend which maintains the LCVG's conformal fit. The basic restraint is made in four quarter panels. An underarm gusset is also used to minimize both fabric employed in the garment and sleeve ride-up when the arm is fully extended. A crotch panel accommodates a Maximum Absorption Garment (MAG). Tunnels made of nylon/ spandex mesh covered with a Teflon fabric for abrasion resistance are sewn down the arms and legs of the restraint. The tunnels accommodate the vent ducts.

The bio-med pocket is a small square pocket located on the left front side of the LCVG restraint that contains the bio-med Signal Conditioner box. The pocket is stitched on three sides and closed with a snap on the fourth side. A corresponding hole exists in the restraint and liner to allow for cable pass-through to the crewmember's body.

### **3.8.2 LINER ASSEMBLY**

The liner assembly is made from a light-weight non-stretchable nylon tricot fabric which feels "silky" to the touch. The tricot aids in the donning and doffing of the LCVG and prevents the tubes from being snagged. All seam allowances are turned under to keep the liner fabric from fraying along its edges and to create a smooth even surface for donning.

The tricot liner is wider and longer than the restraint from neck to ankle to accommodate body movement without loading the liner seams. It is attached to the restraint by means of hand sewn anchor tacks.

### **3.8.3 LCVG VENT SYSTEM**

The vent duct system carries purge/ventilation gases away from the ends of the extremities to a common line

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returning to the HUT/PLSS. Ventilation gases travel through the arm and leg vent duct assemblies to the vent plenum assembly where the gas is channeled into the torso vent duct for return to the HUT/PLSS.

The vent ducts are attached to the restraint by use of spandex and Teflon fabric tunnels. The ducts are threaded through the tunnels. The spandex snugly encloses the vent ducts and the Teflon is sewn onto the top section of the spandex tunnel for abrasion protection. Bladder cloth protects the vent ducts from abrasion in areas where they are not threaded through the vent tunnels.

There are two options for ventilation of the arms. The mini vent duct terminates above the elbow and is the required configuration for use with Phase VI Gloves. The arm vent duct terminates at the wrist. The arm vent duct has a loop which is looped over the thumb when donning the short EMU to keep the LCVG sleeves from riding up the arm and getting caught in the arm bladder.

The vent ducts connect at the plenum assembly in the middle of the crewmember's back. The HUT has enough clearance in the lower back area to accommodate the thickness and volume of the plenum assembly. The plenum assembly is made up of a shell, an extension and a cover. The plenum shell, extension and cover are flexible, dipped polyurethane items pigmented white. The plenum cover anchors the assembly to the restraint by use of Velcro. The plenum extension is a "Y" shaped channel which guides two side-by-side vent duct stubs until they are pushed apart by the plenum wedge to form the left and right arm ducts. The left and right leg ducts extend from the bottom of the plenum assembly. The torso vent duct extends from the right side of the plenum assembly, around the crewmember's waist to the MWC. The plenum assembly and torso vent duct together make up the vent plenum assembly.

### 3.8.4 LCVG WATER SYSTEM

Water is supplied to the LCVG from the PLSS by way of the HUT through the MWC and para-manifold assembly. Water circulates in the LCVG garment through 1/8" diameter garment tubing and 5/16" diameter para-manifold tubing, both of which are flexible and translucent. The tubing is Ethylene Vinyl Acetate.

The para-manifold assembly is made up of two inlet/outlet fittings and eight 5/16" diameter tubes bonded side by side. The para-manifold tubes partially encircle the waist area and are attached to the LCVG via belt loops. For each quarter panel of the LCVG there are two para-manifold tubes; one inlet and one outlet. The para-manifold tubes are bonded to tee fittings which divert the water into 12 circuits of 1/8" diameter tubing.

### 3.8.5 BOOT LEG VENT DUCT ASSEMBLY

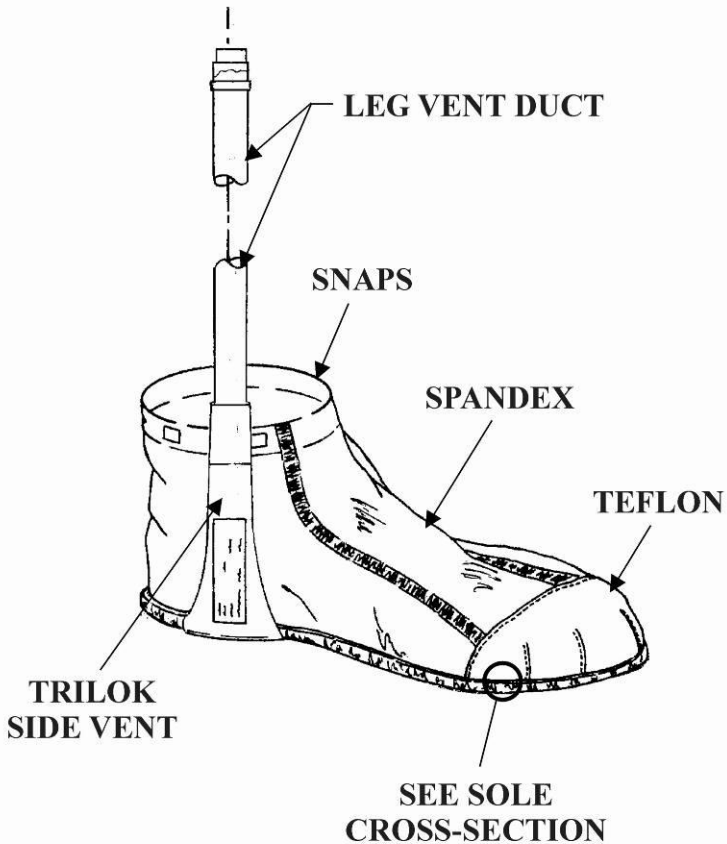
The LCVG Boot Leg Vent Duct (BLVD) shown in Figure 3.8.5 is a soft, flexible, slip-on assembly which fits snugly over the foot. Each size boot has a nylon/spandex mesh mid-section to accommodate varying widths of feet. The side and toe sections are made of woven Teflon fabric. The boot sole and side vent duct contain trilok, a three-dimensional woven fabric made from polypropylene and saran, which allows ventilation around and under the foot.

The boot sole (Figure 3.8.6) is an assembly of five layers of fabric starting with an outside layer of Teflon cloth, then bladder fabric, trilok, another layer of bladder fabric with ventilation holes placed in the toe area, and a final Nomex layer which rests against the foot. Bladder fabric, which is impermeable to gas, encloses the trilok.

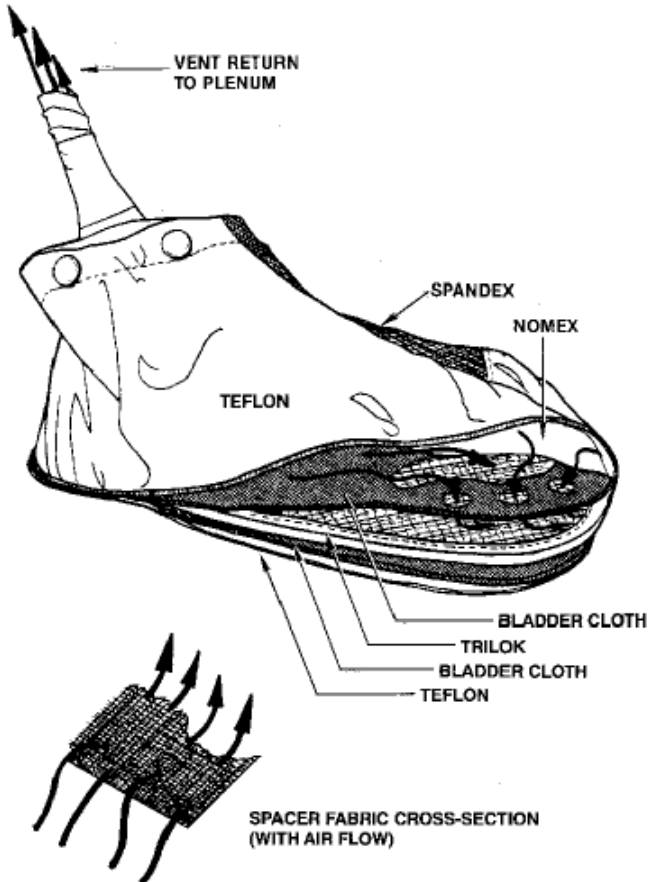
The LCVG boot is attached to the restraint or an optional leg cuff via snaps. The restraint leg vent duct is attached to a transition trilok side vent duct at the ankle using an enclosed slip fitting. Ventilation gas travels from the foot area through

the trilok in the boot sole and boot side vent duct to the garment vent duct system.

**FIGURE 3.8.5      BOOT LEG VENT DUCT  
ASSEMBLY**



**FIGURE 3.8.6 BOOT SOLE PLY-UP (LCVG)**



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# **SECTION 3.9**

## **EXTRA VEHICULAR VISOR ASSEMBLY (EVVA)**

### 3.9      **EXTRAVEHICULAR VISOR ASSEMBLY (EVVA)**

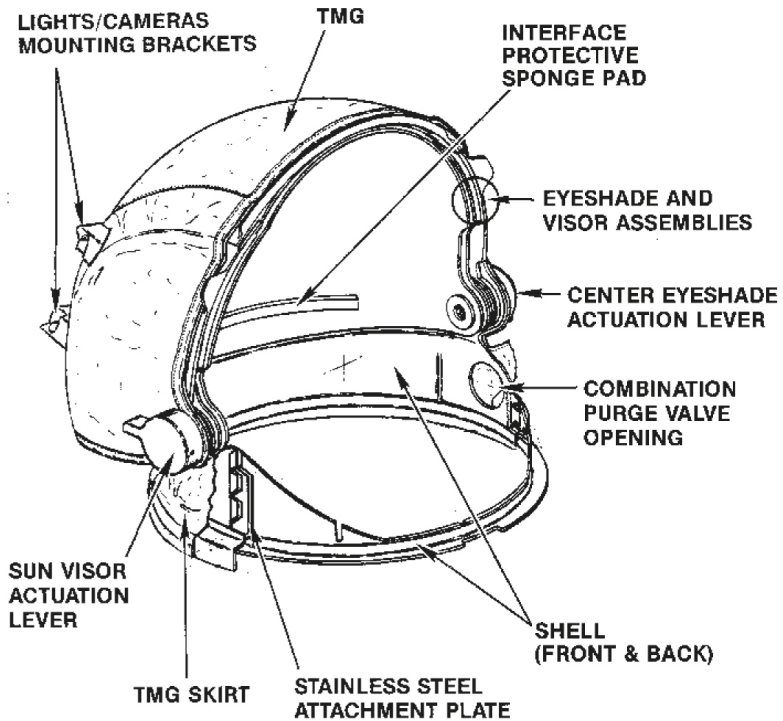
The Extravehicular Visor Assembly (EVVA) is a heat and light attenuating device (via the visors and eyeshades), which attaches to and covers the Helmet. It provides micrometeoroid protection, protects the Helmet from accidental impact damage, and protects against excessive solar radiation.

The EVVA contains the following major parts: Shell, TMG, Eyeshades, Side and Center, Sun Visor, and Protective Visor (Figure 3.9.1). The EVVA contains a polycarbonate shell to which everything else is attached. The Shell has an opening in the left side to allow CPV installation or removal and the Shell Front and Tension Band (Figures 3.9.2 and 3.9.3) are removable so the EVVA can be attached to or removed from a Helmet. It also contains four external brackets for mounting the Lights/Camera package. Finally, the Shell is covered by a thermal garment for thermal protection while the bottom of the Shell forms a skirt which fits down over the Neck Ring for added thermal protection.

The EVVA Shell (Figure 3.9.4) is made in two parts. The back portion of the Shell is formed from a polycarbonate sheet and then machined to print dimensions. The front part of the Shell is made of fiberglass and attached to the main Shell by stainless steel plates. The plates form a compression attachment and use special screw lengths which do not protrude inside the EVVA (to avoid scratching the Helmet). There is a "pass through" in the left side of the shell for the CPV.

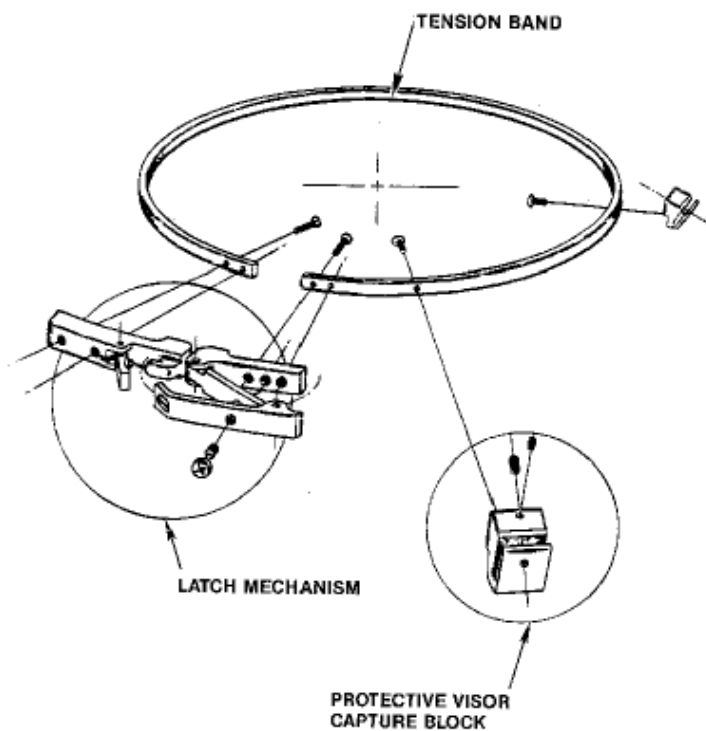
The innermost visor in the EVVA is the Protective Visor (Figure 3.9.5). It is fixed in the full-down position when in use. The front edge contains two small holes which interface with capture blocks on the Tension Band when the visor is closed and are disengaged when the visor is rotated to the full-up position for Helmet removal or

**FIGURE 3.9.1      EXTRAVEHICULAR  
VISOR ASSEMBLY  
(EVVA)**

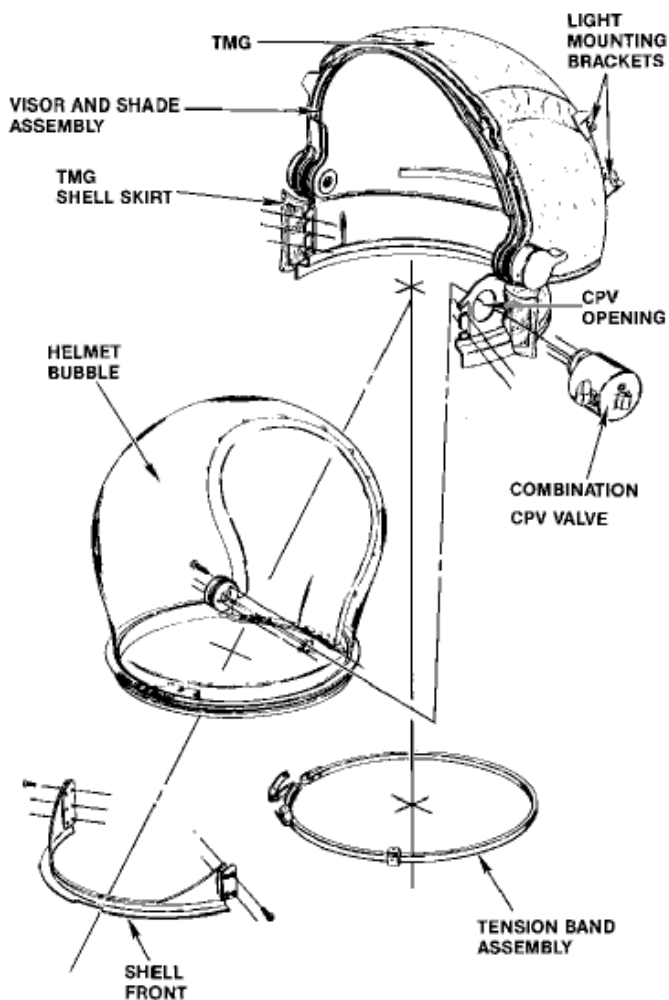


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**FIGURE 3.9.2 EVVA TENSION BAND**

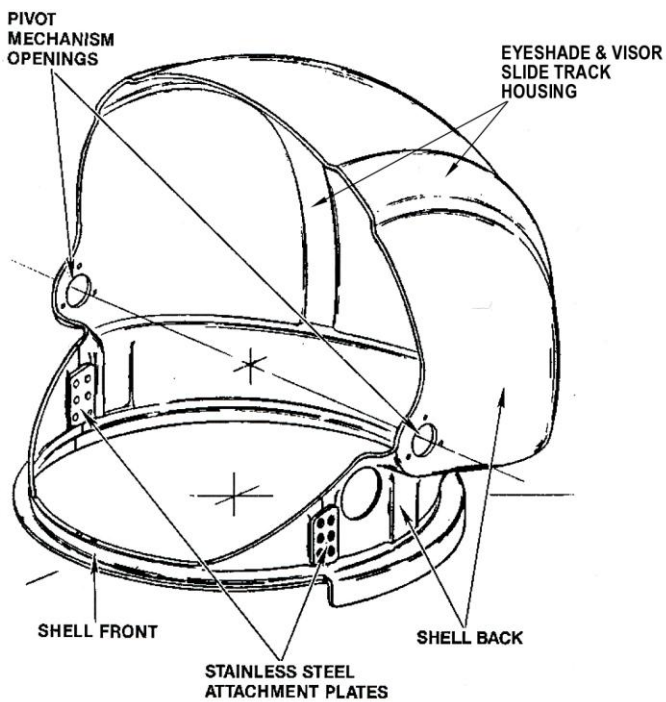


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**FIGURE 3.9.3 EVVA CONSTRUCTION**

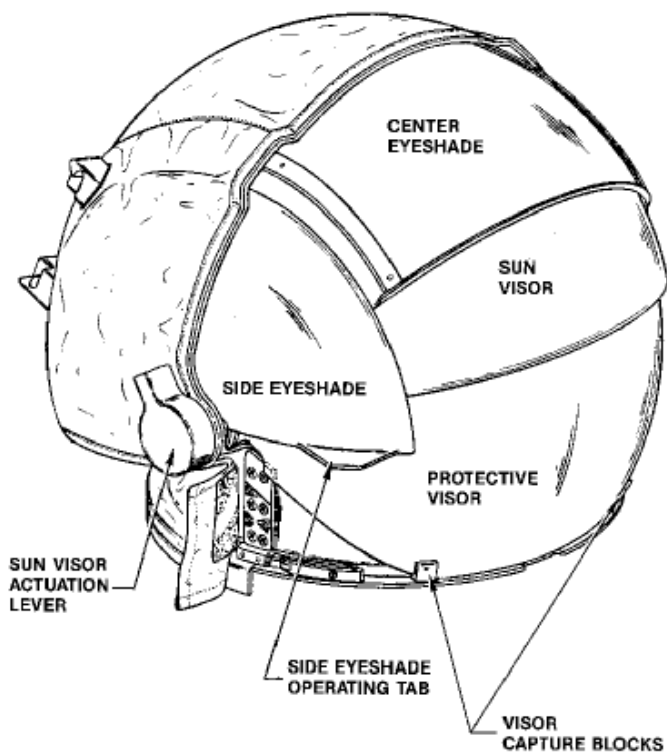
JG8353316cv

**FIGURE 3.9.4 EVVA SHELL**



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**FIGURE 3.9.5 EVVA VISORS AND EYESHADES**



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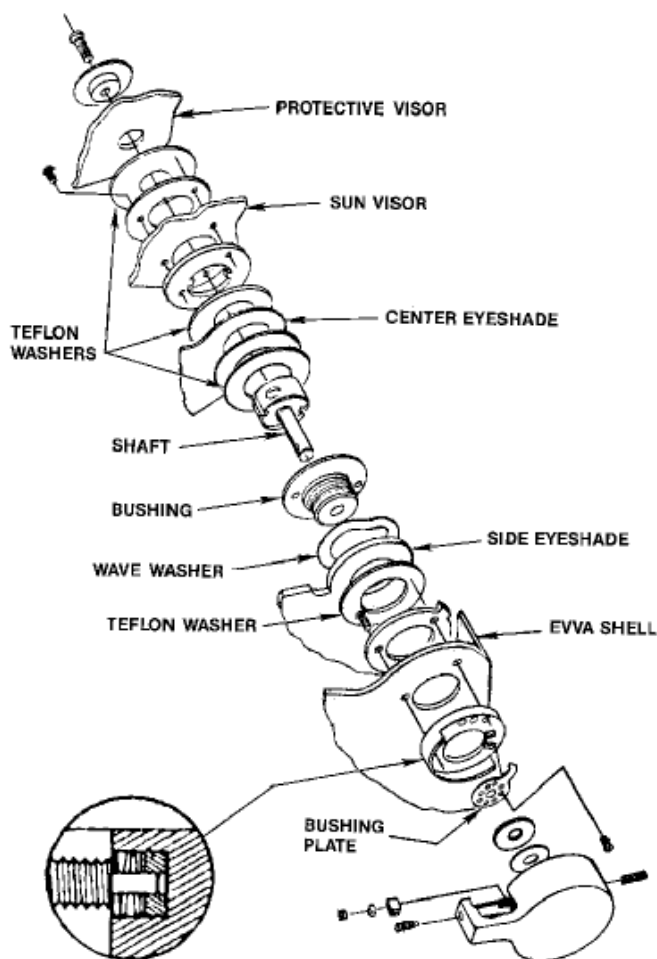
installation. The Protective Visor is formed from a polycarbonate sheet. It is hardcoated for scratch resistance and it is also thinly coated on the inside for both thermal and optical protection. The coating acts to reflect radiative body heat back into the Helmet area and at the same time, attenuate the harmful rays of sunlight. Finally, the rear edge contains a rubber pad, bonded to the inside, which interfaces with the Helmet.

The next visor (in order from the inside out) is the Sun visor (Figure 3.9.5). It is formed from a polysulfone sheet and is hardcoated for abrasion resistance and then vacuum deposited internal thermal/optical coatings are applied. The thermal/optical coating of the Sun Visor is more visible to the naked eye than the coating on the protective visor. Stiffeners to minimize visor flex during use are also bonded to the front and rear edges. The Sun Visor is actuated by rotation of the lever on the right side of the EVVA (Figure 3.9.6) and can be positioned anywhere from the full-up to the full-down position.

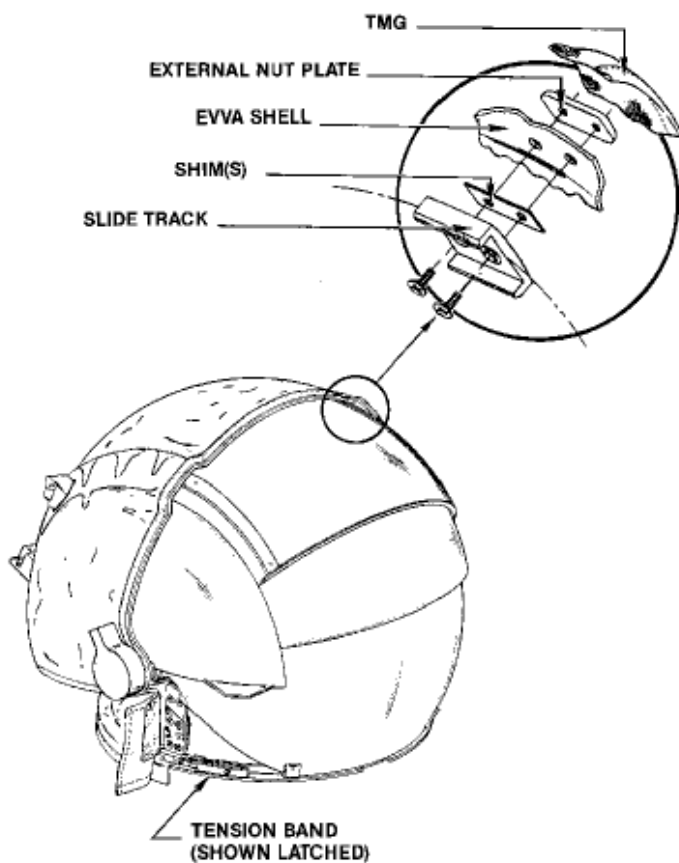
The main Shell contains two internal guides (Figure 3.9.7) for the Center Eyeshade and external brackets for the Lights/Camera. The guides are attached by two screws each, which are installed from inside the Shell. They pass through shims and thread into an external nut plate.

When the EVVA is installed on the Helmet, the alignment positions, which verify that the Helmet is locked in place, are difficult to see. For this reason, a slot in the front of the EVVA shell will align with an engraved line on the Release Button to visually convey the necessary lock/unlock information. The Front Shell is painted with chemglaze paint while the leading edge of the Main Shell is covered with silver Teflon tape for thermal protection. The inside surface of the Shell skirt is covered with an aluminum tape also for thermal protection.

**FIGURE 3.9.6 EVVA HUB PIVOT  
STACKUP**



JG8353313cv

**FIGURE 3.9.7 EVVA SLIDE TRACK****JG8353312cv**

Along with the Visors, Eyeshades (Figure 3.9.5) are also used. The Side and Center Eyeshades are made of fiberglass and are painted with Chemglaze paint. The side Eyeshade, one on each side, is operated by the use of hand tabs on the side of each shade. The Center Eyeshade is operated by an actuation lever located above the Shell CPV opening. The Center Eyeshade is guided by tracks on the inside of the EVVA Shell as it is moved up and down. The Center Eyeshade will cover approximately one-half of the Protective visor in its full-down position.

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## **SECTION 3.10**

# **DISPOSABLE IN-SUIT DRINK BAG (DIDB)**

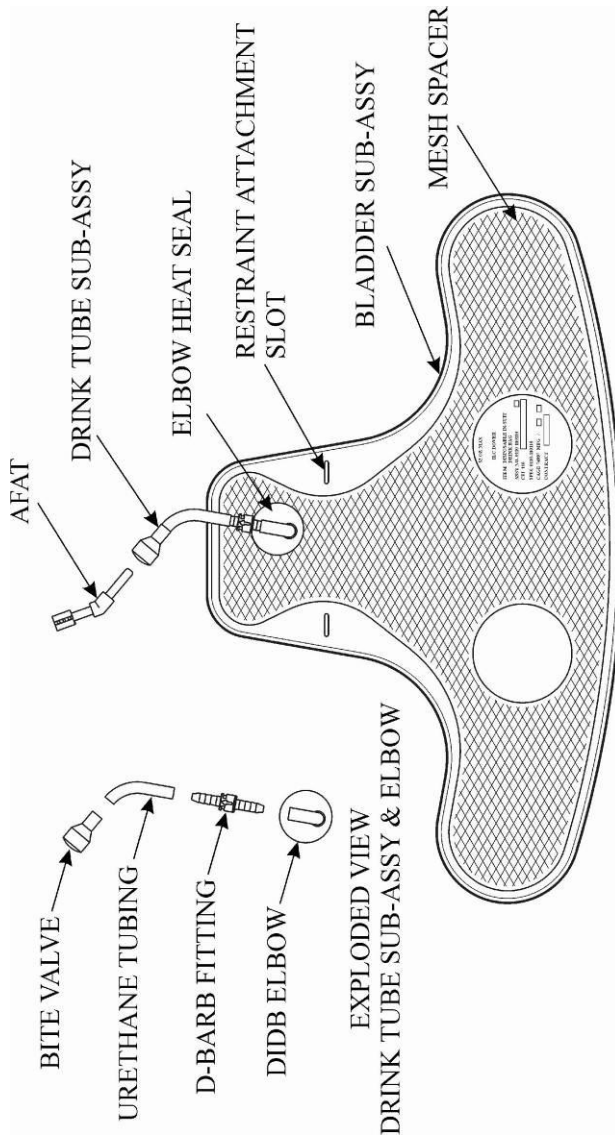
### 3.10 DISPOSABLE IN-SUIT DRINK BAG

The Disposable In-Suit Drink Bag (DIDB) is a single use, heat sealed, flexible bladder assembly mounted within a reusable Restraint Bag, which supplies a crewmember with up to 32 oz. of potable water during an EVA (see Figure 3.10.4). The DIDB is used on ISS and Shuttle EVAs.

The filled DIDB assembly fits into a Restraint Bag, which is attached to the front interior of the HUT. Velcro patches bonded to the exterior surface of the Restraint Bag correspond to Velcro patches (adhesive bonded using an epoxy resin) on the inside front of the HUT. The DIDB assembly is positioned so that the bite valve extends to the neck ring area. Adjusting the DIDB location within the range of the Velcro provides an individualized fit for the crewperson. The flexible drink tube enables unencumbered crew access to the bite valve. Biting down on the end of the valve and applying oral suction actuates the DIDB. DIDB removal is accomplished by separating the mating Velcro.

A DIDB assembly consists of a bladder, mesh spacer, elbow, barb, drink tube, bite valve and Angled Fill Adapter Tool (AFAT). Parts of the drink tube sub-assembly include a barbed fitting, urethane tubing, and a bite valve. The barbed fitting is nylon. The tubing is made from polyurethane and the bite valve is molded from silicone rubber. The bite valve stretches tightly over the delivery tube.

**FIGURE 3.10.4 DISPOSABLE IN-SUIT DRINK BAG (DIDB) COMPONENTS**



The DIDB bladder is constructed from a nylon/polyethylene laminate. Two circular heat seals are placed in the middle of the DIDB to join the front and back surfaces, ensuring proper shape retention, so the bag does not balloon and take up excessive HUT volume. A mesh spacer netting is placed between the two sheets of the nylon/polyethylene laminate. The spacer keeps the bag from collapsing on itself and enables the entire contents to flow freely within the bag.

The AFAT interfaces via an interference fit with a galley filling needle and a septum located inside the AFAT. The other end of the AFAT is inserted through the slit in the bite valve and forms an interference fit with the inner diameter of the drink tube subassembly. The AFAT is capable of filling the DIDB in a hands free mode at the nominal galley flow rate (16 fluid ounces per minute).

# **SECTION 3.11**

## **EMU POWER HARNESSES**

### **3.11    EXTRAVEHICULAR MOBILITY UNIT POWER HARNESS (EMUPH) 12 VOLT SYSTEM**

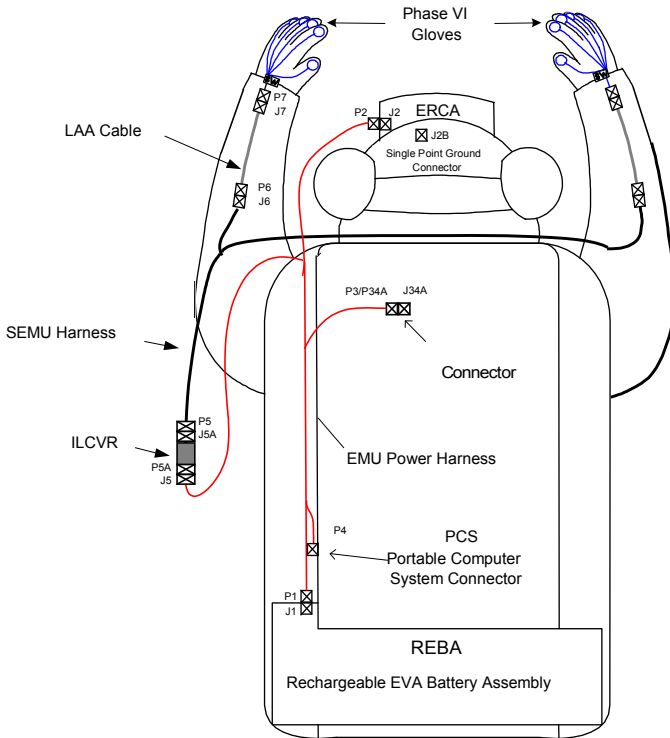
The EMUPH 12 volt system (Figures 3.11.1 and 3.11.2) is an auxiliary electrical subsystem that powers EMU workaids. It is separate from the EMU electrical system that powers the EMU Life Support Subsystem (LSS) to ensure that a failure in the EMUPH does not compromise operation of LSS, on which the life of the EVA crewmember depends. The EMUPH 12 volt system includes heated gloves for improved thermal comfort in cold environments, a GFE battery that is separate from the EMU battery and connecting wire harness assemblies.

The EMUPH 12 V system provides power to the helmet lights, camera, and glove fingertip heaters.

#### **3.11.1    12 VOLT PHASE VI HEATED GLOVE**

The 12 volt heated glove assembly is a Phase VI glove including heater elements, power harness, and on-off switch (Figure 3.11.3).

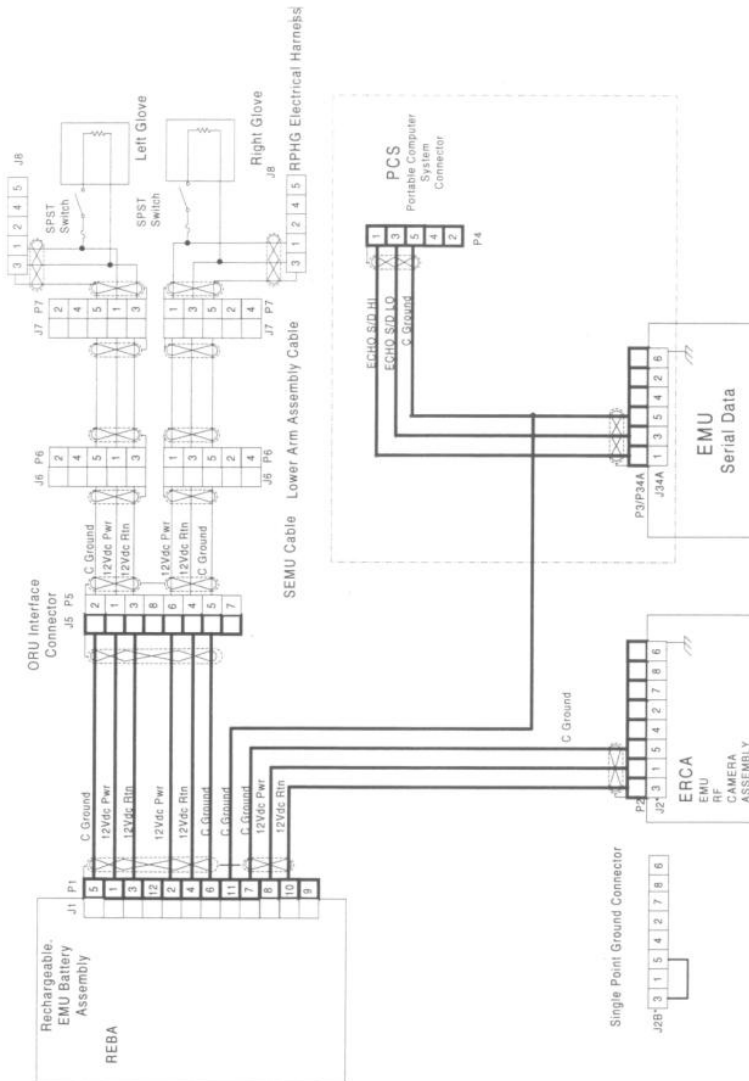
Thermofoil heaters are attached inside each of the fingertips of the glove TMG, located approximately over each of the crewmember's fingernails. The heaters are activated via the gauntlet mounted, hermetic switches (Figure 3.11.4).

**FIGURE 3.11.1 EMU POWER HARNESS****EMU 12V Assembly**

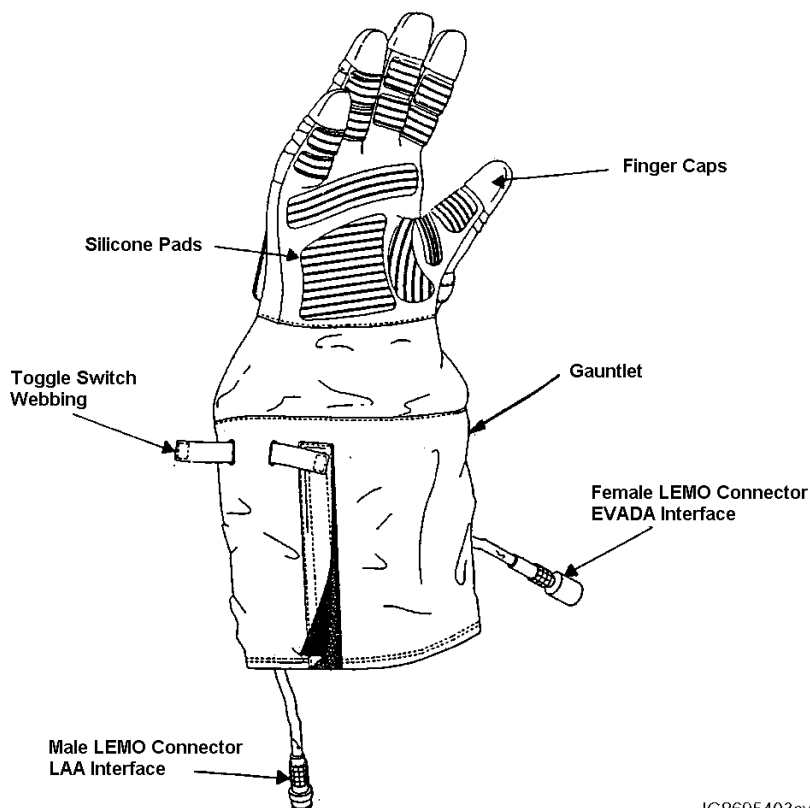
Consists of the:

- EMU Power Harness (EMUPH)  
SHG13101723-302
- EMUPH Single Point Ground Connector (EMUPH SPG)  
SHG13101728-301
- Rechargeable EVA Battery Assembly (REBA)  
SEG33112213-301
- EMU RF Camera Assembly (ERCA)  
SED33111710-305
- Phase VI Gloves  
0106-110106-09/-10 & -11/-12
- Lower Arm Assembly Cable (LAA Cable)  
0103-212419-01
- Short-EMU Harness (SEMU)  
0800-112418-01/02
- In-Line Cable Voltage Regulator (ILCVR)  
0801-112983-01

**FIGURE 3.11.2 EMU POWER HARNESS SCHEMATIC**

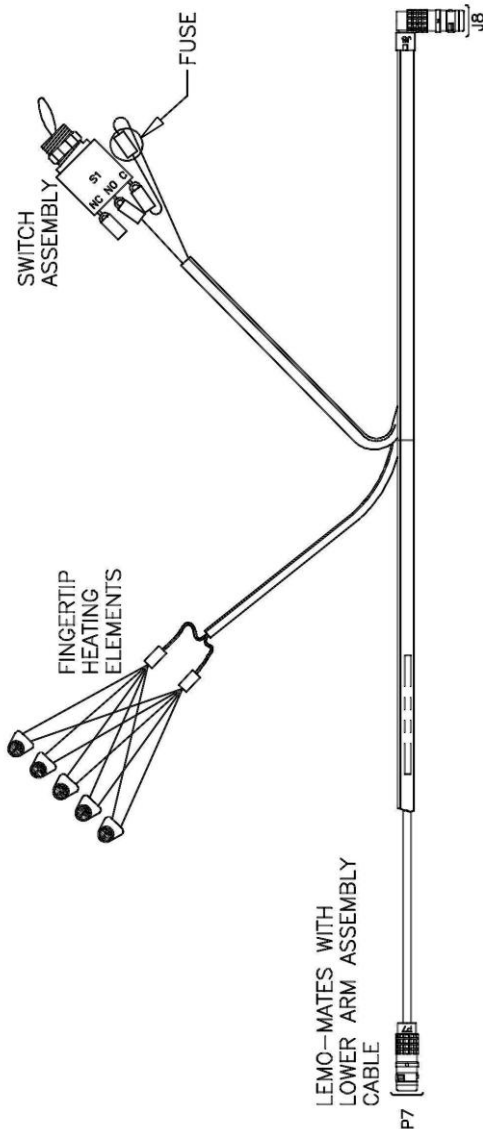


**FIGURE 3.11.3 12 VOLT REMOTE POWERED HEATED GLOVE**



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**FIGURE 3.11.4 PHASE VI HEATED GLOVE  
TMG HEATERS, SWITCH AND  
CABLE**



The heaters are powered by a remote battery pack, called the Rechargeable EVA Battery Assembly (REBA), which is discussed in Appendix C. Each glove is independent with respect to the heaters. Heaters are connected in parallel for system reliability.

The heaters connect to the EMU Power Harness system via a LEMO quick disconnect. The heater electrical harness also includes a scar LEMO connector for an EVA electronic display, or other future option.

### **3.11.2 12 VOLT EMUPH LOWER ARM ASSEMBLY**

Each Lower Arm Assembly (LAA) houses one LAA cable.

The LAA cables continue the power circuit from both SEMU power harnesses to the two gloves. The cables are routed under the LAA TMG. Both ends of the cable terminate outside the TMGs at LEMO connectors. Nine lengths of LAA cable accommodate all lower arm sizes (Figure 3.11.5).

Features of the LAA cable include:

- One cable (3 conductors) running down each arm
- No sheathing or cable ties required

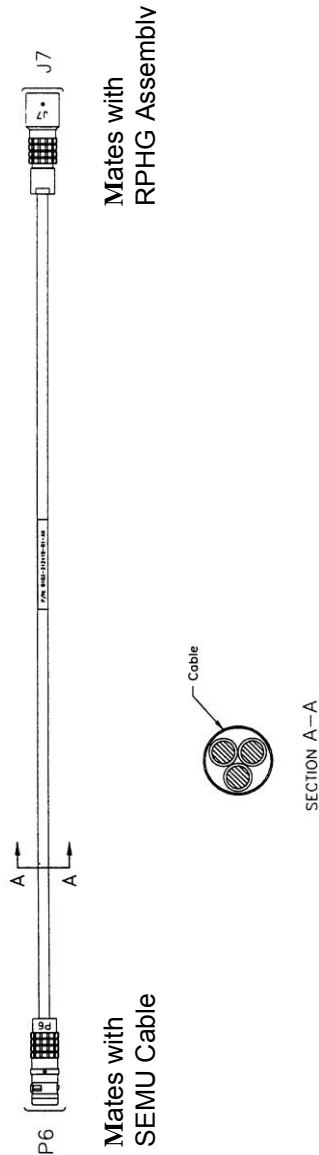
### **3.11.3 SHORT EMU (SEMU) POWER HARNESS**

The 12 V SEMU Power Harnesses are routed through the long-sleeve-HUT TMG tunnels. The lower section of SEMU harness is sheathed to prevent the cables from snagging on the arm sizing brackets to allow easy attachment of the cable to the ORU HUT TMG, as shown in Figure 3.11.6. The SEMU harnesses one length to fit all sizes of Planar HUTs.

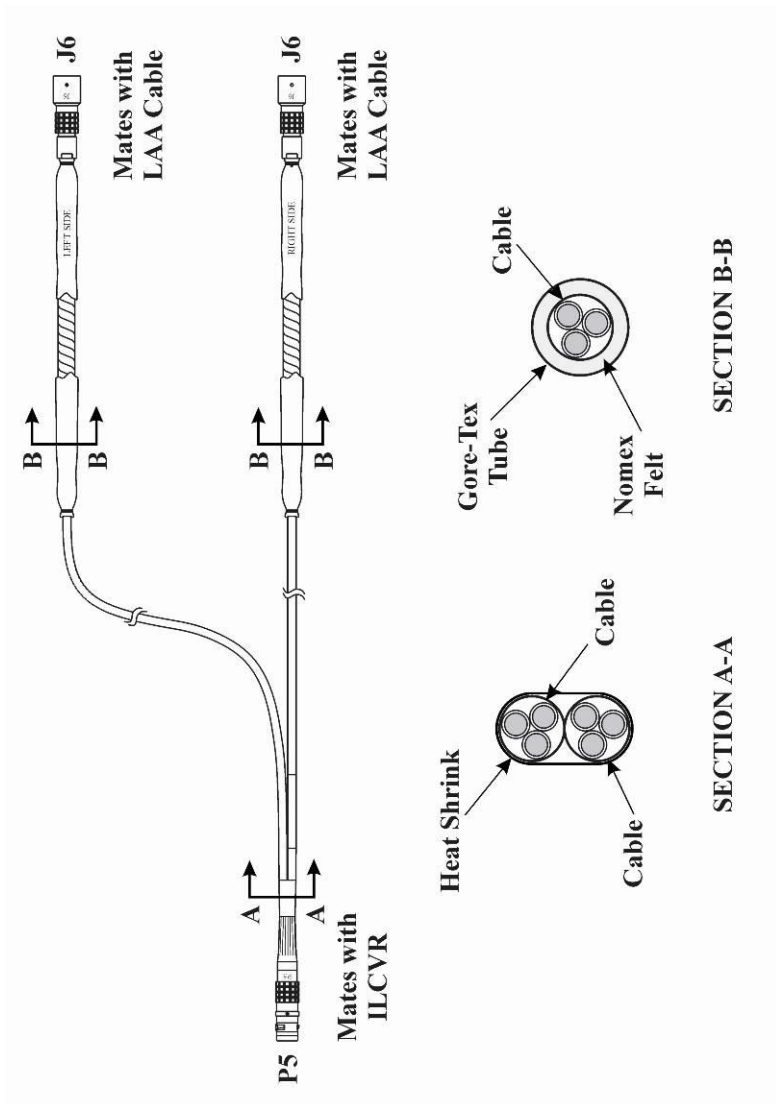
### **3.11.4 IN-LINE CABLE VOLTAGE REGULATOR (ILCVR)**

The In-line Cable Voltage Regulator is module inserted at the interface between the SEMU Harness and the EMUPH that regulates the power provided to the Phase VI Glove heaters. The ILCVR (Figure 3.11.7) converts the REBA output from 14.0V maximum to 9.0 +0.2/-0.5V. It is installed in the Connector Sheath with an extension (P/N 0102-812936-01) located in the ORU HUT O<sub>2</sub> pocket.

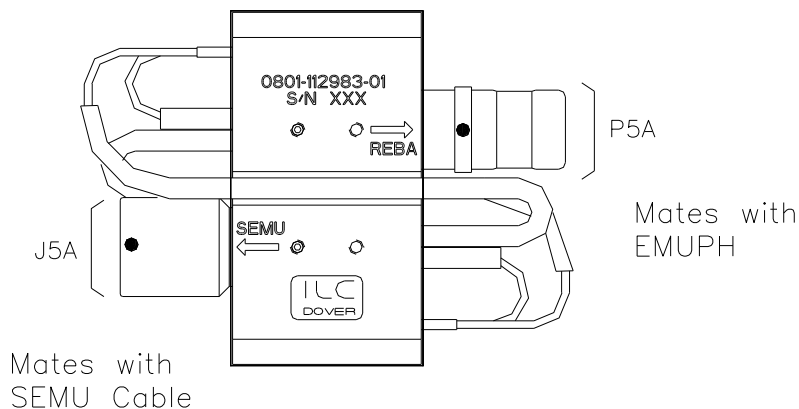
**FIGURE 3.11.5 12 VOLT EMUPH LOWER ARM ASSEMBLY (LAA) CABLE**



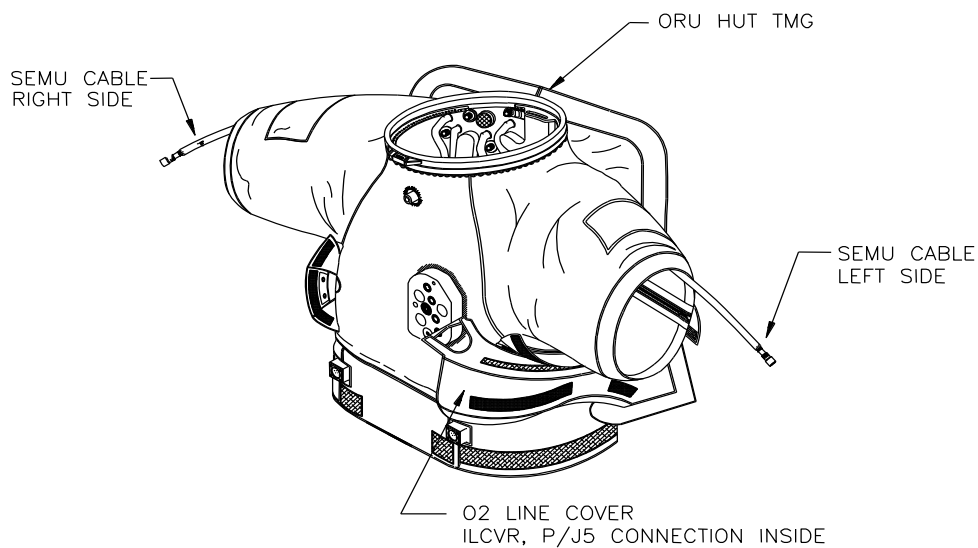
**FIGURE 3.11.6 12 VOLT SHORT EMU (SEMU) POWER HARNESS**



**FIGURE 3.11.7**      **IN-LINE CABLE VOLTAGE  
REGULATOR (ILCVR)**



**FIGURE 3.11.8      ORU SHORT EMU (SEMU)**



### **3.11.5 EMU POWER HARNESS**

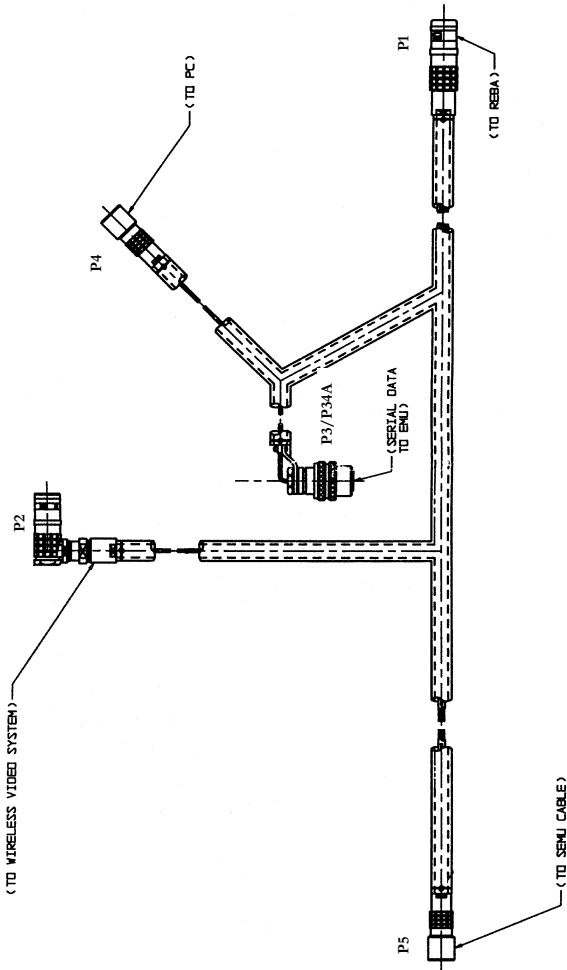
The 12 Volt Power Harness is routed through the ORU/Power Harness PLSS TMG via TMG material tabs attached throughout the PLSS TMG. The Power Harness cable has five individual branches with connectors. The P1 branch connects to the Rechargeable EVA Battery Assembly (REBA) and supplies power to the EMU RF Camera Assembly (ERCA) via the P2 branch connector. The P3 branch connector allows an EMU Serial Data PC Connection. The P4 branch connector allows a Portable Computer System connection. The P5 connector branch connects to the ILCVR, which supplies power through SEMU Harness and the Lower Arm Cables (left and right) to the Glove heaters. There is one length of Power harness to fit all PLSSs (Figure 3.11.9).

### **3.11.6 EMU RECHARGEABLE BATTERY ASSEMBLY (REBA)**

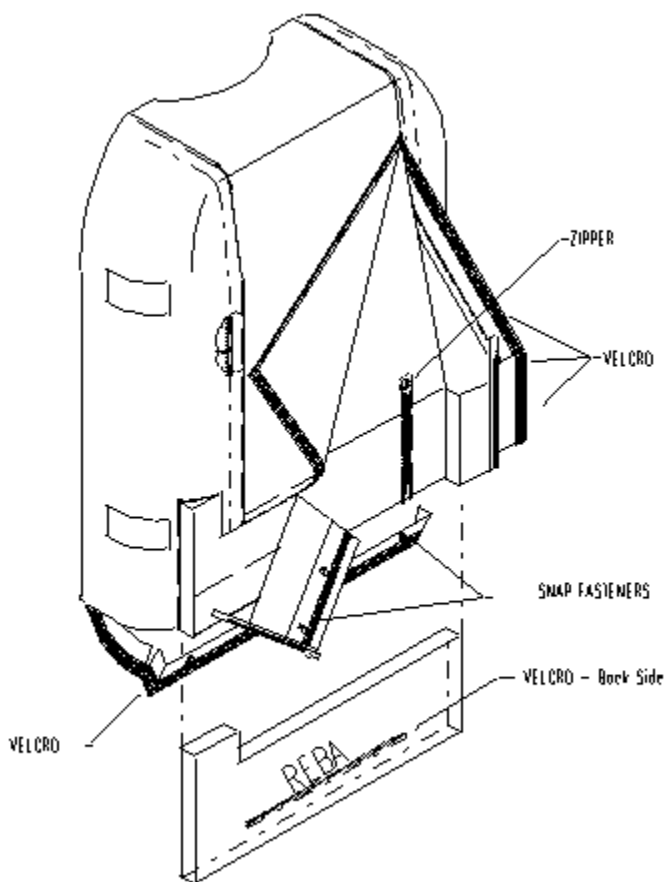
The 12 Volt power source is the REBA which is installed in the PLSS/SOP ORU TMG as shown in Figure 3.11.10.

The REBA is GFE and is described in more detail in Appendix C.

**FIGURE 3.11.9 EMU POWER HARNESS ASSEMBLY**



**FIGURE 3.11.10 RECHARGEABLE EVA  
BATTERY ASSEMBLY (REBA)**



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# **SECTION 3.12**

## **BLADDER AND RESTRAINT ASSEMBLIES**

### 3.12 BLADDER AND RESTRAINT ASSEMBLIES

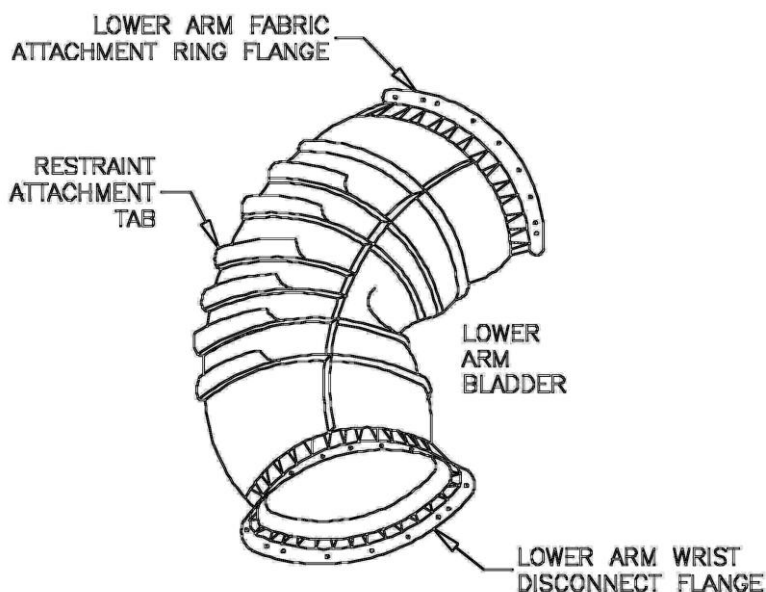
Pressure integrity of the SSA is maintained by Bladder Assemblies which have their envelopes defined by a corresponding Restraint Assembly. Both assemblies interface with the various hardware components via flanges attached to the ends of the Bladder (Figures 3.12.1 and 3.12.2) and Restraint Assemblies (Figures 3.12.3 through 3.12.10). Both assemblies are manufactured softgoods which consist of various elements, such as joints, to provide mobility to the suited crewmember. The following material is discussed with application to the RPHG Arm and Enhanced Lower Torso Assemblies.

"Warp" is the term applied to fibers that run lengthwise in a woven fabric. These fibers can usually sustain the greatest loading. "Fill" is the term applied to the fibers that are woven through the warp at an angle of 90° and "fill" or complete the fabric. These fibers, relative to the warp, also share the fabric loading, but their sustaining capacity is usually less than the warp. "Bias" is the term which defines a direction diagonal to both the warp and fill. A fabric bias is emphasized when it is necessary to "corner" with that fabric.

The Bladder and Restraint Assemblies are fabricated from a series of patterned pieces. In any given Bladder or Restraint Assembly, several factors such as joint length, joint diameter and degree of flexure will affect the size and number of patterned pieces. Some of the patterned pieces incorporate an extra, built-in length of fabric to provide for mobility in the assembly where that piece is used. These parts are referred to as gores. Tabs provided at bladder gore seams locate and index the bladder to restraint.

Regardless of the patterned piece used in the assembly construction, all are marked to align with the fabric warp, fill, or bias as necessary. Finally, the various patterned

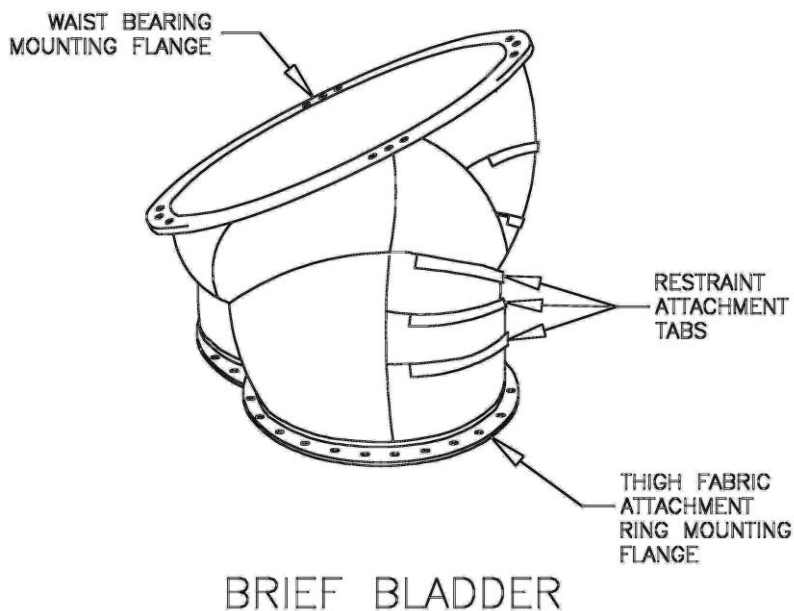
**FIGURE 3.12.1 TYPICAL BLADDER CONSTRUCTION**



**TYPICAL BLADDER CONSTRUCTION**

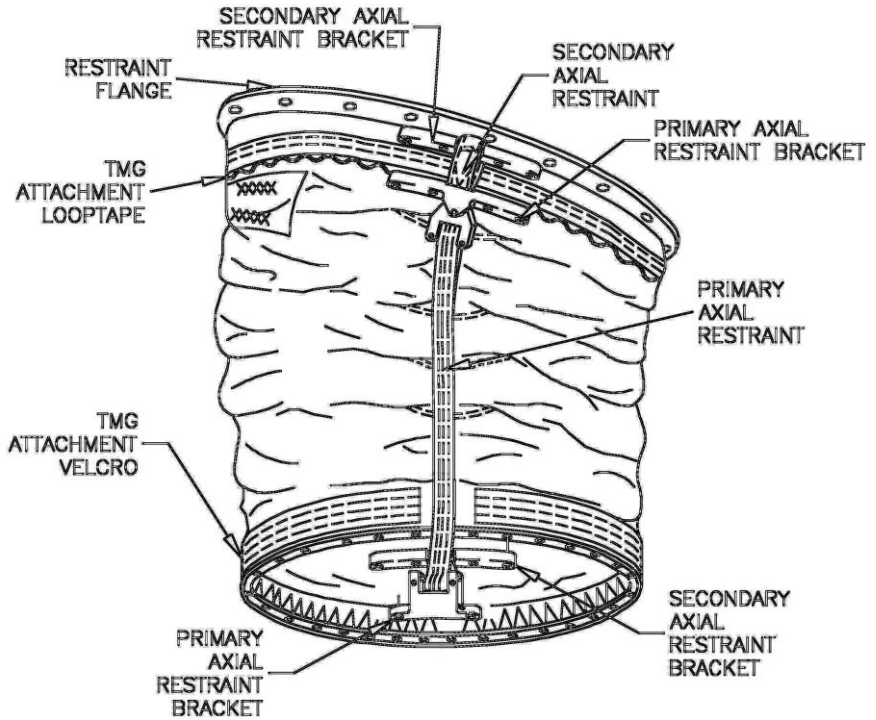
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**FIGURE 3.12.2      BLADDER CONSTRUCTION**



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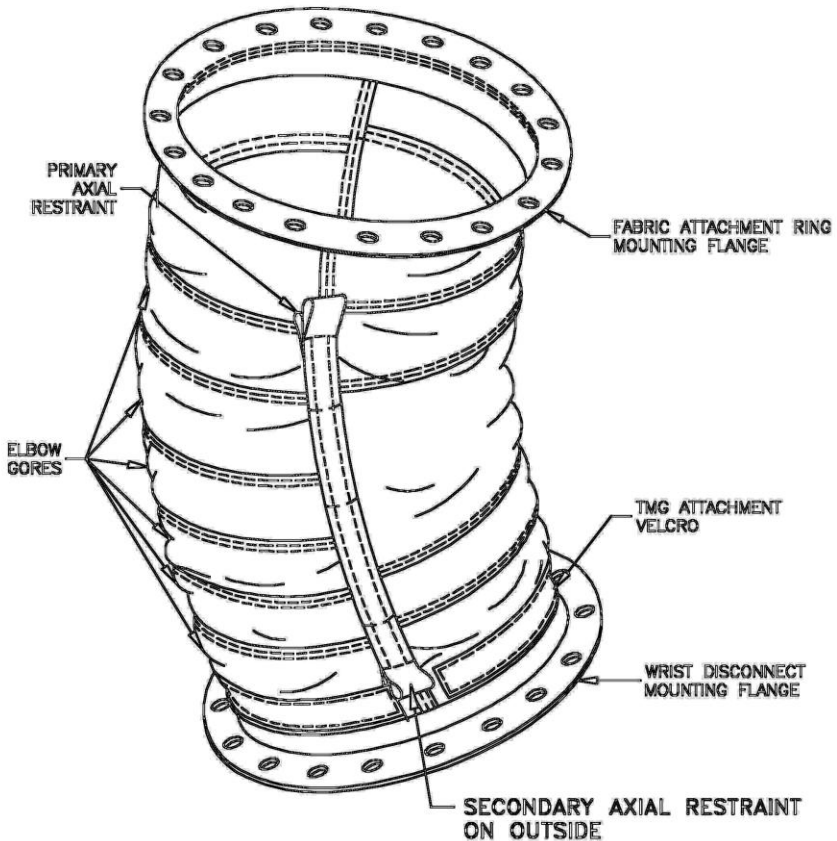
**FIGURE 3.12.3      TYPICAL RESTRAINT  
ASSEMBLY**



**TYPICAL RESTRAINT ASSEMBLY  
(UPPER ARM)**

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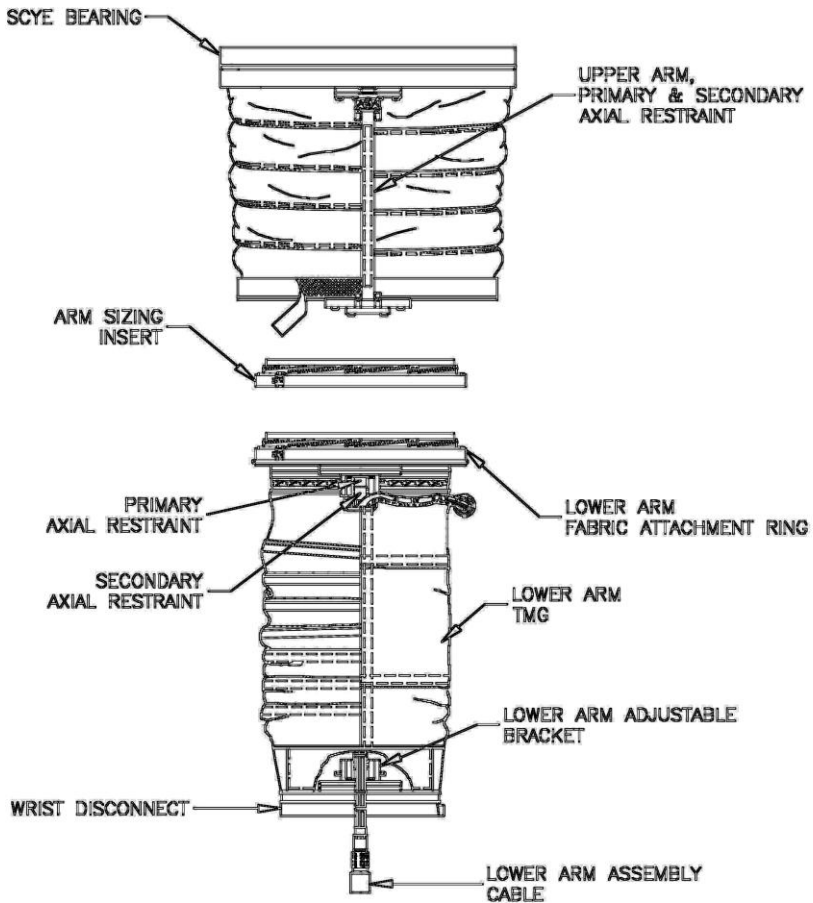
**FIGURE 3.12.4 LOWER ARM RESTRAINT CONSTRUCTION**



LOWER ARM RESTRAINT CONSTRUCTION

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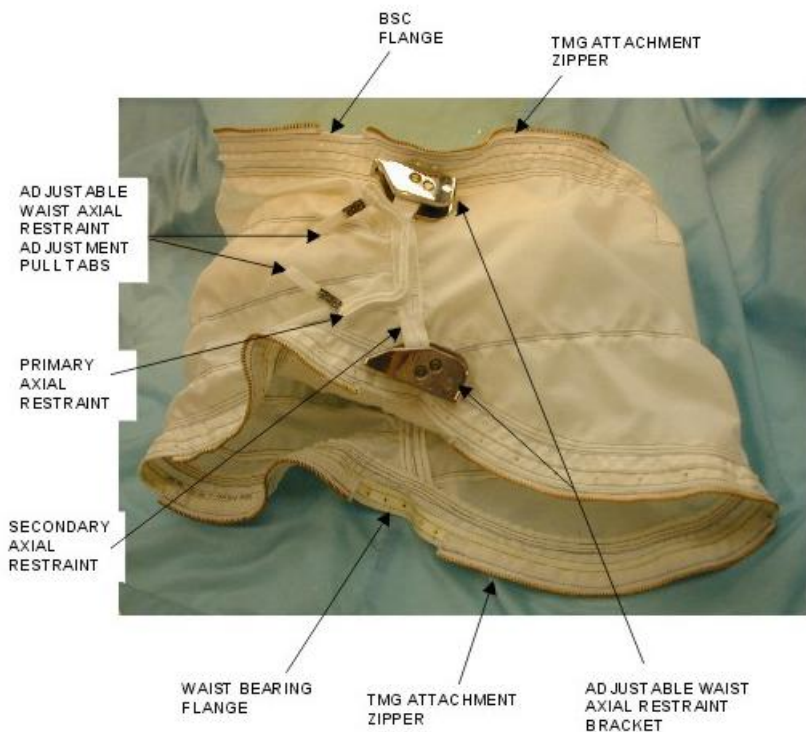
**FIGURE 3.12.5      ARM RESTRAINT  
WEBBINGS**



**ARM ASSEMBLY, AXIAL RESTRAINT**

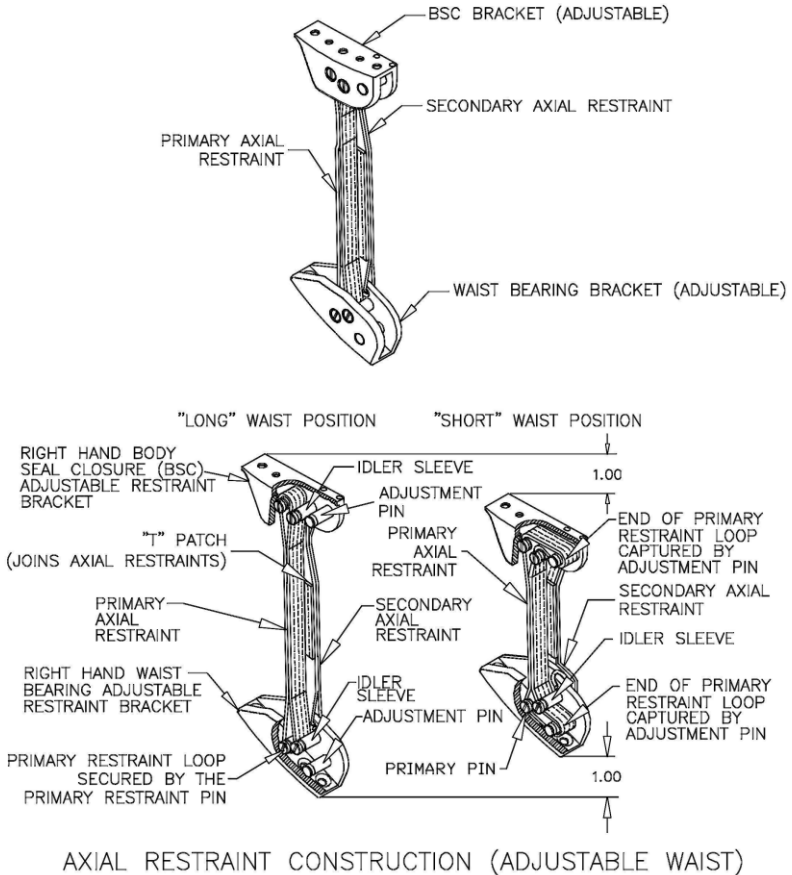
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**FIGURE 3.12.6 WAIST RESTRAINT**



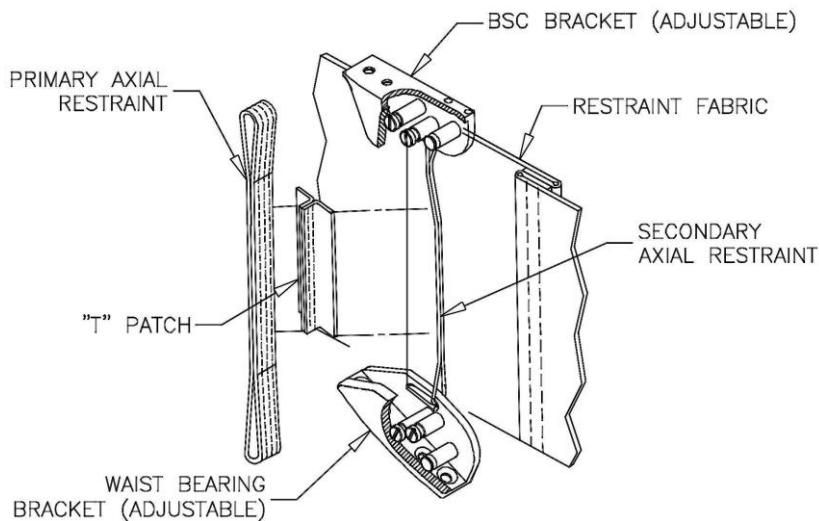
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**FIGURE 3.12.7 AXIAL RESTRAINT CONSTRUCTION (WAIST)**



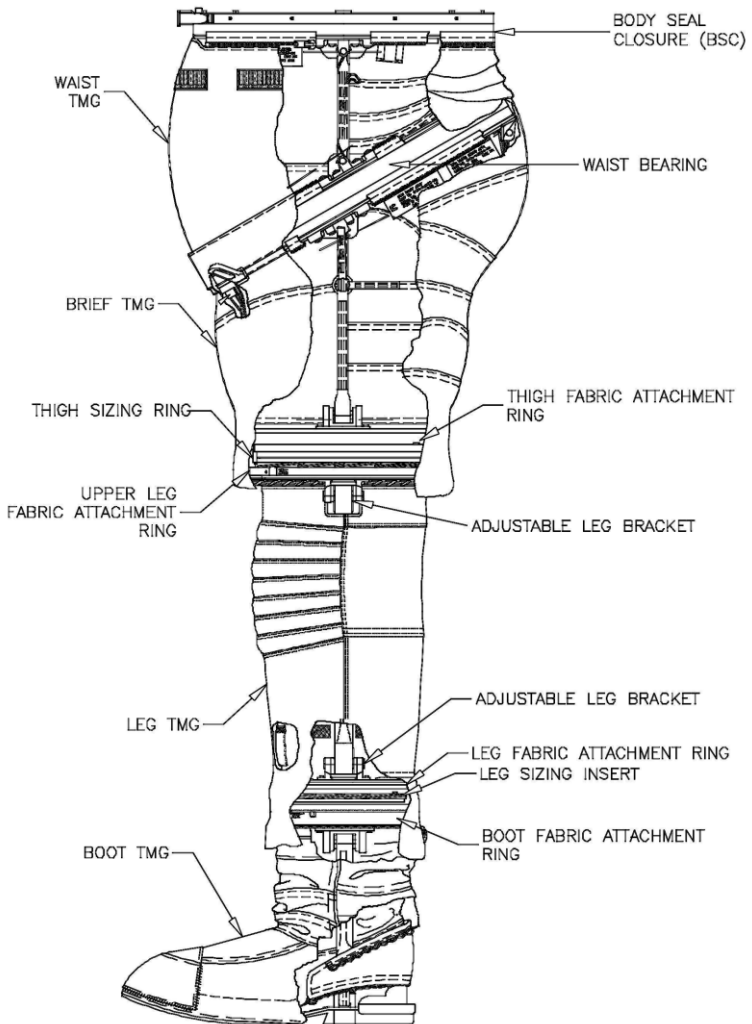
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**FIGURE 3.12.8      AXIAL RESTRAINT  
(WAIST)**



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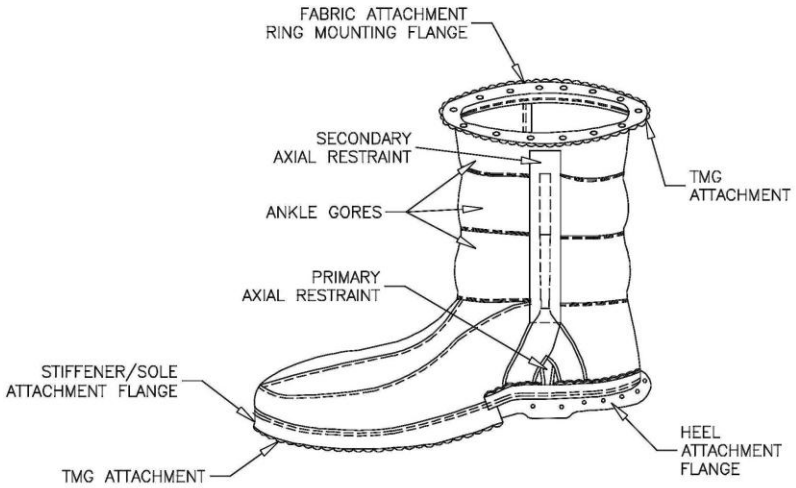
**FIGURE 3.12.9 TROUSER RESTRAINT CONSTRUCTION**



LTA ASSEMBLY

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**FIGURE 3.12.10      BOOT RESTRAINT  
CONSTRUCTION**



BOOT RESTRAINT CONSTRUCTION

ENH8353322cv

pieces are seamed together to form the shape of the desired component.

### **3.12.1 BLADDER ASSEMBLIES**

To reinforce structural integrity of the Bladder Assemblies, reinforcement tapes are installed over the seams. The reinforcement tape is coated on two sides and is bias cut to allow for conformal shaping during installation. Reinforcement tapes are attached by dielectric heat sealing.

The Bladders are fabricated from urethane coated nylon oxford fabric which is yellow in color. Various patterned pieces are seamed together using dielectric heat sealing, and the seams are reinforced with nylon tape, also heat sealed into position (Figures 3.12.1 and 3.12.2). Finally, the flanges are heat sealed into position on the Bladder/Hardware mating ends. The completed assembly is structurally capable of containing normal operating pressure load without external support, when enclosed in the restraint assembly, which manages pressure loads. The bladder is capable of containing ultimate pressure loads.

Areas of the bladder which are subject to abrasion during normal use are reinforced with additional layers. These "abrasion layers" are used on portions of every bladder assembly on the SSA with the exception of the Lower Arm (no abrasion layer is used on the Lower Arm).

All the flanges for the bladders are formed or fabricated from a polyester polyurethane film. The film flange is then reinforced with a layer of coated fabric. The reinforcements are all attached to the outside surface of the flange/bladder interface to eliminate potential leakage through the fabric weave.

### 3.12.2 RESTRAINT ASSEMBLIES

Structural integrity of a bladder is maintained both circumferentially and axially by a Restraint Assembly (Figures 3.12.3 through 3.12.10). Circumferentially, a plain weave polyester fabric encloses the bladder to provide the necessary support.

In the axial direction, webbings are utilized to maintain structural integrity. Both a primary and a secondary webbing are sewn to the restraint fabric of all components in the axial direction and interface at the various connect/disconnect and bearings via brackets. Polyester webbings are utilized for the brief restraint. All other restraint assemblies utilize Spectra webbings.

The basic restraint seam utilized in the construction of the SSA assemblies consists of a joining stitch and then two rows of topstitching. The patterned sections, properly stitched, form the restraint assemblies. Other seams in the restraint assembly, which are small variations of the basic restraint seam, include the attachment of the restraint flanges, attachment of Velcro strips, and the incorporation of the looptape used for TMG attachments. At either end of the restraint assembly, a flange is incorporated to provide for proper hardware interface. The flange is constructed of the same polyester weave fabric used throughout the restraint and a bias ply fabric that controls the flange shape and reinforces screw holes in the flange.

In addition to the flanges attached to each end of the bladder, tabs are also provided at each bladder gore seam. These tabs are an extension of the gore pattern (Figure 3.12.1) and serve to secure the bladder to the restraint. (The attachment is made only at joints to index and orient the bladder for maximum range and lowest torque in the joints.)

Whenever possible, circumferential “O” rings are used in conjunction with the polyurethane sealing surface of the

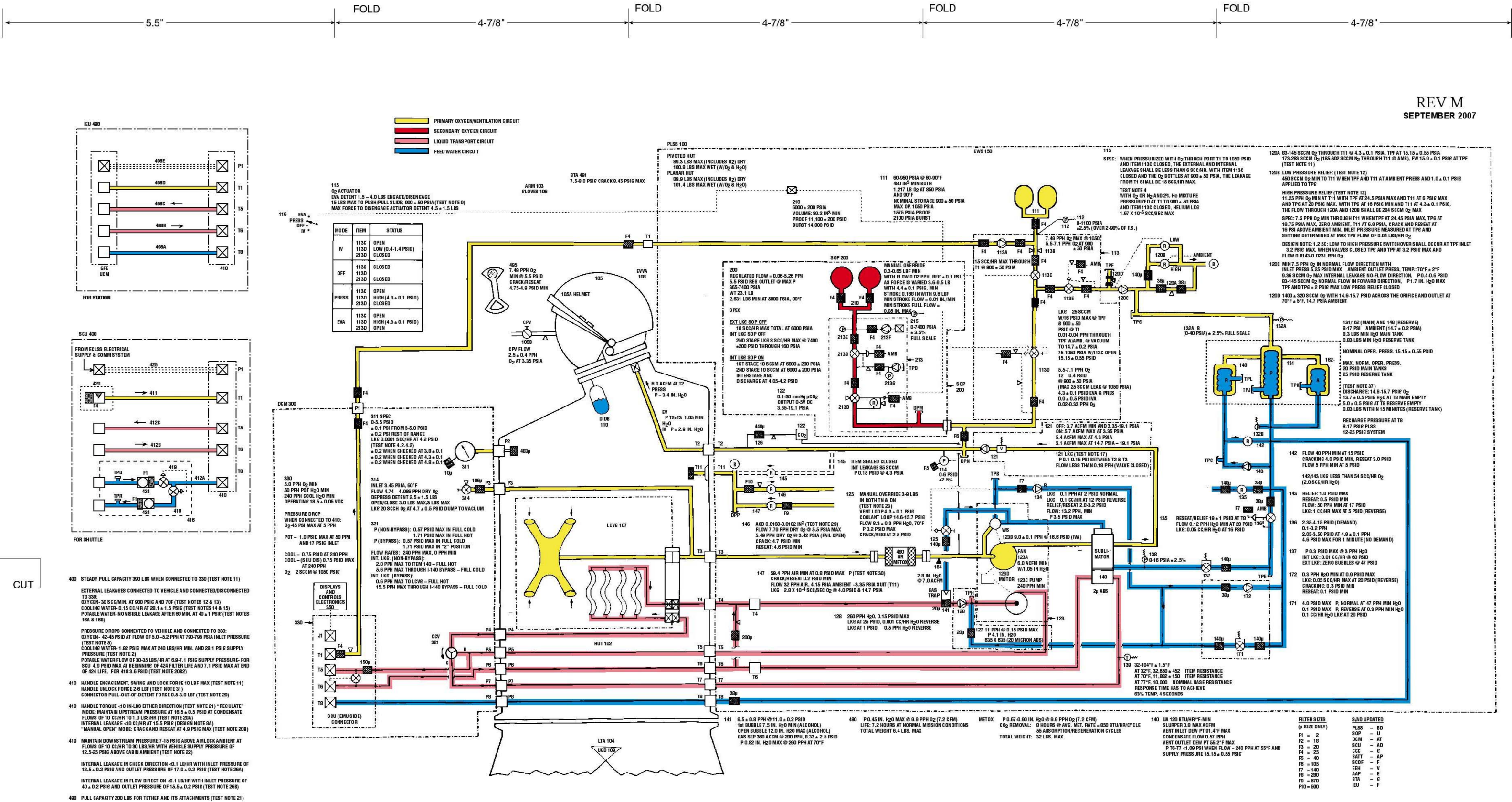
flange and the smooth metal surface of disconnects and bearings to accomplish a leak free interface. This particular mounting configuration is utilized at the Wrist Disconnect, Boot Disconnect, Waist Bearing and Body Seal Closure, and component fabric attachment rings. An exception to the use of the circumferential "O" ring and the conventional flange mounting occurs in the Arm and Scye Bearing due to the limited area available on the respective flange-sealing surface. The arm bearing utilizes a Polyurethane sealing surface to achieve a leak free interface while the Scye bearing utilizes "O" seals with each clamping ring screw.

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# **SECTION 4.0**

# **SCHEMATIC**

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**METOX REGENERATOR**

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## A.1 GENERAL DESCRIPTION

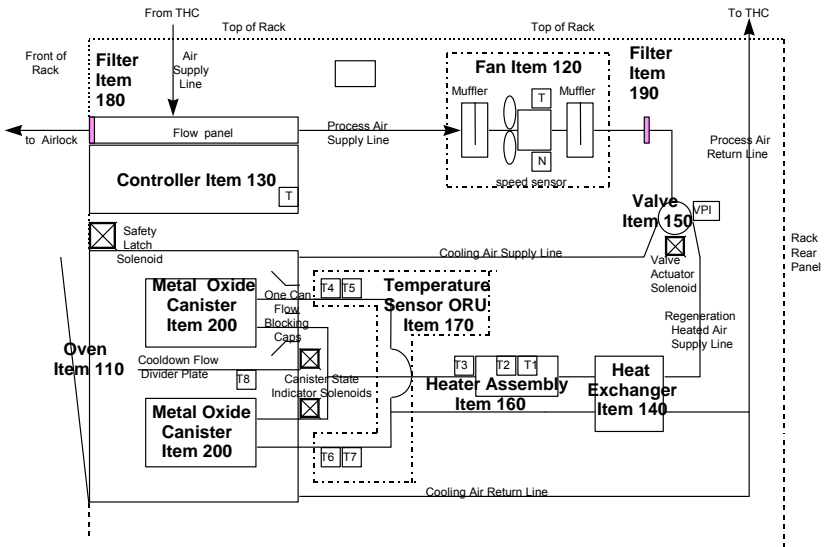
The Regenerable Metal Oxide based Extravehicular Mobility Unit (EMU) Atmospheric Control System, (Metox) Regenerator (Figure A.1) has been designed for use in the ISS Airlock to regenerate up to two item METOX/200 canisters. The canisters, H.S. part number SV821799-1, remove metabolically produced carbon dioxide and trace contaminants from the Shuttle EMU ventilation loop while on Extravehicular Activity (EVA). The canisters may also be used in the ISS Airlock during unsuited “camp-out” at reduced pressure for denitrogenation. The metal oxide sorbent is regenerated by flowing air at approximately 400°F at 7.5 scfm through each expended canister for a duration of 10 hours. This is followed by a 4 hour cooldown period to return the canisters and oven to a safe touch temperature.

Schematics of the regenerator, showing the flow path during heating and cooling, major components and item numbers are presented in Figures A.2 and A.3. Additional Regenerator information can be found in the User's Manual for the Metal Oxide Regenerator, SVHSER 19836.

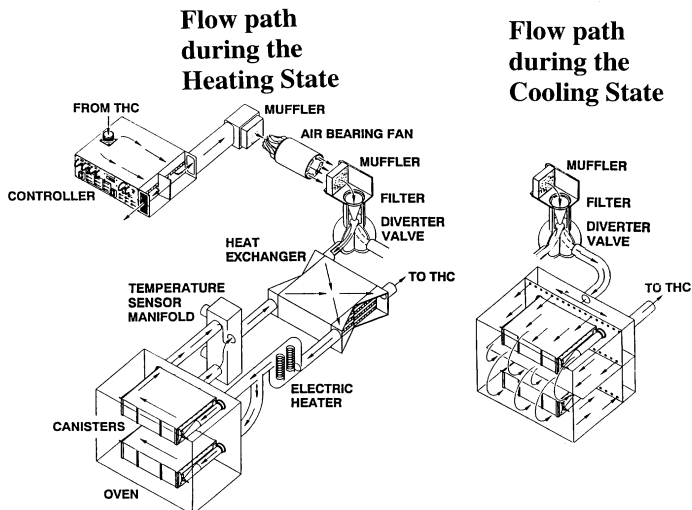
**Item Number Confusion:** Because the Metox was developed under a separate contract, the regenerator and the canister were not assigned EMU item numbers, but rather were independently assigned item numbers 100 and 200 respectively. This can lead to confusion since the EMU's Primary Life Support System (PLSS) and the Secondary Oxygen Pack (SOP) are referred to as Items 100 and 200 respectively and the CCC, which the Metox replaces, is an Item 480. To minimize this problem, it is recommended that use of the Metox item numbers should be avoided and that where they are used, the Metox name should also be used (i.e. Metox Item 100 or Metox Item 113 etc.).



**FIGURE A-1 – METOX REGENERATOR ASSEMBLY**



### FIGURE A-2 - REGENERATOR SCHEMATIC



### FIGURE A-3 – METOX REGENERATOR SCHEMATIC

## A.2 NORMAL OPERATION

The operating regenerator is mounted in the lower left side of the Airlock Temperature and Humidity Control Rack (Figure A.4). The regenerator inlet process air is drawn from and returned to the Airlock THC System. A portion of the inlet process air is split to provide ventilation flow through the controller to remove waste heat generated by the logic board when the fan is not operating during the low power mode or at the end of the cycle. This ventilation flow exhausts out the front of the controller through the item 180 Outlet Filter Assembly into the Airlock. The Outlet filter is an ORU which contains a 130 micron hydrophobic (Teflon) filter to prevent particulate contamination and accidental liquid spills from entering the process air stream. It is mounted on the controller display panel which contains the switches for system operation, LEDs for system status and health monitoring, and the LCD for time remaining in the cycle and error code display.

During the regeneration or heating mode, process air is drawn from the THC supply through the item 130 Controller Assembly through an integral heat exchanger within the controller to remove waste heat generated by the electronics. The controller is designed to be an ORU that is removable from the front of the regenerator package. The display and controls for system operation are located on the front face of the controller for easy access and monitoring (Figure A.4). The controller contains all the logic for fully automatic operation, fault detection and emergency shutdown capability. In addition, a thermostat (T9), item 131, is embedded on the driver board for over temperature monitoring and safety shutdown if required.

The process air is drawn from the controller into the item 120 Fan Assembly which provides the head to overcome the system pressure losses. The Fan Assembly consists of inlet and outlet mufflers, a fan, an acoustic enclosure, and a mounting frame. The fan is a mixed flow unit with thrust and journal air bearings and a 120 volt brushless DC motor. Speed and temperature sensors mounted on the fan are used for fan fault detection. In addition, the controller also monitors the fan current as part of the fault detection.



**FIGURE A-4 – METOX REGENERATORS IN THE RACK**

The airflow from the fan exits through the item 190 Duct Filter and Seal assembly which is a 150 mesh stainless steel filter designed to capture particulate contamination in the event of a failure of the foam mufflers. This filter is located in the duct work between the fan assembly and the item 150 Diverter Valve Assembly. The diverter valve is a two position ball valve which directs the process air flow to the item 140 Heat Exchanger during regeneration and to the Oven during canister cool down. It has an aluminum ball and valve body, item 152, and a spring loaded actuator. Opening the oven door through an angle greater than 90 degrees automatically moves the valve to the heating position where it is latched in place. When regeneration is complete and canister cool down has begun, a valve mounted electrical solenoid, item 151, is actuated which releases the latch and allows the spring to reposition the valve. The valve has two position indicator switches to provide an indication in either position for process control and fault detection.

During the heating mode, the process air flows through the regenerative heat exchanger, item 140, which utilizes an aluminum brazed plate-fin construction in a counter flow single pass arrangement to achieve an effectiveness of approximately 80%. The heat exchanger is used to reclaim the energy contained in the exiting air. This reduces both the required peak heater power and the total energy required for regeneration. Reducing the total energy requirement also reduces the waste heat load on the Airlock environment.

From the heat exchanger the process air flows to the item 160 Heater Assembly ORU. This item consists of a 750 watt, 120 VDC cal rod heating element, item 161, which is wound in a circular coil pattern to minimize pressure drop while maintaining a high convective heat transfer. It is mounted within a stainless steel housing and insulated with high temperature insulation. The heater ORU also consists of a single element platinum probe RTD (T3), item 163, which is used for air outlet temperature control, and a dual element platinum probe RTD (T1 and T2), item 162, for over/under temperature fault detection. The air outlet temperature is limited to 425 +/-5°F by controlling the heating element duty cycle by pulse width modulation of the heater drive circuitry.

Air exiting the heater ORU then enters the oven manifold where it is directed to flow in through the canister inlet port for regeneration. The Oven Assembly, item 110, consists of a stainless steel inner liner covered with approximately 1.5 inches of insulation. The chamber is designed to hold two canisters and is divided into upper and lower berths. Each berth has a set of canister guides which insure that the canister is properly aligned and oriented, and an electrical solenoid, item 111, used to reset the canister's state indicator to the regenerated position following regeneration. The upper berth has port covers to seal the oven air supply and return ports when only one canister needs to be regenerated. The upper berth also contains the cooling air inlet manifold and the lower berth contains the cooling air return manifold. The lower berth also contains a platinum probe RTD (T8), item 113, to measure the chamber/canister touch temperature. This measurement is used to provide detection of a failed cooling cycle, and will prohibit the door latch solenoid, item 112, from opening whenever the interior temperature exceeds 105 +/-5°F. (Note: the door latch can be manually overridden). An oven door position indicator switch is provided for operational monitoring and fault detection.

Hot air exiting each canister outlet port is rejoined within the Temperature Sensor ORU, item 170, and then flows to the regenerative heat exchanger. This ORU is mounted on the oven outlet manifold and consists of two dual element platinum probe RTDs (T4/T5 and T6/T7), item 171, one for each canister or oven berth position, and are used to confirm canister regeneration and fault detection. The process air flow exits the regenerative heat exchanger and then is returned to the THC air return interface.

After 10 hours, the canister regeneration is complete and the diverter valve is actuated to direct the process air flow to the oven cooling air inlet manifold. The canisters are then cooled by flowing air over the external surfaces of the canisters for approximately 4 hours. The air is flowed over the outside surface so as not to reload the sorbent with CO<sub>2</sub>. The process air then exits the oven via the cooling air return-manifold and is discharged to the THC air return interface.

### A.3 COMPONENT DESCRIPTIONS / PERFORMANCE

#### A.3.1: Metox Regenerator Assembly, Item number 100 Part number SV822000-2, (S/AD SV822000/2)

**Description / Function:** The Metox Regenerator Assembly has been designed for use in the ISS Airlock to regenerate up to two item METOX/200 Canisters. The assembly is mounted in the lower left side of the Airlock Temperature and Humidity Control Rack (reference Boeing drawing number 683-50141 Crossover Structure Assembly and Cabin Air.) The regenerator inlet process air is drawn from and returned to the Airlock THC System. A portion of the inlet process air is split to provide ventilation flow through the controller to remove waste heat generated by the logic board when the fan is not operating during the low power mode or at the end of the cycle. This ventilation flow exhausts out the front of the controller through the item 180 Outlet Filter Assembly into the Airlock. The metal oxide sorbent is regenerated by flowing air at approximately 400<sup>0</sup> F at 7.5 scfm through each expended canister for a duration of 10 hours. This is followed by a 4 hour cooldown period to return the canisters and oven to a safe touch temperature.

**Performance:**

**Voltage:** 120 VDC

**Power:** Shall not exceed 1000W except during start-up transients which are to be limited to a 1500W max for no more than one minute

**Weight:** 105 pounds maximum

**Envelope:** 17.72 in. high x 19.0 in. wide x 30 in. deep

**Interfaces:** 1.75 in. dia. air inlet duct  
1.75 in. dia. air outlet duct  
NATC type electrical connectors (power and software loading)

**Operating Pressure:** During CO<sub>2</sub> removal: 14.5-15.2 psia  
During canister cooling: 10.0-15.2 psia

**Operating Media:** Air

### A.3.2 Metox Oven Assembly, Item number 110

#### Part number SV821688-1

**Description / Function:** Air exiting the Heater ORU enters the Oven manifold where it is directed to flow in through the canister inlet port for regeneration. The Oven Assembly consists of a stainless steel inner liner covered with approximately 1.5 inches of insulation. The door is fabricated from a fiberglass lay-up with a phenolic liner. The cavity between the door and the liner is filled with insulation. The oven handle is also made of phenolic, so that heat is not conducted from the handle brackets. In its latched position, the oven handle is recessed beyond the oven door to provide a smooth, flat frontal surface. The action of opening the door greater than 90° resets the diverter valve to the heating mode via a mechanical linkage, running the length of the regenerator assembly. The chamber is designed to hold two canisters and is divided into upper and lower berths. Each berth has a set of canister guides which insure that the canister is properly aligned and oriented, and an electrical solenoid (item 111) used to reset the canister's state indicator to the regenerated position following regeneration. The upper berth has port covers to seal the oven air supply and return ports when only one canister needs to be regenerated. The upper berth also contains the cooling air inlet manifold, while the lower berth contains the cooling air return manifold. The lower manifold is used to cool the external surfaces of the canister to a safe touch temperature without re-depositing CO<sub>2</sub> laden process air within the canisters. The lower berth also contains a platinum probe RTD (T8), item 113, to measure the chamber/canister touch temperature. An oven door position indicator switch is also provided for operational monitoring and fault detection.

**Performance:**

<b>Voltage:</b>	N/A
<b>Power:</b>	N/A
<b>Weight:</b>	32 pounds approx.
<b>Envelope:</b>	19.0 in. high x 17.7 in. wide x 20.0 in. deep
<b>Interfaces:</b>	1.5 in. dia. air inlet/outlet ducts NATC type electrical connectors
<b>Mounting Interface:</b>	(4) .250 in. dia. Bolt holes, (2) alignment pins 0.375 in. dia.
<b>Operating Pressure:</b>	N/A
<b>Operating Media:</b>	Air

### A.3.3 Temperature Sensor (T8) ORU, Item number 113

#### Part Number SV821682-1

**Description / Function:** The Temperature Sensor (T8) is a platinum probe RTD used to measure the oven chamber/canister touch temperature, and is housed in the lower berth of the oven. The temperature measurement is used to determine when the canisters and oven have returned to a safe touch temperature, detect a failed cooling cycle, and will prohibit the door latch solenoid (Item 112) from opening whenever the interior temperature exceeds  $105 \pm 5^{\circ}$  F. (Note: the door latch can be manually overridden.) An oven door position indicator switch is provided for operational monitoring and fault detection.

**Performance:**

<b>Voltage:</b>	N/A
<b>Power:</b>	max current 1 ma DC
<b>Weight:</b>	0.40 pounds max
<b>Envelope:</b>	1.75 in. high x 1.75 in. wide x 2.4 in. deep
<b>Interfaces:</b>	NATC type electrical connectors
<b>Mounting Interface:</b>	Captive Fastener, 0.4375 in. dia.
<b>Operating Pressure:</b>	10.0 to 15.2 psia
<b>Operating Media:</b>	Air

### A.3.4 Fan Assembly, Item number 120

#### Part number SV821900 (S/AD SVHS14416)

**Description / Function:** The Metox Fan Assembly consists of a modified Avionics Air Assembly air bearing fan, mounting plate, support brackets, inlet and outlet mufflers and a molded enclosure. The fan is mounted to isolated brackets, which are bolted to the mounting frame. The mufflers are bonded into the enclosure. Each muffler consists of a stack of three  $\frac{3}{4}$ " foam pieces with a thin plastic sheet between them. The mufflers have sixteen 1" diameter holes for air passage. The air enters through the side of the enclosure at the inlet end of the assembly, is drawn through the fan and exits the assembly through a rectangular opening in the mounting plate.

The Metox Fan Assembly is not an ORU, but it can be replaced in orbit. The Metox Fan Assembly is mounted to the Regenerator Frame via captive fasteners accessible from the top of the Regenerator Assembly. Both the Regenerator Controller and Heater Assembly ORU must be removed prior to removing the Metox Fan Assembly. Once the Metox Fan Assembly is removed, the item 190 filter is no longer captive and must be retained. The fan electrical harness carries power from the controller and returns sense signals (temperature and speed) to the controller. The harness exits the Metox Fan Assembly through a sealed opening in the mounting plate.

**Performance:** The fan assembly generates an air flow of  $16 \pm 0.5$  CFM at the supply duct interface of 5.5 inches of water pressure rise minimum, and a motor speed not exceeding 50,000 rpm. It also generates 16 CFM at 10.0 inches of water pressure rise minimum at a motor speed not exceeding 60,000 rpm.

**Operating Pressure:** @ Inlet Muffler Interface Air Pressure  
-0.5 to +0.5 psia  
@ Ambient Air Interface Air Pressure  
10.0 to 15.2 psia

**Leakage:** The maximum allowable external air leakage shall be 0.076 ppm when a positive differential pressure of 10 inches of water is applied at 70° F and 14.7 psia.

**Voltage:** (Normal Range) 111.5 - 127.5 VDC  
Transients to 94.5 and 144.6 VDC for less than one second

**Power:** Maximum steady state power consumption shall be 75 watts with a 5.5 inch pressure rise, and 110 watts with a 10.0 inch pressure rise

**Weight:** The total dry weight shall not exceed 11.3 lb.

**Envelope:** 6.9 in. high x 16.8 in. wide x 6.6 in. deep

**Interfaces:** 0.5 in. x 4 in. air inlet/outlet  
NATC type electrical connectors

**Operating Media:** Air

**A.3.5 Controller, Item number 130****Part number SV821750-2 (S/AD SVHS14417)**

**Description / Function:** The Metox Controller provides the interface between the user and the Metox Regenerator and performs the functions of power supply conditioning, signal processing and Metox Regeneration control for the diverter valve solenoid, canister state indicator solenoid, oven inter-lock solenoid, heater and fan. The controller is an orbit replaceable unit (ORU) and contains a front panel with switches, light emitting diodes (LED) and a liquid crystal display (LCD) for user control and monitoring. The controller has four printed circuit boards: logic board, driver board, LCD board, and motor controller board. In addition, the controller contains EMI filters and an integral heat exchanger passage to provide a means of heat rejection for the electronics.

**Performance:**

**Voltage:** The controller will receive 120 VDC

**Leakage:** nominal power via an electrical connector  
The controller leakage shall not exceed 0.01 pounds per minute with the ventilation and process air outlet ports blocked and the air inlet pressurized to 10 inches of water using gaseous nitrogen or air.

**Pressure Drop (Vent Flow):** The air inlet pressure shall be less than 0.25 inches of water at an air or nitrogen flow rate of 5 scfm with the process air outlet port blocked and the ventilation air port open to ambient.

**Pressure Drop (Process Flow):** The air inlet pressure shall be less than 0.35 inches of water at an air or nitrogen flow rate of 15 scfm with the ventilation port blocked and the process air outlet port open to ambient.

**Power:** Maximum steady state power consumption during standby shall be 20.0 watts.

**Weight:** The total weight of the Controller shall not exceed 24 lbs.

**Envelope:** 5.5 in. high x 17.0 in. wide x 15.2 in. deep

**Interfaces:** 1.75 in. dia. air inlet duct

0.5 x 4 in. air outlet port  
 NATC type electrical connectors  
**Operating Pressure:** Pressure Range: 10.0 to 15.2 psia  
**Operating Media:** Air

### **A.3.6 Heat Exchanger Assembly, Item number 140** **Part number SV821660-1**

**Description / Function:** The regenerative heat exchanger flows process air during the heating mode. The heat exchanger utilizes an aluminum brazed plate-fit construction in a counter flow single pass arrangement to achieve an effectiveness of approximately 80%. It is comprised of alternate layers of hot and cold flow, giving a total of ten layers (five hot, five cold.) The heat exchanger is used to reclaim the energy contained in the exiting air from the oven, and preheat the air going to the heater. To improve its efficiency, the heat exchanger is covered with thermal insulation with a minimum thickness of 0.50 inches. This reduces both the required peak heater power and the total energy required for regeneration. Reducing the total energy requirement also reduces the waste heat load on the Airlock environment. The Heat exchanger mounts are thermally isolated from the regenerator support frame using phenolic washers.

#### **Performance:**

**Voltage:** N/A  
**Power:** N/A  
**Weight:** 5.5 pounds maximum  
**Envelope:** 5.5 in. high x 12.4 in. wide x 6.8 in. deep  
**Interfaces:** 1.685 in. dia. air inlet duct  
 1.685 in. dia. air outlet duct  
**Mounting Interface:** (4) bolt holes: 2 x .266 in. dia.  
 2 x .312 in. dia.  
**Operating Pressure:** 14.7 psia  
**Air Flow Rate:** 67.5 lb/hr minimum  
**Pressure Drop:** Maximum drop of 1.5 inches of Water  
**Leakage:** Shall be less than 0.005 lb/min at 10 inches of Water  
**Operating Media:** Air

**A.3.7 Diverter Valve, Item 150****Part number SV821670-1 (S/AD SVHS14415)**

**Description / Function:** The diverter valve assembly consists of a 90°, two way ball valve with an actuator assembly mounted to it. The ball valve housing and ball are made of aluminum, and the valve has spring-loaded Teflon seals. The inlet side of the valve is flange mounted, and bolts onto the Regenerator Frame directly under the outlet of the fan assembly. The outlet ports are beaded for hose and band-clamp connections, are perpendicular to the inlet, and are 90° from each other.

Opposite the inlet flange the actuator assembly is mounted on the valve surface where the valve stem extends from the housing. The actuator assembly consists of a lever, a puller assembly, a torsion spring and cup assembly, latch assembly, a solenoid, two microswitches and a cover.

The lever fits over and is bolted to the valve stem. The lever extends out both sides of the stem, with one side attached to the puller assembly and the other side attached to the spring. The puller assembly consists of a sliding mechanism and housing. The sliding mechanism has two Teflon covered areas for smooth movement in the housing, and angled surface that pulls on a roller attached to the lever, and a through hole for connecting it to the oven door actuator mechanism. The puller assembly housing is mounted to the valve housing and provides stability for the sliding mechanism.

The torsion spring is attached to the lever on one end and the cup assembly on the other. The cup assembly bolts to the valve housing and its centerline coincides with the valve stem centerline. The cup assembly has notches for the spring every 30° to allow adjustment in the spring actuation force, and has a Teflon sleeve to minimize wear between the cup and torsion spring. The latching assembly is spring loaded, pivots at one end and has a roller at the other end. This roller rides up a ramped surface on the lever as the valve is actuated by the oven door. When the oven door is opened, the lever rotates winding up the spring. As the lever continues to rotate, the roller reaches the peak of the ramp and the lever spring pulls the latch down behind the ramp on the lever.

When the oven door is closed and the puller assembly is returned to its original position, the latch assembly prevents the spring from moving the lever to its original (cooldown) position.

After the heating portion of the regeneration cycle, the flow is diverted directly to the oven through a manifold to cool the canister externally. The solenoid is actuated and it pushes the latch over the ramp on the valve lever. The force in the torsion spring can then return the valve to the cooldown position. There are two microswitches used for valve position indication. The switches are identical and have a roller bearing assembly welded onto their arms. The switch is actuated when a ramped surface on the valve lever forces the switch roller bearing down.

**Performance:**

**Voltage:** For all normal conditions of nominally 120 VDC, with a range of 105.5 to 127.5 VDC. Transients to 88.5 and 144.5 VDC may occur for less than one second.

**Current Draw:** Shall not exceed two (2) amperes when actuated at the component level.

**Power:** See Performance

**Weight:** Shall not exceed 3.2 pounds

**Envelope:** 6.5 in. high x 4.5 in. wide x 8.545 in. deep

**Interfaces:** 1.75 in. dia. air inlet duct  
1.75 in. dia. air outlet duct  
NATC type electrical connectors

**Operating Pressure:** See Performance

**Pressure Drop:** Valve pressure drop shall not exceed 0.5 inches of water with an airflow of 15 scfm.

**Leakage:** (Internal) With a pressure of 10 inches of water at the inlet, the leakage to the inactive port shall be less than 0.010 lb/min for the "regen" position, and less than 0.001 lb/min for the "cooldown" position.  
(External) With a pressure of 10 inches of water at the inlet, the external leakage shall be bubble tight when checked with leakage detection compound.

**Operating Media:** Air

**A.3.8 Heater Assembly, Item number 160****Part number SV821662-1 (S/AD SVHS14460)**

**Description / Function:** The Heater Assembly takes process air flow from the Heat Exchanger and heats it to a control set point on 425° F to regenerate canisters within the oven. It consists of a 750 watt, 120 VDC cal rod heating element which is wound in a circular coil pattern to minimize pressure drop while maintaining a high convective heat transfer. It is mounted within a stainless steel housing and insulated with high temperature insulation along the inlet/outlet ducts and external housing surfaces. The heater ORU also consists of a single element platinum probe RTD (T3) which is used for air outlet temperature control, and a dual element platinum probe RTD (T1 and T2) for over/under temperature fault detection. The air outlet temperature is limited to  $425 \pm 5^{\circ}\text{F}$  by controlling the heating element duty cycle by pulse width modulation of the heater drive circuitry which resides within the metox controller.

**Performance:**

<b>Voltage:</b>	120 VDC
<b>Power:</b>	750 Watts max
<b>Weight:</b>	shall not exceed 3.0 pounds
<b>Envelope:</b>	6.38 in. high x 2.5 in. wide x 11.9 in. deep
<b>Interfaces:</b>	1.44 in. dia. air inlet/outlet ducts NATC type electrical connectors
<b>Operating Pressure:</b>	(Inlet) 10 to 15.2 psia
<b>Pressure Drop:</b>	shall not exceed 0.5 inches H <sub>2</sub> O at a flow of 15 scfm shall not exceed 0.9 inches H <sub>2</sub> O at a flow of 20 scfm
<b>Leakage:</b>	External leakage shall be less than 0.01 lb/min with an internal pressure of 10 inches H <sub>2</sub> O
<b>Operating Media:</b>	Air

**A.3.9 Temperature Sensor ORU, Item 170****Part number SV821678-1**

**Description / Function:** Hot air exiting each canister (Item 200) outlet port is rejoined within the Temperature Sensor ORU, and is then flowed to the regenerative heat exchanger. This ORU is

mounted on the oven outlet manifold and consists of two dual element platinum prone RTDs (T4/T5 and T6/T7), item 171, one for each canister or oven berth position, and is used to confirm canister regeneration and for fault detection. The temperature sensor ORU is covered with insulation to minimize heat loss within the system. The process air flow exits the regenerative heat exchanger and is returned to the THC air return interface.

**Performance:**

<b>Voltage:</b>	N/A
<b>Power:</b>	Max Current 1 ma DC
<b>Weight:</b>	N/A
<b>Envelope:</b>	1.5 in. high x 7.25 in. wide x 3.25 in. deep
<b>Interfaces:</b>	NATC type electrical connectors
<b>Mounting Interface:</b>	Captive Fasteners (4), 0.120 in. dia. shank
<b>Operating Pressure:</b>	10 to 15.2 psia
<b>Air Flow Rate:</b>	20 to 100 lb/hr
<b>Operating Media:</b>	Air

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**SAFER**

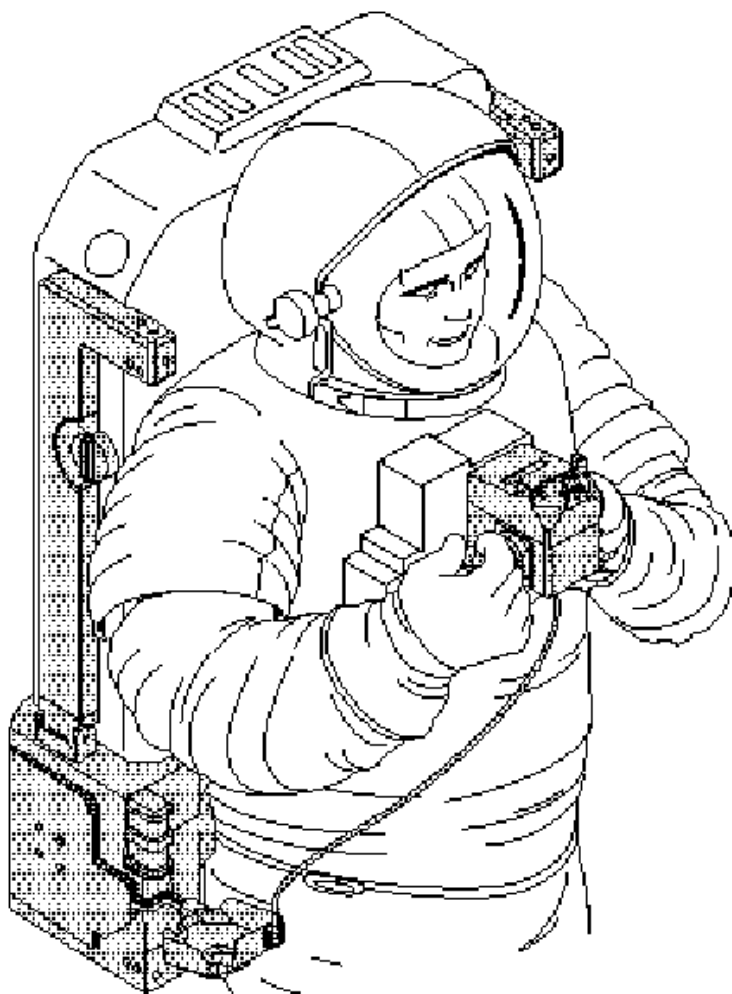
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## B.1 SAFER SYSTEM DESCRIPTION

The Simplified Aid for EVA Rescue (SAFER) is Government Furnished Equipment (GFE) provided by NASA for use on the Extravehicular Mobility Unit (EMU). The technical descriptions in this Appendix are referenced from:

Space Shuttle Analysis Report  
USA SAFER Baseline Reliability Analysis  
SSMA-99-012, June 30, 1999

The Simplified Aid for EVA Rescue (SAFER) Flight Article is a small, self-contained, 24 jet free-flyer that provides adequate propellant and control capability to allow an EVA crewmember, who is separated from the Space Shuttle Orbiter or International Space Station, to perform a self-rescue and maneuver back to the vehicle (Figure B.1). The SAFER fits around the Extravehicular Mobility Unit (EMU) Primary Life Support Subsystem (PLSS) without limiting suit mobility. Control is provided in 6 degrees-of-freedom through crewmember inputs from a single Hand Controller Module (HCM). The HCM is stowed in a small cavity on the right side of the SAFER propulsion module when not in use and deployed when needed. To deploy the HCM, the crewmember pulls up on the deployment handle mounted on the front, right side of the propulsion module. By pulling up on this handle, a spring-loaded tray starts swinging out of the side of the propulsion module. This tray (which holds the HCM) swings to the front right corner of the propulsion module. The crewmember grabs the HCM from the tray, holds the HCM in his left hand, turns on the power switch which fires a pyrotechnic device and pressurizes the propulsion system. The SAFER contains an auto-stabilization feature that can be activated to neutralize any rotations the CM may be experiencing as a result of separation from the vehicle. The HCM can then be used to orchestrate the self-rescue. Velcro on the back of the HCM allows the crewmember to attach the HCM to the EMU Display and Controls Module (DCM) while reaching for and tethering



**FIGURE B. 1**

**SAFER FLIGHT ARTICLE  
ATTACHED TO THE EMU**

to a structure. A minimum total delta velocity of 10-ft/sec-nitrogen charge is provided during ground processing. The SAFER flight unit folds for storage in the Orbiter during launch and landing and when not in use on-orbit. The SAFER flight unit consists of four hardware modules: Propulsion, Hand Controller, Intravehicular Activity (IVA) replaceable Battery Pack (Figure B.2), and Hand Controller Module Hardmount.

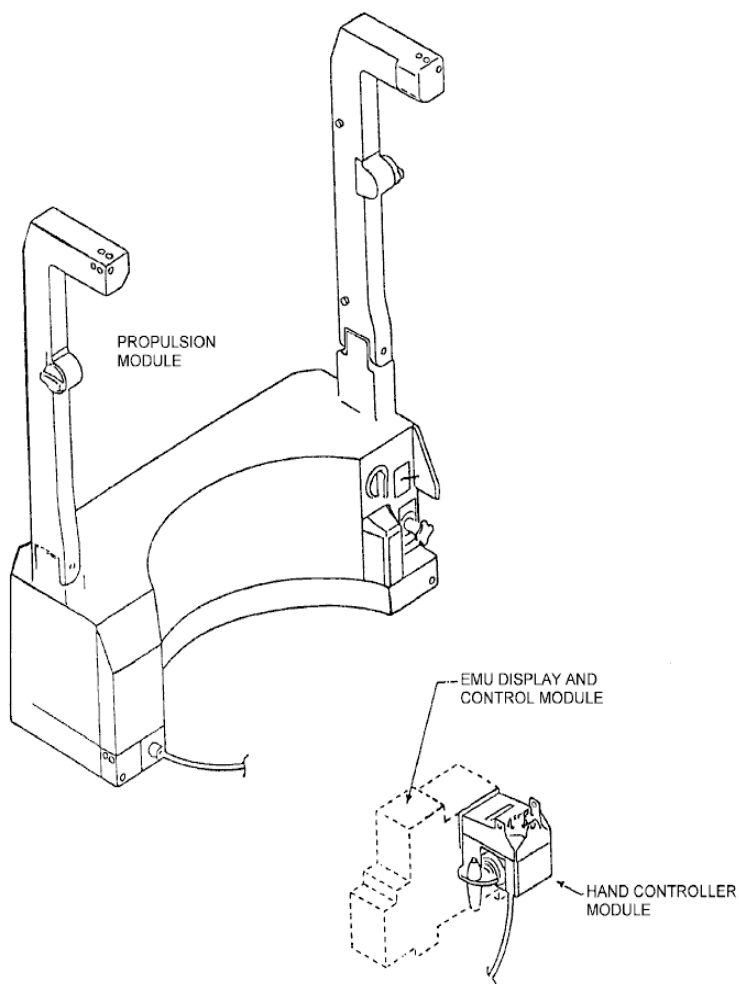
## **B.2 PROPULSION MODULE**

The propulsion module is the bulk of the SAFER Flight Article. It consists of three subsystems: Propulsion, Structures/Mechanisms, and Avionics. Figure B.3 shows the propulsion subsystem schematically.

The propulsion subsystem operates with gaseous nitrogen ( $\text{GN}_2$ ) as its propellant, which is supplied by a cylindrical pressure vessel (or tank). The  $\text{GN}_2$  tank has a maximum design pressure of 10,000 psig at 200°F and a factor of safety on burst of two. Each pressure vessel has a limited life of 100 cycles to the maximum design pressure. The nominal ground load is approximately 8,000 psig at 80°F. The propulsion system can operate at up to 10,000 psig and is regulated down to 215 +25/-15 psig for the thruster manifolds. A pressure transducer is provided for monitoring tank pressure with a range of 0 to 10,000 psig. A temperature sensor is provided on the tank outlet flange to determine the temperature of the  $\text{GN}_2$  supply and used as data input for the avionics subsystem.

The pressure regulator is a direct acting design set to 215 psig nominal. The regulator is sized to support flow to four thrusters down to approximately 1,000-psig inlet pressure.

The relief valve protects the low-pressure system against a failed-open or leaking regulator. The relief valve is sized to prevent the downstream pressure from exceeding 400 psig. The batteries provide capacity for the avionics subsystem



Note: This figure shows the DTO SAFER. USA SAFER is similar. IVA battery pack is not shown.

**FIGURE B.2**

**MAJOR SAFER FLIGHT  
ARTICLE PARTS**

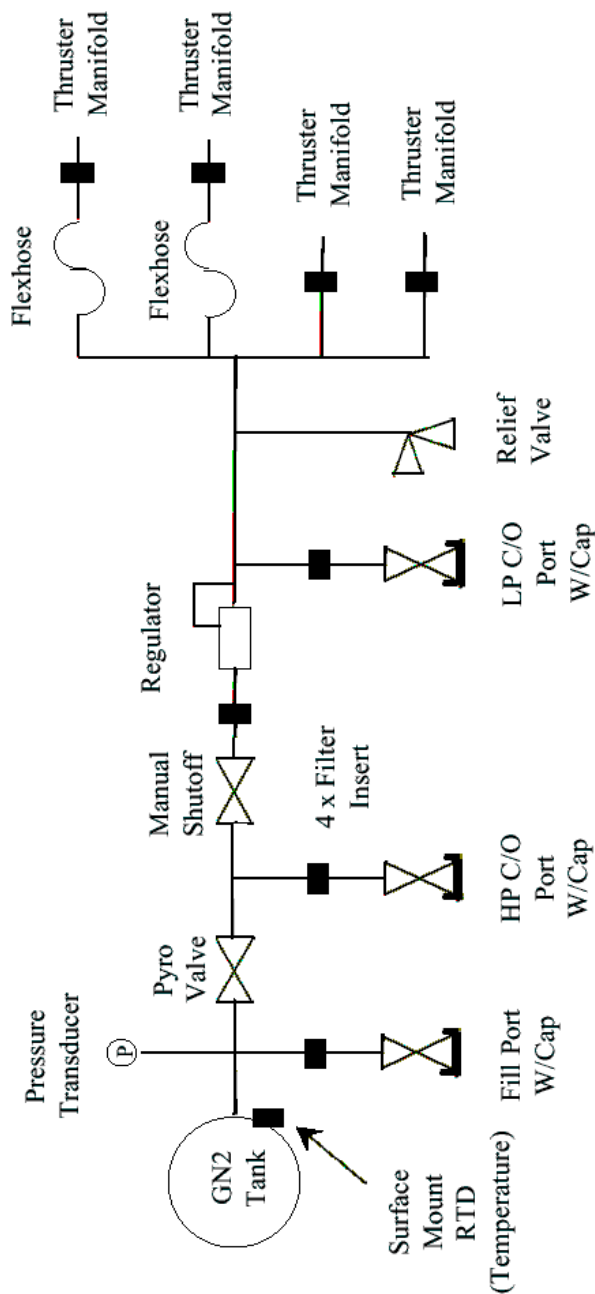


FIGURE B.3

### SAFER PROPULSION SUBSYSTEM SCHEMATIC

Two high pressure and one low pressure fill/test ports are provided to recharge the propellant pressure vessel and to perform regulator/relief valve checkout during ground servicing. Pressure caps are used to seal each port. These caps are tethered to prevent loss when removed during ground operations, vented to assure that no pressure remains behind them while being removed, and are torqued/lockwired prior to flight. The caps are removed and installed during ground operations only.

The pyrotechnic isolation valve provides long-term leak-free storage of the GN2 supply. The valve is rated for 10,000 psig with a minimum burst rating of 20,000 psig. The initiator is the NASA Standard Initiator (NSI) already certified and widely used on the Space Shuttle.

The manual isolation valve is a hand-operated, manual unit used to separate the low-pressure system from the high-pressure system, allowing supply pressure isolation. Flow through the valve is in either direction. The valve has a burst pressure of 52,000 psig.

The thruster cluster (or thruster integral module) contains six identical thrusters located at four corners of the SAFER Flight Article unit. Each thruster cluster contains an electrically operated solenoid valve for each of the six thrusters, and an electrical connector that accommodates the wires from the valves. Four clusters (twenty-four fixed-position thrusters) are located about the crewmember/EMU and SAFER Flight Article center of mass. Based on hand controller and rate sensor inputs, electrical power to the thruster solenoid valves results in expansion of the GN2 through the thruster nozzle to produce propulsion. Each thruster provides a nominal vacuum thrust of  $0.8 \pm 0.08$  lbf.

The high pressure lines and fittings of the propulsion system are made of Inconel 718 and are rated at 10,000 psig, proof tested to 15,000 psig, and have a burst pressure greater than 40,000 psig (expected ~53,000 psig). The

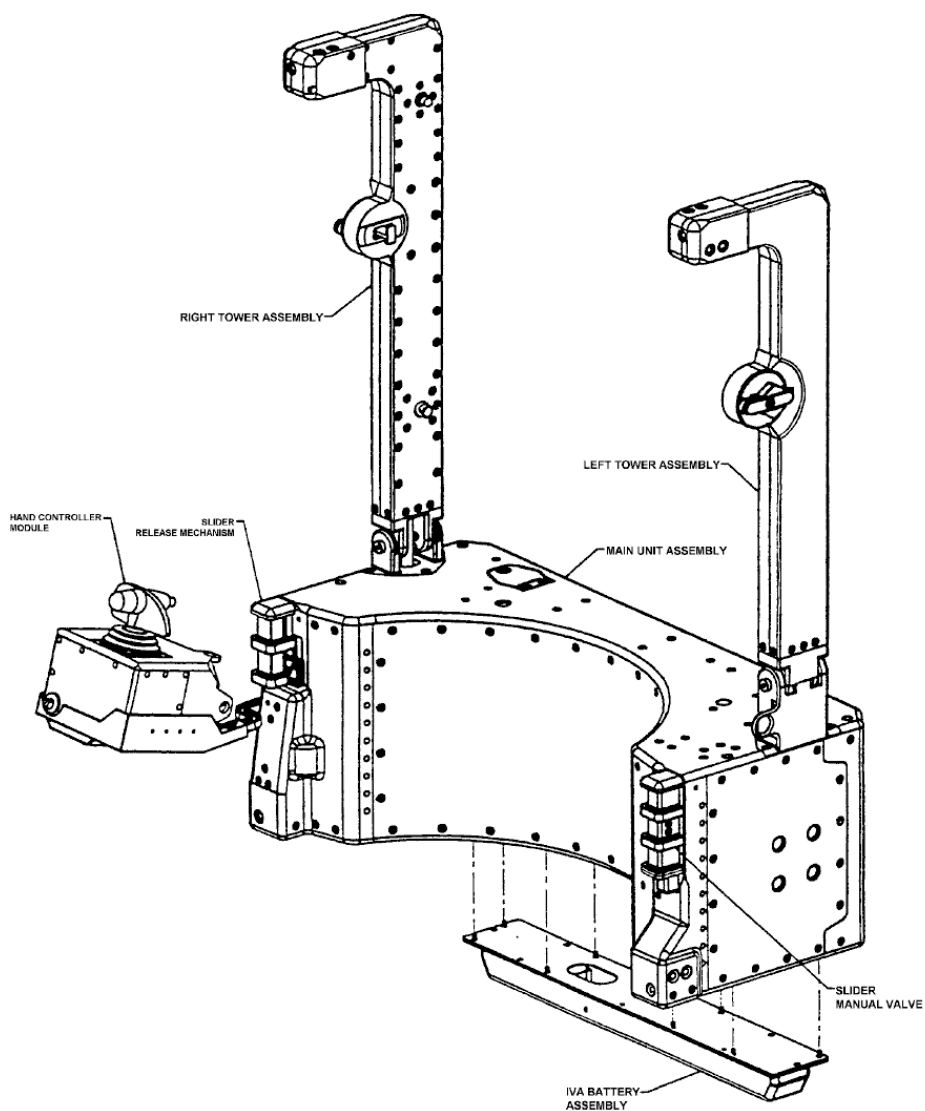
low pressure lines and fittings are made of 304L and 306L stainless steel, respectively.

The flex hoses are located in the tower assemblies at the hinge joints. The hoses are convoluted Teflon flex hoses with a NOMEX braid, which allows the tower assemblies to be folded to reduce the SAFER Flight Article stowage volume. These flex hoses have a minimum burst pressure rating of 1,600 psig.

The SAFER Flight Article recharge interfaces include an inlet filter with a 25 micron absolute rating and a 10,000 psig collapse rating. The SAFER Flight Article provides a high pressure line filter with a minimum of 25 micron absolute rating installed at the manual valve inlet to prevent any possible pyro valve debris from contaminating the GN2 going to the regulator. The -303 SAFER configuration units include an additional 25 micron high pressure line filter installed at the manual isolation valve outlet to prevent any possible manual isolation valve debris from lodging in the regulator. The SAFER Flight Article provides four filters located at each thruster cluster just upstream of the thruster manifold. The filters have a 10 micron absolute rating and use KC fittings. The operating pressure is 0 to 3,000 psig.

The propulsion module structures and mechanisms (Figure B.4) are used to attach the SAFER to the EMU Primary Life Support Subsystem (PLSS) interface points, which already exist for MMU and AAP attachment. Four guide pins are employed to aid on-orbit installation by the EVA crewman. The tower assemblies house lines and fittings, filters, valve cable assemblies, EMU PLSS attachment latches, and thrusters.

Two independent, manually operated EVA latches are provided in order to secure the SAFER to the EMU PLSS. The SAFER is locked into place by rotating each latch until the latch ratchets internally. A mechanical lock is then engaged to ensure that the latch mechanism does not loosen or disengage.



**FIGURE B.4 SAFER TOP ASSEMBLY LAYOUT**

The tower hinges allow the SAFER tower assemblies to rotate to a folded position for minimum stowage volume. The hinge joints allow routing of GN<sub>2</sub>, electrical power, and signal to the thrusters.

The HCM is stowed in the HCM stowage compartment and mounted on a deployment device (or arm/tray). The HCM stowage compartment is located in the right hand end of the propulsion module. When self-rescue is needed, the crewmember pulls up on an actuation lever mounted on the right forward face of the propulsion module. When the actuation lever is lifted, the spring-loaded deployment arm/tray (which holds the HCM) is released to swing out and forward. As the deployment arm/tray swings out, it pushes the HCM stowage compartment door (spring-loaded closed) open and out of the way. Once the deployment arm/tray is deployed, the door returns to the closed position.

The Power Supply Assembly receives power from the SAFER battery assembly and provides the regulated voltage required by the Control Electronics Assembly (CEA), Valve Driver Assembly (VDA), HCM, and Inertial Reference Unit (IRU). The Inertial Reference Unit provides roll, pitch, and yaw angular rate sensor measurement data for the CEA.

The Valve Driver Assembly accepts thruster firing commands from the Control Electronics Assembly and applies appropriate drive signals to selected thrusters. The VDA provides for the control of all 24 thrusters. The VDA uses a 24 volt direct current (VDC) output generated by the Power Supply Assembly to drive selected thruster valves open. After 5 milliseconds, the signal is pulse-width-modulated (PWM) at 5 KHz and 25% duty cycles to sustain valve opening. The VDA also uses the same 24 VDC output from the PSA to fire the NSI during SAFER power up. Finally, the VDA has the capability to sense current flow through all thruster solenoids and provide a signal to the CEA indicating thruster activity.

The Control Electronics Assembly provides capability to process crewmember commands from the hand controller module through a serial bus, inputs from the IRU, and actuates the propulsion system accordingly. Eleven (11) discrete inputs, 23 discrete outputs, 2 analog to digital (A/D) channels, and 5 serial interfaces are provided. The control software is embedded in the CEA's 64 kilobyte Electrically Erasable Programmable Read Only Memory (EEPROM). The CEA also provides a total of 66 kilobytes of static Random Access Memory (RAM).

The NSI Inhibit Jumper Plug provides the ability to inhibit NSI firing when the power switch is placed in the ON or TEST positions. Under emergency conditions, when the power switch is placed in the On position, the NSI would fire and release the GN<sub>2</sub> supply for self-rescue. The NSI firing must be inhibited prior to IVA checkout so that the power switch may be placed in the test position and a checkout can be performed. In order to inhibit the NSI firing, a 19 pin avionics GSE connector is inserted into a receptacle on the top of the propulsion module. Selected pins on the 19 pin connector are used to create a low resistance path (short) which prevents current from passing through the NSI circuit. Other pins on this connector are used to activate circuitry on the VDA that provide a low current signal through the NSI to perform a NSI continuity check during SAFER IVA checkout. The placement of the NSI inhibit plug receptacle on the top plate of the propulsion module creates an interference when SAFER is being attached to the EMU PLSS and prevents going EVA with the NSI inhibit jumper plug installed.

### **B.3 HAND CONTROLLER MODULE**

The Hand Controller Module (HCM) provides the necessary controls and displays for the SAFER crewmember. The HCM is readily attached and detached by Velcro to the front of the EMU DCM and provides a

minimum profile so as not to interfere with the CM's overall view or access to the EMU DCM controls and displays. The Velcro is used as a semi-rigid mount and is not meant to fully support the HCM. The HCM also has a thumb loop and a deployable finger bar for those crewmembers that don't want to use the Velcro attachment. In either case, the crewmember would use a two-hand technique to hold the HCM and manipulate the controls. The HCM consists of two distinct units mounted together.

The Hand Controller Unit (HCU) consists of the functions associated with grip displacements and the Automatic Attitude Hold (AAH) push-button switch. The grip is compatible with an EVA crewmember glove and is based upon the proven Manned Maneuvering Unit (MMU) Rotational Hand Controller design with an integral push-button switch. The grip is mounted for right hand operation. The HCU is a four axis device; three rotary axes and one transverse axis.

The Displays and Control Unit (DCU) is integrated with the EMU DCM. All displays are positioned on the HCM to allow the SAFER pilot to view/read each display from any head position inside the EMU helmet when the HCM is properly attached to the EMU DCM. The displays are visible under all light and dark orbit conditions.

The DCU displays include the following:

- a) A Light Emitting Diode (LED) shines whenever an electrical current flow is sensed through any one of the SAFER thrusters (Thruster Light).
- b) An LED shines whenever AAH is enabled for one or more SAFER rotational axes (AAH Light).
- c) A 16-character back-lit Liquid Crystal Display (LCD) displays SAFER instructions

and status information to the SAFER crewmember (Alphanumeric display).

The Power Switch is a three-position toggle switch that controls the SAFER power and test functions. The toggle switch is oriented towards the pilot for ON/TEST, center position for power ON, and away for power OFF.

The Display Mode Switch is a three-position, momentary toggle switch, which controls the LCD display. The toggle switch remains in the center position when not being used and is oriented so that positioning the switch towards or away from the pilot controls the LCD menu selection.

The Control Mode Select Switch is a two-position toggle switch, which directs hand controller commands for either a rotation or a translation control mode with pitch rotation and "X" translation available at all times. The toggle switch is positioned to the pilot's left for the Rotation Mode and to the pilot's right for the Translation Mode.

An electrical umbilical consisting of a cable and connector electrically interfaces the HCM to the SAFER Flight Article. This interface consists of power and a serial data bus for data/command transmissions. The umbilical contains strain relief for loads up to 125 lbs. and is removable at the Propulsion Module interface. The umbilical is S-folded and stowed in a soft loop on the HCM to prevent entanglement during HCM deployment.

## **B.4 BATTERY PACK**

The battery pack is made up of 42 lithium manganese dioxide cells and is replaceable during ground servicing and on-orbit IVA. The battery pack is attached to the bottom plate of the propulsion module with eight captive bolts.

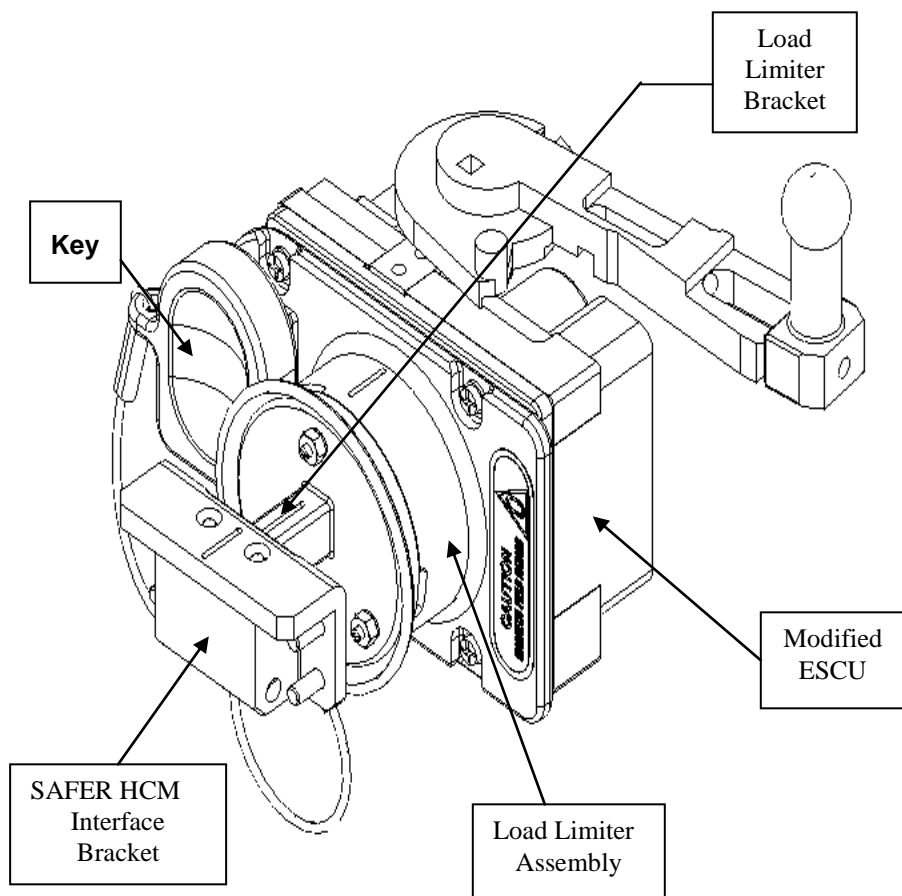
The batteries provide capacity for the avionics subsystem to perform 52 one-minute on-orbit IVA checkouts and one EVA self-rescue of 13 minutes minimum duration, with a voltage range of 19 to 42 volts. The batteries also provide capacity to pull-in four thruster valves simultaneously 210 times followed by simultaneously holding open 4 thruster valves for at least 2 minutes.

The battery capacity gauge Integrated Circuit (IC) calculates battery voltage, temperature, and % battery capacity remaining. It is only active when power is supplied to the SAFER avionics. All calculated values are displayed to the SAFER pilot via the LCD.

## **B.5 SAFER HAND CONTROLLER MODULE HARDMOUNT (SHCMH)**

The Simplified Aid For Emergency Rescue (SAFER) Hand Controller Module Hardmount (SHCMH) has been developed by the contractor to work with the SAFER GFE. It is a rigid mount that attaches the SAFER Hand Controller Module (HCM) to the EMU via the DCM Common Multiple Connector (CMC). The SAFER Hand Controller Module Hardmount allows one-handed operation of the SAFER HCM while performing Tile Repair Activities.

The SHCMH consists of five major components: A modified ESCU Multiple Connector, Load Limiter Assembly, Load Limiter Bracket, Key and Interface Bracket (Figure B.5).



**FIGURE B.5**

**SAFER Hand Controller Module  
Hardmount (SHCMH)**

The modified ESCU Multiple Connector uses the existing ESCU design modified to remove the O2 poppet pin, add the electrical connector housing to facilitate mating, change the handle and incorporate minor changes to the lead-in chamfer of the cam. It is also modified to accept the Load Limiter Assembly.

The Load Limiter Assembly has a conical shaped housing that guides the Load Limiter Bracket onto a magnet. The flange of the housing contains Velcro to hold the Key in position.

The Load Limiter Bracket contains 2 spring-loaded pins at one end that interface with the Interface Bracket. The opposite end is the disk that mates with the magnet.

The Key is used to remove the Load Limiter Bracket from the Interface Bracket. Two pins fit into the holes in the Interface Bracket and press the spring-loaded pins.

The Interface Bracket is the interface between the SHCM and the SHCMH. It is installed onto the SHCM by four screws. Two holes at the top accept the spring-loaded pins from the Load Limiter Bracket.

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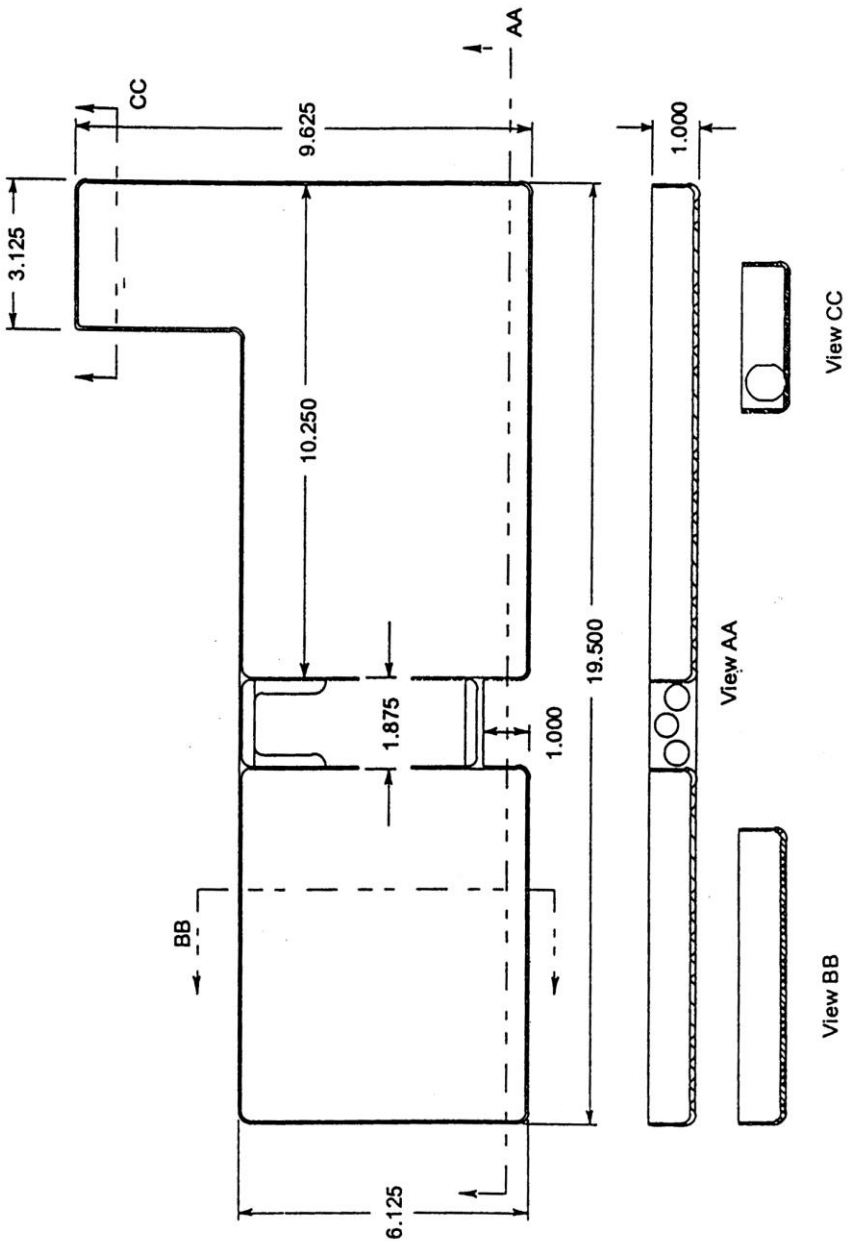
## **C.1 RECHARGEABLE EVA BATTERY ASSEMBLY (REBA)**

The Rechargeable EVA Battery Assembly (REBA) is Government Furnished Equipment (GFE) provided by NASA for the Extravehicular Mobility Unit (EMU).

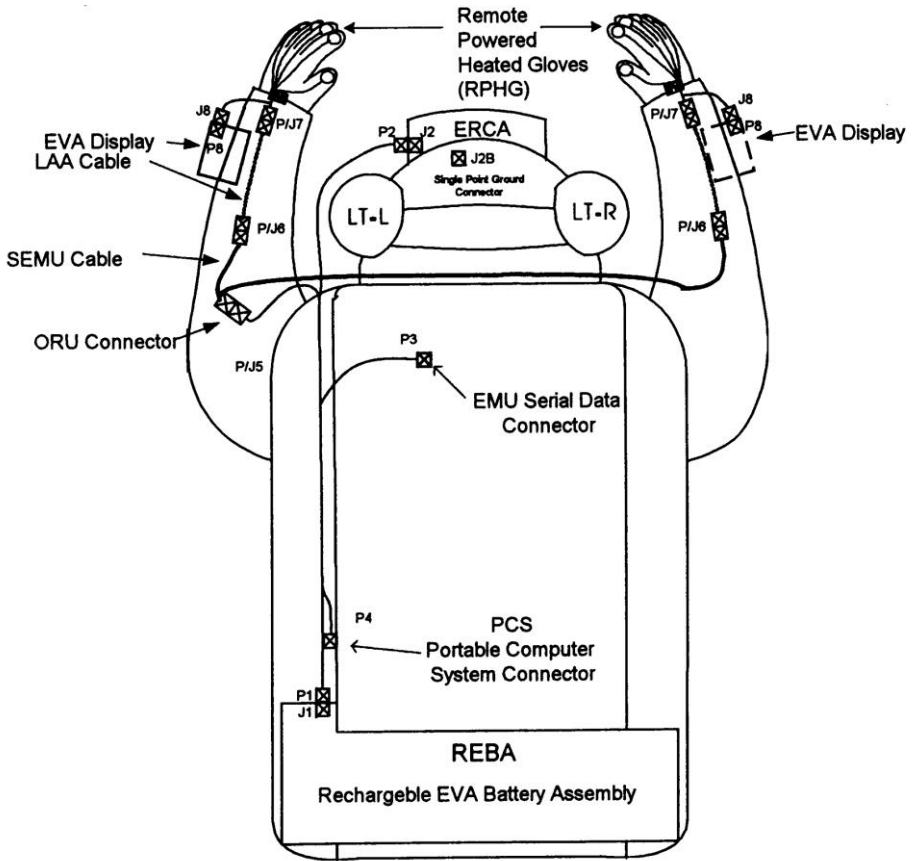
The REBA is a supplemental  $12.5 \pm 1.5$  Volts DC battery assembly to power the glove heaters, the EMU RF Camera Assembly (ERCA). The REBA contains a spare connector at P8 for a future item such as a wrist mounted display. The REBA is integrated with the EMU Primary Life Support Subsystem (PLSS) and powers these electronic devices via the EMU power harness (Figures C.1 and C.2).

## **C.2 REBA CONFIGURATIONS**

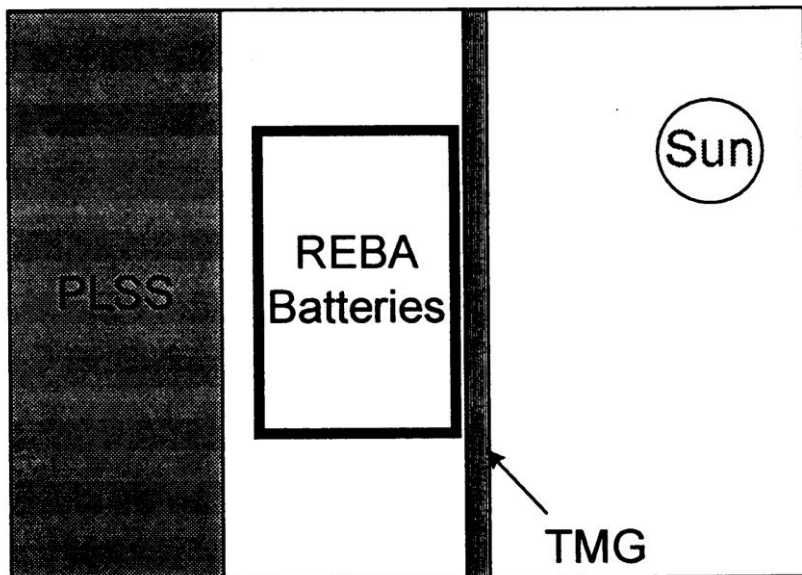
For the ISS, the ORU configuration will mount the REBA package between the PLSS and the TMG with no MLI in-between the batteries and the PLSS. This will allow approximately 10.2 BTU/hour to be dissipated to the PLSS during the discharge cycle (Figure C.4).



**FIGURE C.1 REBA HOUSING, VIEWED FROM PLSS INTERFACE**



**FIGURE C.2**      **EMU POWER HARNESS**  
**ASSEMBLY**



**FIGURE C.4 ORU REBA CONFIGURATION**

### C.3 REBA SPECIFICATIONS

REBA consists of 5 strings of 10 small rechargeable nickel-metal hydride (NiMH) batteries (50 batteries total). Each string is separately wrapped in felt and then packed in a shallow aluminum tray. The combined weight of the REBA components does not exceed 12 pounds.

The REBA provides 2.5 A continuously and a 5 A peak for 5 seconds. It provides continuous power for at least 7 hours.

A single-hand operable on/off power switch is provided for the assisting crewmember during IVA or EVA. This switch is operable by IV when the EMU is attached to the Airlock Adapter Plate (AAP) or the EMU Don/Doff Assembly (EDDA).

The REBA is attached to the PLSS of the EMU. It is capable of being attached/removed from the PLSS during IVA without removing any other EMU component.

Charging can be accomplished while attached to the PLSS (either on or off an AAP or EDDA) and while detached from the PLSS on the Shuttle or ISS. Charging is done in a pressurized environment. On the Shuttle, the REBA is charged using a dedicated REBA Battery Charger. On the ISS, the REBA is charged using the Battery Charging Assembly (BCA) via the REBA BSA Cable. Charging on either vehicle is completed within 8 hours.

The operational life of the REBA is a minimum of 200 charge/discharge cycles. The shelf/storage life is 5 years with planned maintenance.

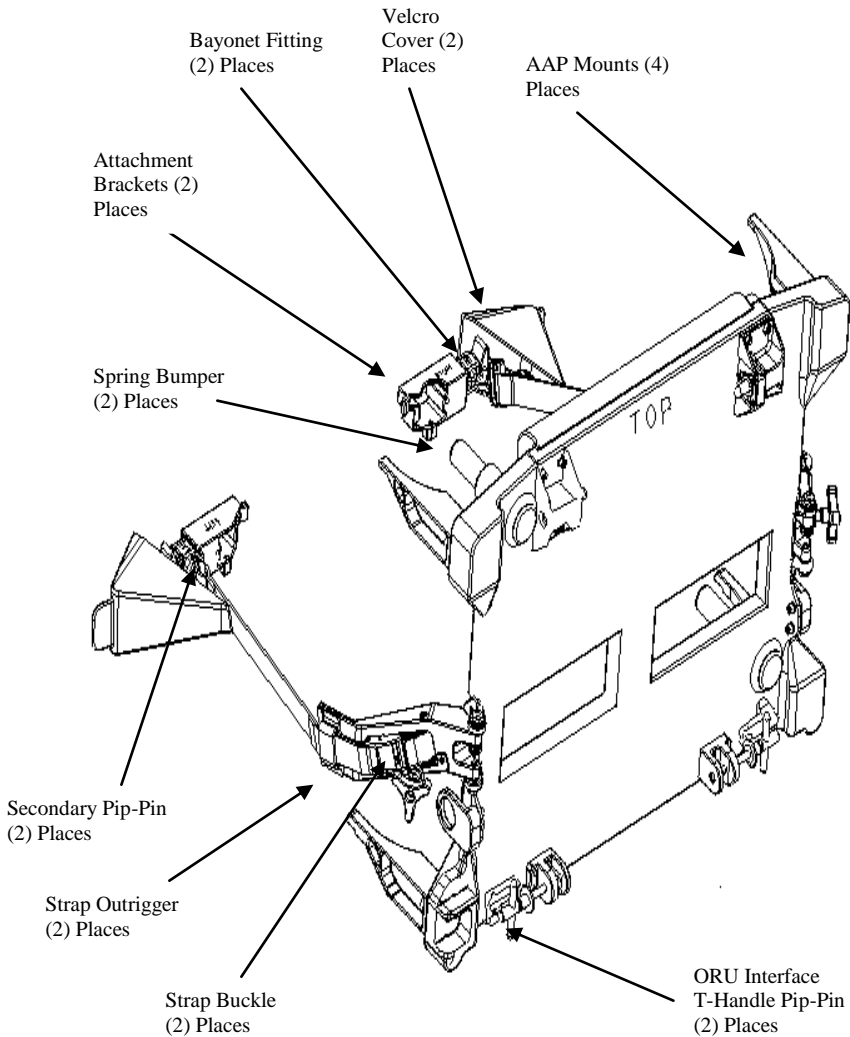
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**TRBF**

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**D.1 GENERAL DESCRIPTION**

The Tile Repair Backpack Frame (TRBF) and Attachment System when integrated to the Extravehicular Mobility Unit (EMU) and Cure in Place Ablator Applicator (CIPAA), is considered an emergency system. This unique EVA item is designed to hold the CIPAA on the back of the EMU for tile repair tasks.

The TRBF consists of a hard-coated aluminum frame with brackets that mount to the PLSS Water Tank Structure at the AAP mounts. The frame is attached to the EMU through straps that reside on the frame Strap Adjuster Brackets. These straps attached to the BSC by use of a bayonet and ring bracket setup. Securing the assembly is accomplished by cinching the frame straps and adjusting the system tension using the Secondary Strap Adjusters.



**Figure D.1 Tile Repair Backpack Frame (TRBF)**

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**E.1 VENT LOOP TEST MANIFOLD (VLTm), Item-811**

**Description / Function:** The Vent Loop Test Manifold (VLTm) is used to isolate the Life Support Subsystem (LSS) from the Space Suit Assembly (SSA) to perform a pressure decay leakage test. The VLTm can also be used to minimize the oxygen used during Airlock Cooling Loop Recovery (ALCLR) operations. The VLTm is used in conjunction with the SOP Check-Out Fixture (SCOF). A schematic of the VLTm mated to the EMU is shown in Figure E.1. Figure E.2 shows the VLTm out of its packaging. The Item frame/manifold provides a fluid connection between the T11 port on the Hard Upper Torso (HUT) and the Contaminant Control Cartridge (CCC) vent loop elbows on the Primary Life Support System (PLSS).

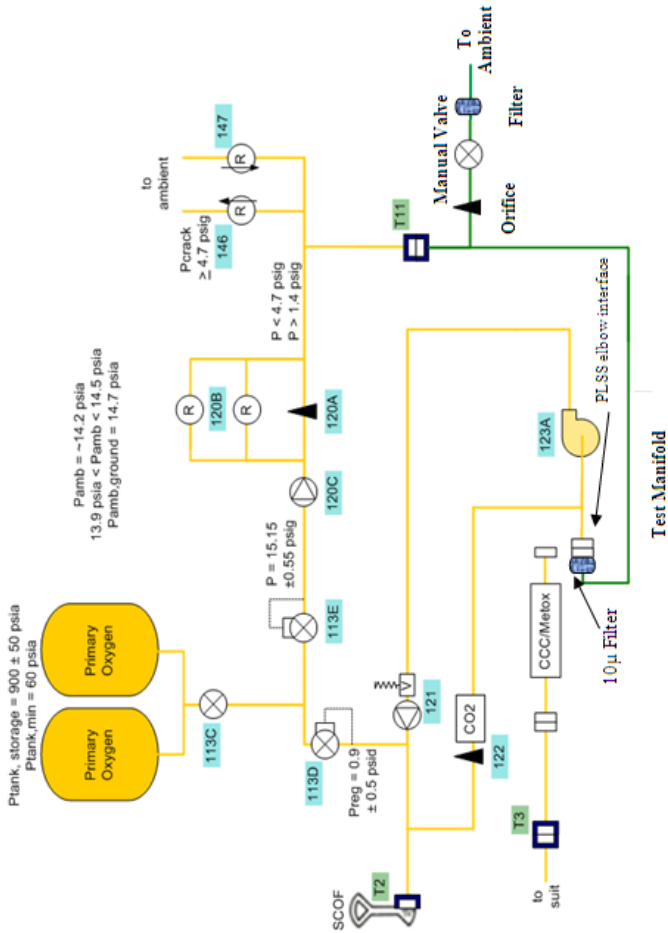
The Item contains a manual shut-off/bleed valve to bleed the system post use. An orifice is used to maintain suit pressure during ALCLR use.

**Performance:****External Leakage:**

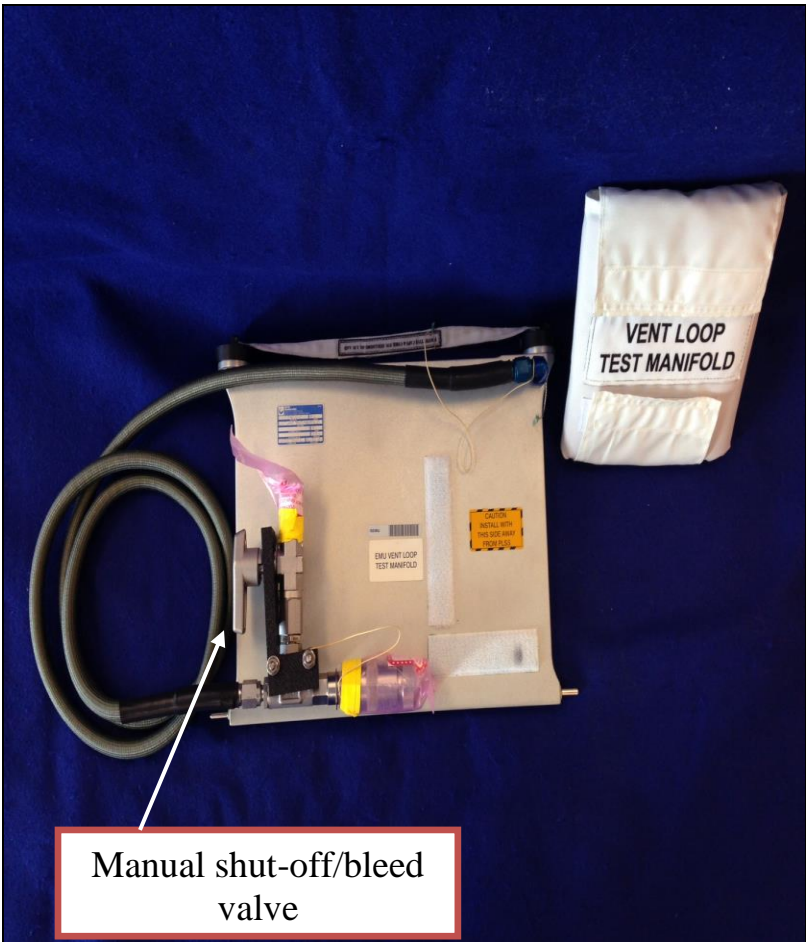
The item has an external leakage less than 1.0 sccm of oxygen at 5.0 +/- 0.1 psig at the Item after all connections are properly made.

**O<sub>2</sub> Saving Performance:**

The item maintains the vent loop pressure between 1.8 psig and 4.2 psig while flowing 163 to 254 sccm of oxygen through the outlet at temperatures between 60°F and 90°F with an ambient pressure of  $14.2 \pm 0.3$  psia.



**FIGURE E.1 – SCHEMATIC OF VLTM MATED TO EMU**



**FIGURE E.2 – VLTM OUT OF PACKAGING**

## E.2 TRANSPORT WATER FLOW METER (TWFM), Item-813

**Description / Function:** The Transport Water Flow Meter (TWFM), shown in Figure E.3, measures the water flow in the EMU transport water loop. The meter is installed in place of the Liquid Cooling and Ventilation Garment (LCVG) in the transport water loop circuit. The Item is engaged and disengaged while the PLSS is unpressurized similar to the LCVG on-orbit. Flow measurement verifies proper transport water flow.

The TWFM takes the pressure, temperature and pressure drop across the laminar flow plates to calculate the water flow. The temperature affects the viscosity of water across the laminar flow plates so this variation is part of the flow meter calculation for flow. The default display of the TWFM upon power up is depicted in Figure E.4.

### **Performance:**

#### **Operating Performance:**

The flow meter can read from 60 to 240 PPH +/- 10 PPH at temperature from 50-100 °F.

The flow meter temperature sensor needs to be stable (18 to 21 minutes) for an accurate flow reading.

#### **External Leakage:**

The item has an external leakage less than 1.0 sccm of oxygen at 5.0 +/- 0.1 psig after all connections are properly made.

#### **Power Supply:**

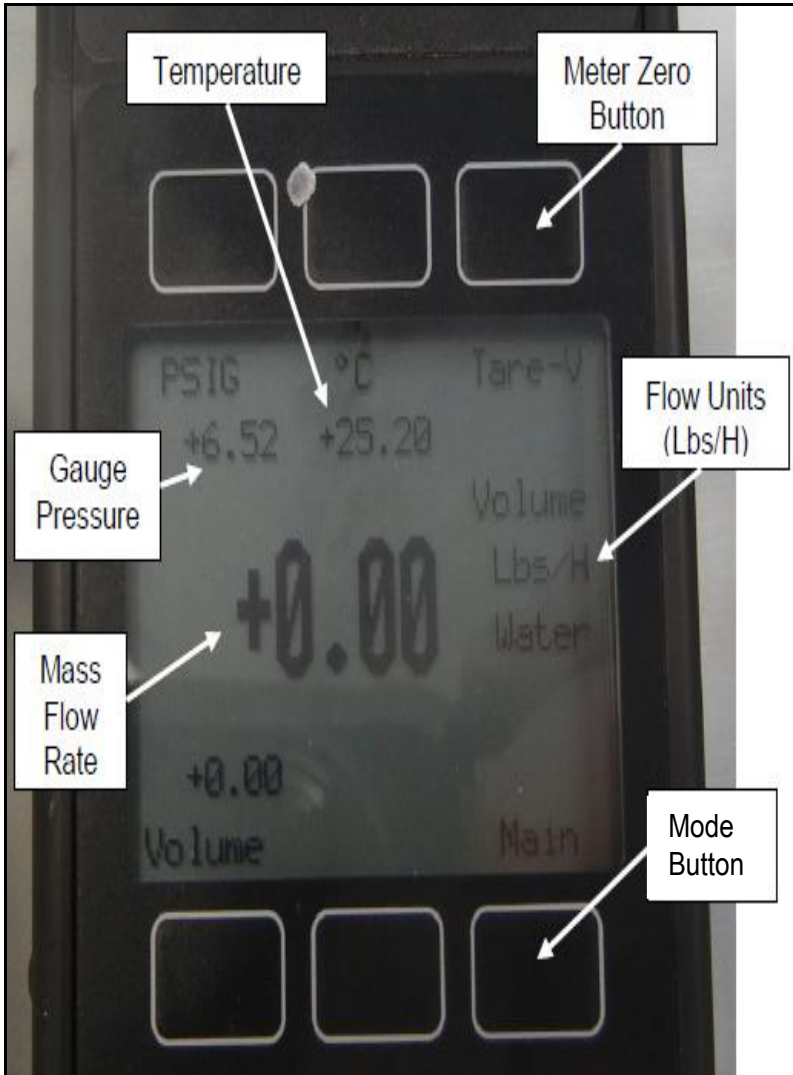
Item is powered by a standard 9 Volt battery.

#### **Cycle Life:**

Item has a cycle life of 300 mate/de-mate cycles.



**FIGURE E.3 – TRANSPORT WATER FLOWMETER**



**FIGURE E.4 – TWFM DISPLAY UPON POWER-UP**

### E.3 ELECTRICAL-DIAGNOSTIC AND CONVERTER HARNESS, Item-810

**Description / Function:** The Electrical-Diagnostic and Converter Harness interfaces with the EMU and provides capability to download EMU hardware performance data or upload Enhanced Caution and Warning System (ECWS) software. The converter allows two way communications between Universal Serial Bus (USB) laptop and the RS-485 ECWS. The converter contains an optically isolated device that protects against voltage spikes and grounding. A commercial software driver is provided to allow communication between the Converter and a laptop. A Government furnished USB cable connects the Converter Box to an ISS laptop. The laptop can read EMU data or load ECWS software as needed.

A picture and illustration of the Electrical-Diagnostic and Converter Harness are shown in Figures E.5 and E.6.

**Performance:**

**Data Transfer Accuracy:**

Item-810 will echo data with 95% accuracy, while configured with a laptop, in loop-back mode for a minimum of two minutes

**Cycle Life:**

The item has a cycle life of at least 208 mate/de-mate cycles for P40 Boot and Test Connectors.



**FIGURE E.5 – ELECTRICAL-DIAGNOSTIC AND  
CONVERTER HARNESS**



**FIGURE E.6 – ELECTRICAL-DIAGNOSTIC AND  
CONVERTER HARNESS CONNECTED TO LAPTOP**

## E.4 WATER INDICATING TEST STRIPS (WITS), Item-812

**Description / Function:** The Water Indicating Test Strips (WITS) are used periodically to check for water leakage around the exposed edges of the sublimator flange, Item 140. This activity supports the on-orbit servicing intended to assure EMU availability for use for a 6 year maintenance interval. The WITS consists of a set of seven laminated, multilayer paper strips of various shapes that allow a crewmember to wipe the sublimator. If the strip encounters liquid water, the strip edge changes color from white to red. Figure E.7 depicts an example of liquid water indication. Figure E.8 depicts the WITs shapes.

The strips are sensitive to humidity and are stored in bags made from MIL-PRF-131 material. The storage material's moisture permeation rate is very low. In addition, the packaged I-812 is capable of readout after exposure to 90% relative humidity at 68°F within the Item's defined useful life.

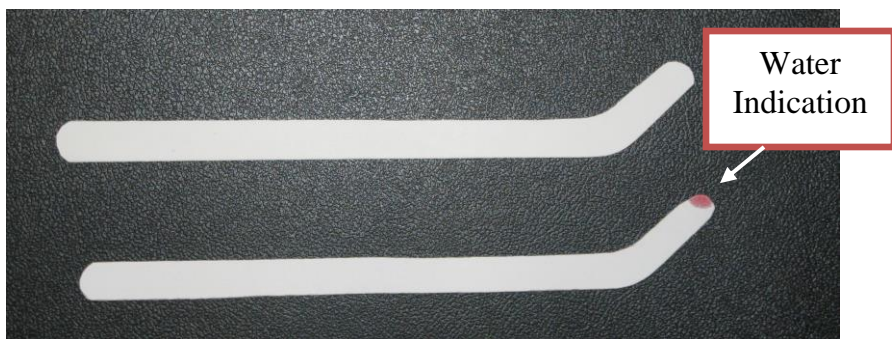
**Performance:**

**Start of Indication:**

Within 5 seconds of contact with liquid water, strip will begin to change color from white to red.

**Readout:**

Within 5 minutes of contacting liquid water, the strip will develop a reddish color along the wetted edge.



**FIGURE E.7 – WITS LIQUID WATER CONTACT INDICATION**



**FIGURE E.8 – WITS SHAPES**

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## F.1 SEMU LAUNCH ENCLOSURE

The Short EMU Launch Enclosure (SLE) is a 6-sided aluminum container used to safely launch and land the SEMU in a soft stowage configuration. It provides for safe ground handling, transportation, and stowage of the SEMU and is designed to provide sharing of the launch loads between the PLSS Shear Plate and Water Tank Structure. Load sharing was accomplished by redesigning the PLSS Upper Support Adapters to tighten tolerances, thereby providing a near-zero clearance fit with the Launch Enclosure upper mounting pins. A second method of tightening up this interface was devised for SEMUs that were already aboard ISS, providing custom tolerance upper pins for the Launch Enclosure and keeping the stock Upper Support Adapters on the PLSS. While not as effective at providing a tight fitting interface, risk of damage to the SEMUs was low enough to utilize this approach for in-flight SEMUs. The tight fit of the pins with the Upper Support Adapters combined with the “tuning fork” design of the enclosure upper mount assures that the upper mounts take approximately 30% of the load and that the SEMU lower mounts are load limited. A partially “exploded” view of the SEMU Launch Enclosure (with the SEMU) is portrayed in Figure F.1. Figure F.2 shows the Launch Enclosure side view, with magnified internal views of the six bolt hub and the “tuning fork” mounting pins.

The enclosure contains numerous openings, some to provide visual assistance during installation or removal of the SEMU; all provide venting during launch, landing, and prevention of oxygen pressurization caused by nominal tank leakage or component failure.

## **F.2     ANCILLARY HARDWARE**

The Ancillary Hardware (Figure F.3) configures the SEMU for launch within the SEMU Launch Enclosure. This hardware includes HUT opening covers, a SOP Regulator Holding Fork and Fork Restraint Assembly with Cable Ties, and an Elbow and Connector Cover Assembly. The covers protect the HUT interior from Foreign Object Damage (FOD) and provide impact protection between the arm bearings and HUT scye openings for the arm restraint and bladder assemblies.

The Holding Fork, which is held in place by the Fork Restraining Assembly and locked by two Cable Ties, prevents the SOP regulator from opening when subjected to launch loads.

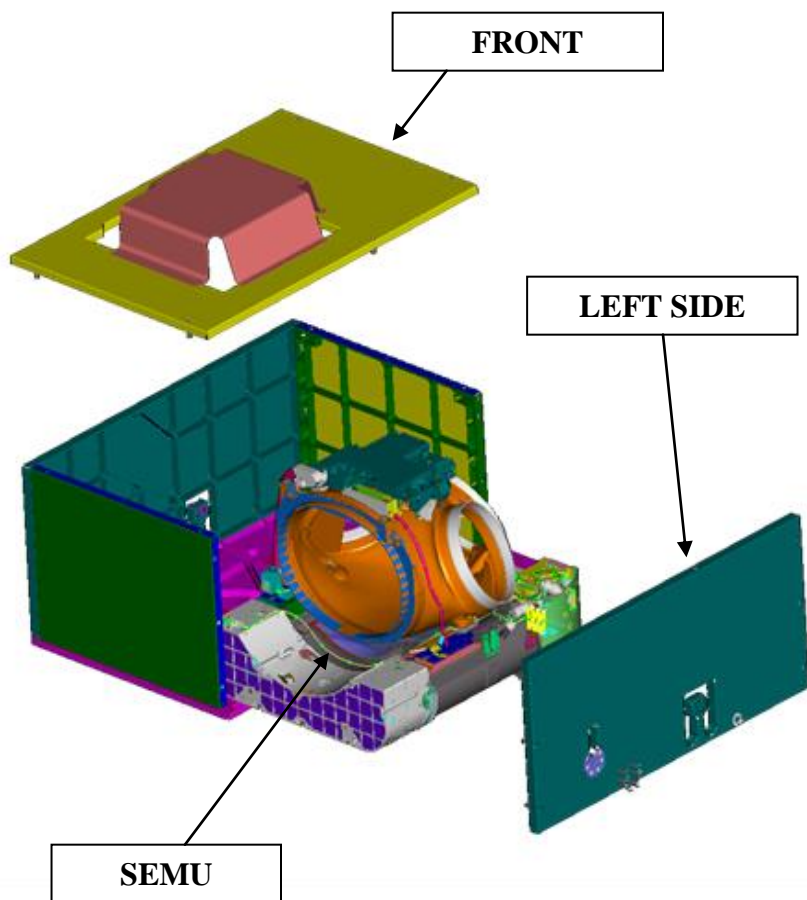
Lastly, the Elbow and Connector Cover Assembly plugs into both of the CCC/Metox swivel elbows, to prevent FOD from entering the ports. It also has an appendage that closely covers the Battery Connector. The Elbow and Connector Cover Assembly locks in place using both CCC latches.

## **F.3     LAUNCH PACKAGE**

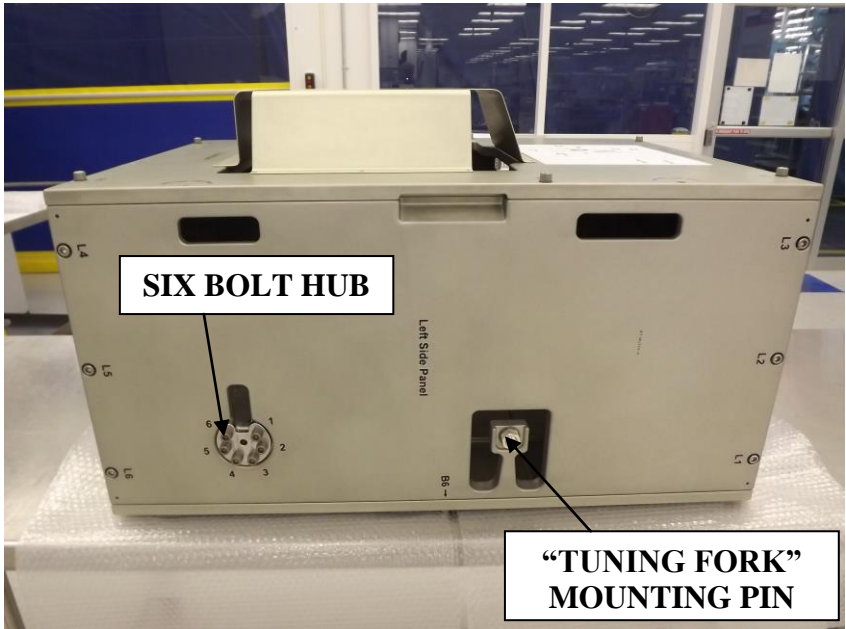
The Launch Package is the top level assembly of the SEMU, the SEMU Launch Enclosure and the Ancillary Hardware assembled together for launch or landing. This assembly includes an M03 soft stowage bag and an external Nomex covered foam clamshell. Minimum foam thickness is 1" of Zotec. The Launch Package interfaces with launch vehicles via multiple cargo straps that wrap around the Launch Package and connect to an appropriate vehicle rack interface. This configuration of the launch package, with the MO3 bag zipped open and the foam clamshell cover partially removed, is depicted in Figure F.4; Figure F.5 depicts the Launch Package as a flight ready assembly.

**Simplified SEMU Removal Procedure:**

1. Remove all cargo straps.
2. Zip open MO3 Bag, remove upper foam clamshell and remove SEMU Launch Enclosure.
3. Translate SEMU Launch Enclosure to a convenient work site and bungee it in place.
4. Remove main bolts from Front Cover; remove and temporarily stow Front Cover.
5. Remove main bolts from Left Side Cover; remove and temporarily stow Left Side Cover while assuring SEMU stays in place (bungee).
6. Slide SEMU from Launch Enclosure and temporarily stow.
7. Remove all Ancillary Hardware from the SEMU
  - a. Covers for Body Seal Closure, Neck Ring and Arms (first remove Multiple Connector and Electrical Connectors from dedicated pockets)
  - b. Elbow and Connector Cover Assembly
  - c. Regulator Holding Fork Assembly and Fork Restraining Assembly with Cable Ties (2)
8. SEMU Launch Enclosure may now be either reconfigured to accept the next SEMU for return to Earth, or simply reassembled for use at a later date. Ancillary Hardware should be stowed as a unit to prevent loss. Cable ties are cut to disassemble and are disposable.
9. SEMU may now be checked out for flight use.



**FIGURE F.1 - PARTIALLY “EXPLODED” VIEW OF LAUNCH ENCLOSURE WITH SEMU IN PLACE**



(SIDE VIEW OF SEMU LAUNCH ENCLOSURE)



(INTERNAL VIEWS OF "TUNING FORK" AND SIX BOLT HUB MOUNTING PINS)

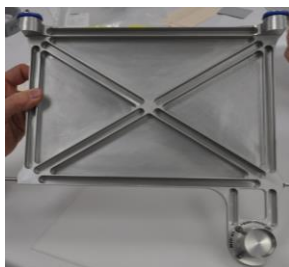
**FIGURE F.2 - LAUNCH ENCLOSURE SIDE VIEW & INTERNAL VIEWS OF THE SIX BOLT HUB AND THE "TUNING FORK" MOUNTING PINS.**



SEMU Covers



SOP Regulator Holding  
Fork Assembly

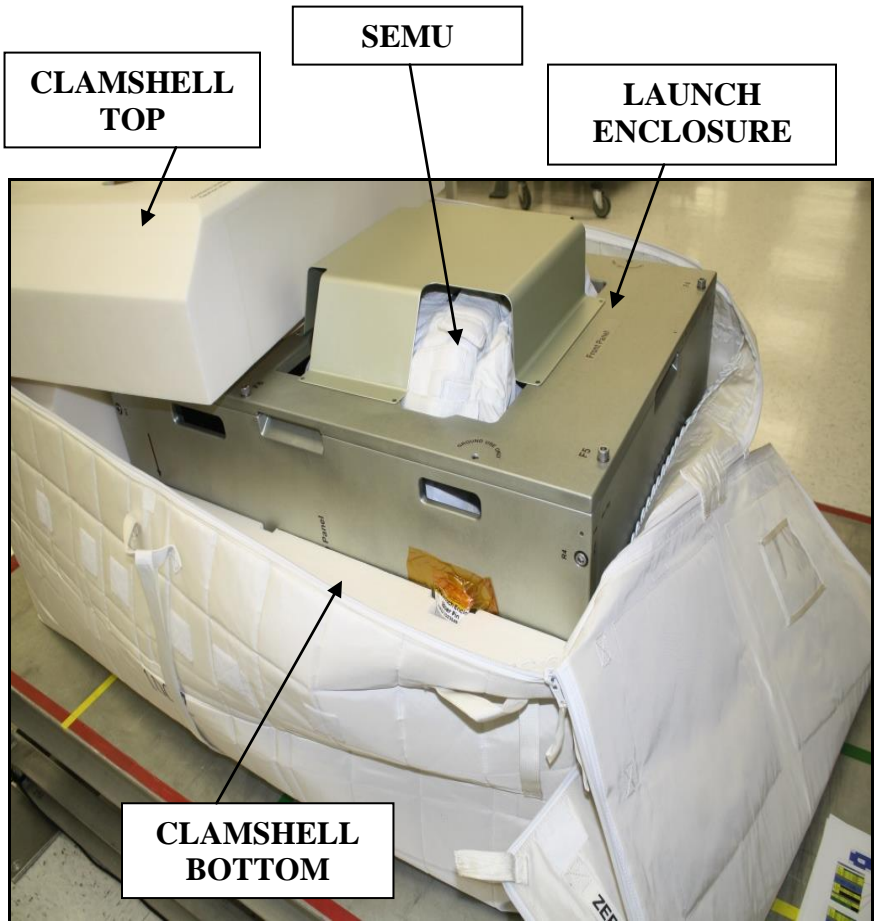


Elbow & Connector  
Cover Assy.



SOP Fork Restraining  
Assembly

## FIGURE F.3 - SEMU LAUNCH ENCLOSURE ANCILLARY HARDWARE



**FIGURE F.4 - SEMU LAUNCH PACKAGE (M03 BAG ZIPPED OPEN; TOP CLAMSHELL PARTIALLY REMOVED REVEALING LAUNCH ENCLOSURE)**



**FIGURE F.5 - FLIGHT READY LAUNCH PACKAGE**

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**TABLE OF CONTENTS**  
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**SEVICING, PERFORMANCE AND CHECKOUT EQUIPMENT**  
**(SPCE)**

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## G.1 EDDA - EMU DON / DOFF ASSEMBLY

The EMU Don / Doff Assembly (EDDA) is Government Furnished Equipment (GFE) provided by NASA onboard the ISS for use with the EMU. The technical descriptions in this Appendix are referenced from:

ASSURED EMU AVAILABILITY (AEA)  
FLEET LEADER EVALUATION PLAN  
ROUND 1, for EMU Don/Doff Assembly  
(EDDA) P/N SEG39128210

The purpose of the EDDA ORU is to provide EMU restraint while donning and doffing the EMU. Two EDDAs are provided within the ISS joint airlock; one is mounted to the Avionics rack, and the other to the Cabin Air Rack. See Figure G.1 for an installation example.

The EDDA attach points as shown in Figure G.2 use Shuttle heritage Airlock Adapter Plate (AAP) latches and handles, including four seat track anchors for fastening to the rack seat tracks on a standard ISS rack. The seat track anchor interface also provides for vertical adjustment on the racks, but normally the EDDAs remain in the same vertical location.

This configuration allows for the EDDA to be rotated away from the ISS wall, and allows for access to the rear of the EMU for removing and installing the EMU Battery and METOX Canister. This swing-out configuration also provides access to rack mounted items (METOX Regenerator Oven, PSA, and Battery Chargers) without having to remove the EMU from the EDDA.

During extension a strut assembly, nominally stowed within the EDDA, provides a 60 degree stop feature to restrain the EDDA from rotating too far away from the wall. See Figure G.3 for a photo of an EDDA in the extended position, and Figure G.4 for a detail of the EDDA Strut Assembly.

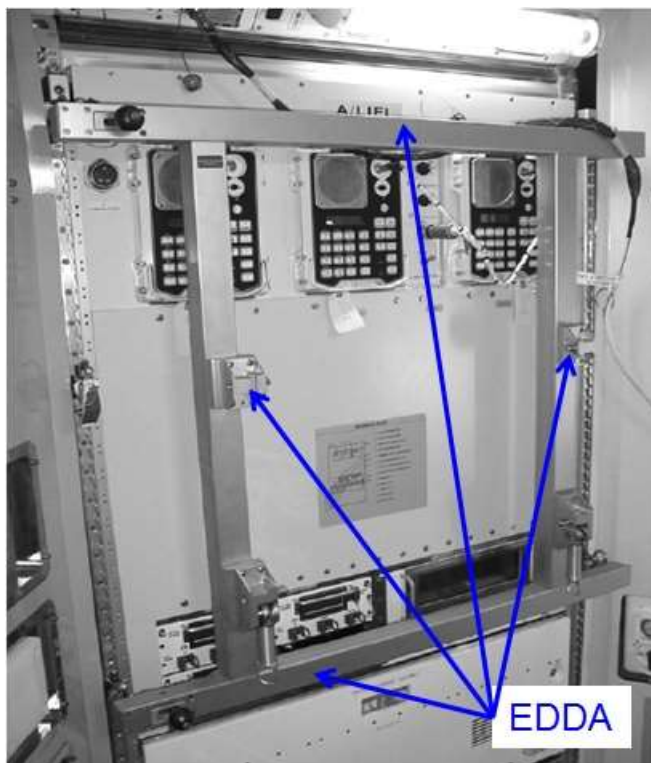
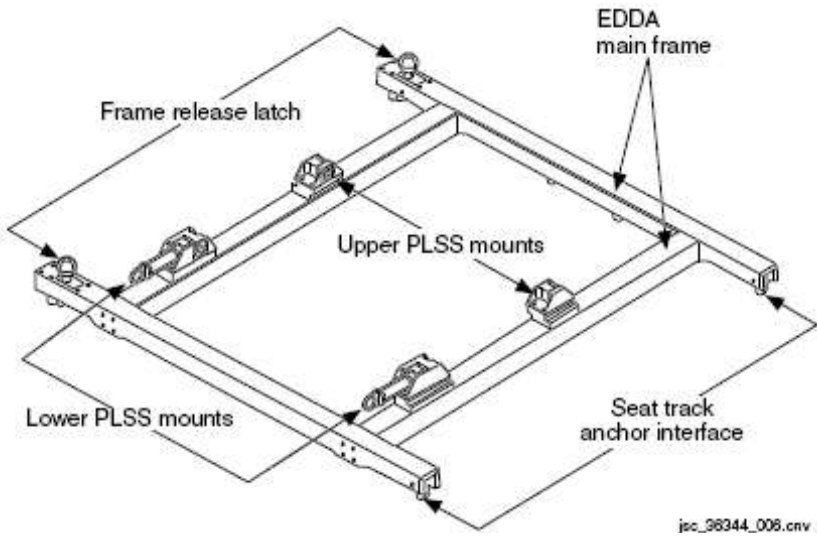
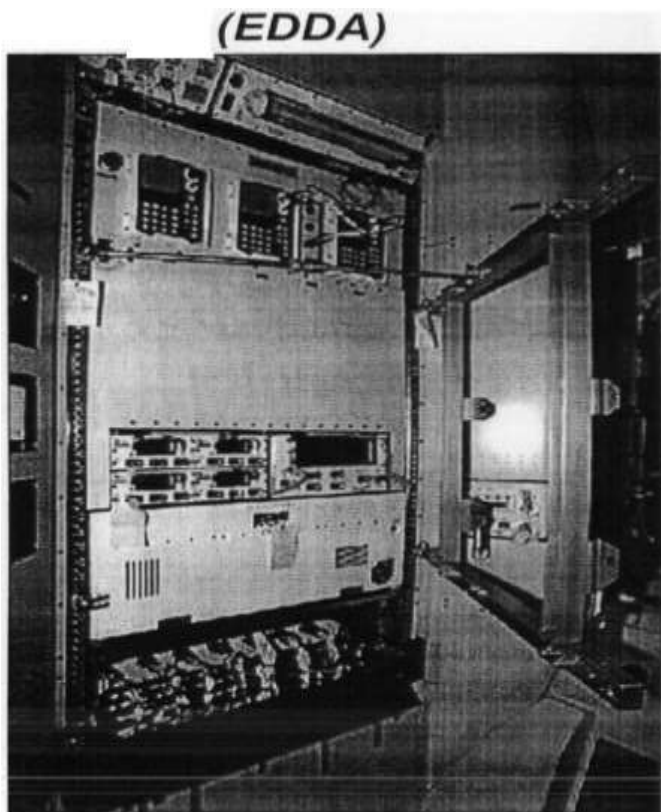


FIGURE G.1

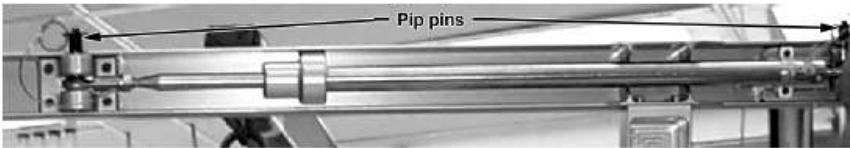
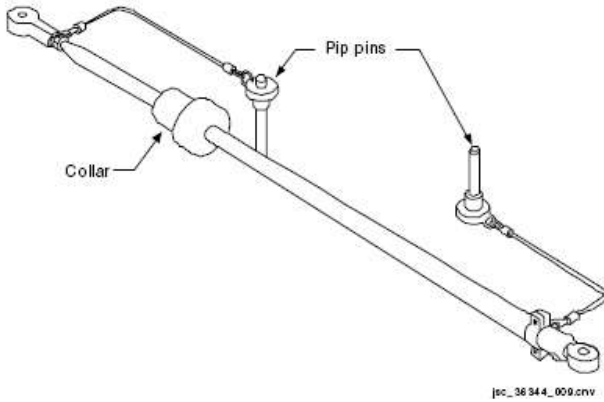
EDDA IN STOWED POSITION



**FIGURE G.2 EDDA ATTACH POINTS**



**FIGURE G.3                      EDDA IN EXTENDED POSITION**



**FIGURE G.4                      EDDA STRUT ASSEMBLY**

## G.2 BFA - BIOCIDES FILTER ASSEMBLY

The Biocides Filter Assembly (BFA) is supplied to the ISS to condition water for use with the EMU. The technical descriptions in this Appendix are referenced from:

ASSURED EMU AVAILABILITY FLEET  
LEADER EVALUATION PLAN, Round 1,  
Biocides Filter Assembly (BFA), P/N  
SEG39128318

The Biocides Filter Assembly is a component of the Umbilical Interface Assembly (UIA) which is part of the SPCE Hardware. The UIA is located in the crewlock section of the Joint Airlock of the ISS. The function of the Biocides Filter Assembly is to filter the Feed Water flowing into the EMU and the Waste Water drained out of the EMU through the UIA.

The BFA operates only during EMU servicing. Figures G.5-G.7 include cross-sectional views, installation, and exploded views of the BFA portraying its major components. Figure G.8 depicts an isometric rear view pictorial of the UIA with the two Biocides Filter Assemblies installed. These Biocides Filters are installed in the feed water and waste water circuits of the UIA potable water fill and drain system. Figure G.9 contains an operational schematic of the BFA in the UIA during EMU servicing operations.

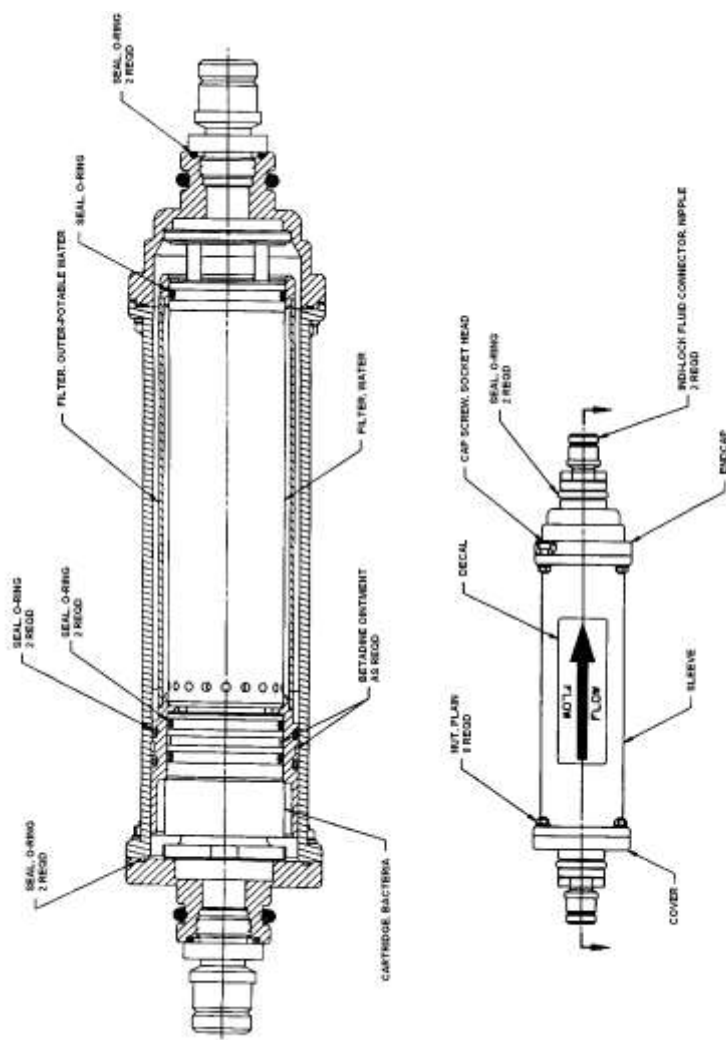
The function of the BFA is to filter and iodinate feedwater and wastewater to and from the EMU during spacesuit servicing operations: I-423 releases iodine in both the feedwater and wastewater circuits to suppress bacterial growth, and I-424 removes particles greater than 2 microns flowing into and out of the EMUs.

The BFA uses the same internal cartridges and filter media (I-423, & I-424) as those formerly used in the obsolete Space Shuttle Item 400 Servicing and Cooling Umbilical (SCU) Bacteria Filter (I-416): the I-423 Bacteria Cartridge contains iodinated epoxy resin spheres, and the I-424 Potable Water Filter is equipped with 2 micron inner and outer filters.

The BFA operational life is reached when 520 lb. of water passes through cartridges and filter media, which is equivalent to passing a volume of water of 63 gallons. The BFA useful life is 15 years, limited by the 15 year useful of the Bacteria Cartridge (I-423) resin bead and seal. The useful life of the inner and outer Water Filter (I-424) is 23 years.

The BFA outer housing has been redesigned specifically for the SPCE mounting application. The UIA has been designed for easy on-orbit replacement of the Biocide Filter Assembly. Two quick disconnects, one on each end of the BFA, provide for this easy interchangeability. The filter access door in the front panel in the UIA provides easy access to the BFA from where the unit can be pulled out and a new or refurbished filter assembly can be installed.

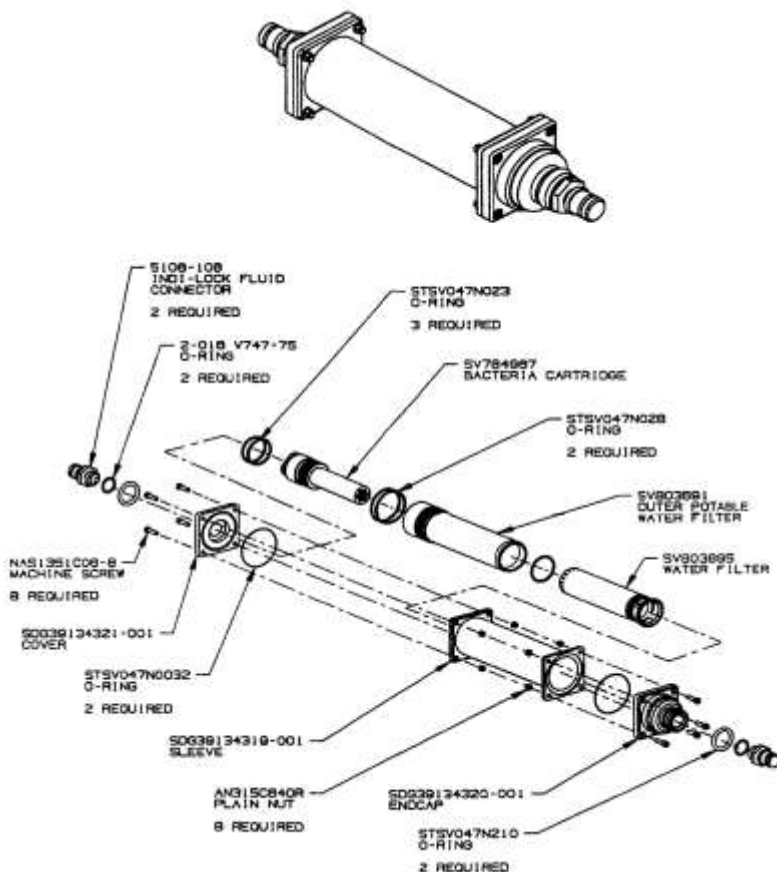
The Biocide Filter Assembly is described separately from the UIA in this appendix even though it is part of the Umbilical Interface Assembly. The BFA is an on-orbit Replaceable Unit (ORU) and tracking of it is distinctive from the other SPCE hardware. This allows the BFA to be inspected, tested and evaluated separately.



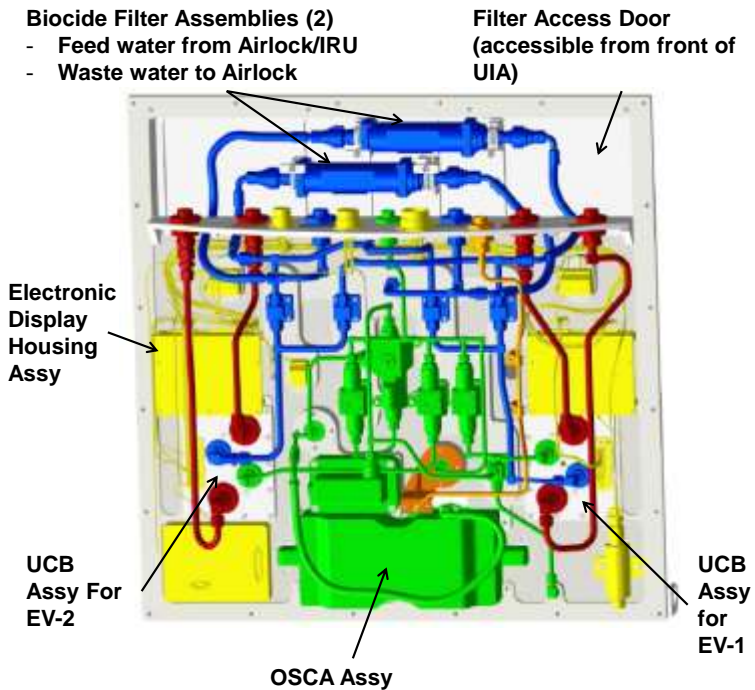
**FIGURE G.5 Cross-Sectional View and Overall View of the SPCE Biocide Filter Assembly (not to scale)**



**FIGURE G.6**      **Installation of the SPCE Biocide Filter Assemblies (not to scale)**

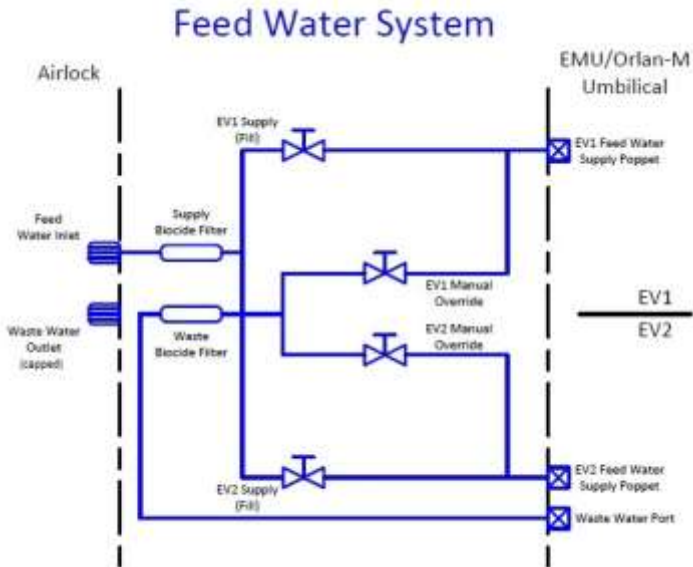


**FIGURE G.7** Exploded view of the SPCE Biocide Filter Assembly (not to scale)



**FIGURE G.8**

**Isometric Rear View of the UIA Assembly showing the Biocide Filter Assemblies as Installed**

**FIGURE G.9**

**UIA Fill/Drain System Schematic  
with EMUs Attached: BFAs in the  
Feed Water and Waste Water  
Circuit shown**

### G.3 PSA – POWER SUPPLY ASSEMBLY

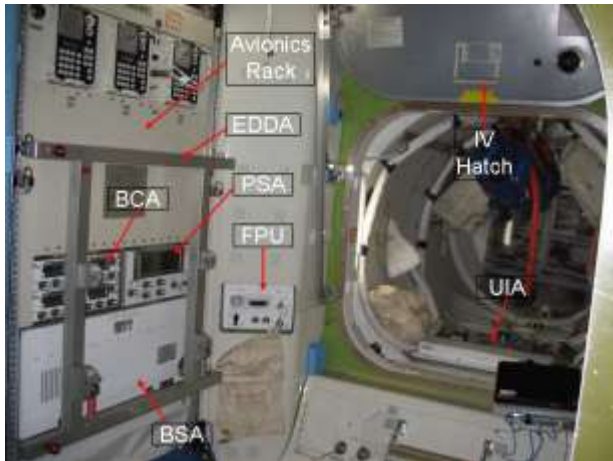
The Power Supply Assembly (PSA) is Government Furnished Equipment (GFE) provided by NASA onboard the ISS to power EMUs or Orlan spacesuits. The technical descriptions in this Appendix are referenced from:

ASSURED EMU AVAILABILITY (AEA)  
FLEET LEADER EVALUATION PLAN  
Round 1, POWER SUPPLY ASSEMBLY (PSA)  
– SPCE, P/N SEG39128211

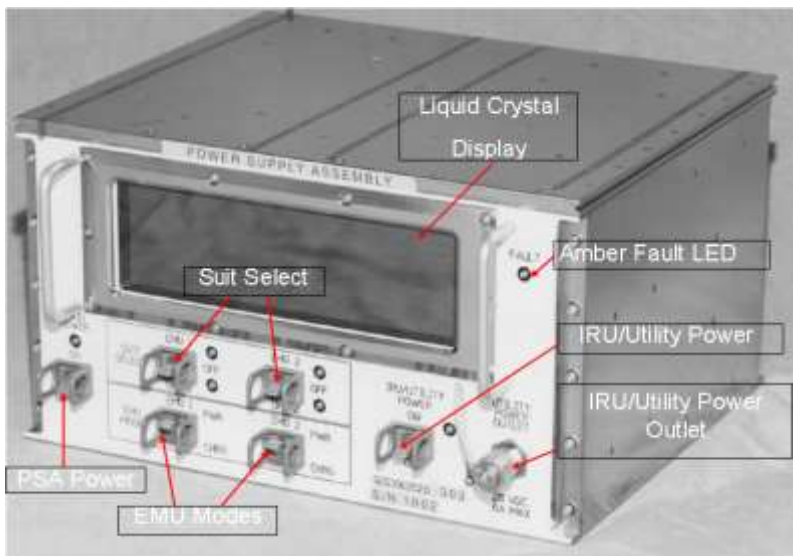
The PSA is rectangular housing that is mounted onto a cold-plate in the Joint Airlock Avionics Rack as shown in Figure G.10. It is an On-Orbit Replacement Unit (ORU) component and its replaceable spare is located in the Airlock.

The PSA provides the capability to power two EMUs, two Orlan spacesuits, or one of each. The PSA also supplies power, as well as over-voltage and over-current protection, to the Fluid Pumping Unit (FPU), UIA, and the auxiliary port, which are not capable of operating from the Airlock's 120 VDC bus.

The PSA includes a general purpose 28 VDC utility electrical port on the front panel, shown in Figure G.11 for powering portable equipment such as the stand alone EVA battery chargers. A large LCD provides status and loads information to the crew. Analog data, which includes the voltage and current for each PSA output, is continuously provided to the Airlock Multiplexer/Demultiplexer (MDM) to be accessed by either on-orbit or ground personnel.



**FIGURE G.10**      **Location of the PSA in the Joint Airlock**



**FIGURE G.11**      **Power Supply Assembly (PSA)**

## G.4    **UIA – UMBILICAL INTERFACE ASSEMBLY**

The Umbilical Interface Assembly (UIA) is supplied to the ISS and serves as the exclusive interface between the EMU and the ISS airlock.

The UIA is an On-Orbit Replacement Unit (ORU) and is part of the SPCE hardware. It is located in the crewlock section of the Joint Airlock of the ISS and is exposed to the vacuum of space when EVAs are performed.

The UIA includes the controls and displays necessary for servicing and maintaining the EMUs as well as those necessary to support EVA egress and ingress activities for the EMU. It also supports operation of the airlock depress pump by housing the control and status indicators and the airlock pressure sensor.

The UIA system is a collection of separate plumbing and electrical systems interfaces between the spacesuit and airlock. The UIA block diagram is shown in Figure G.12. Interfaces supplied include a high pressure oxygen loop that provides  $900 \pm 50$  psi O<sub>2</sub> to the EMU, loops for EMU feed water and cooling water, and electrical passthroughs for EMU power and communications. The UIA also houses a depress pump control and monitoring circuit.

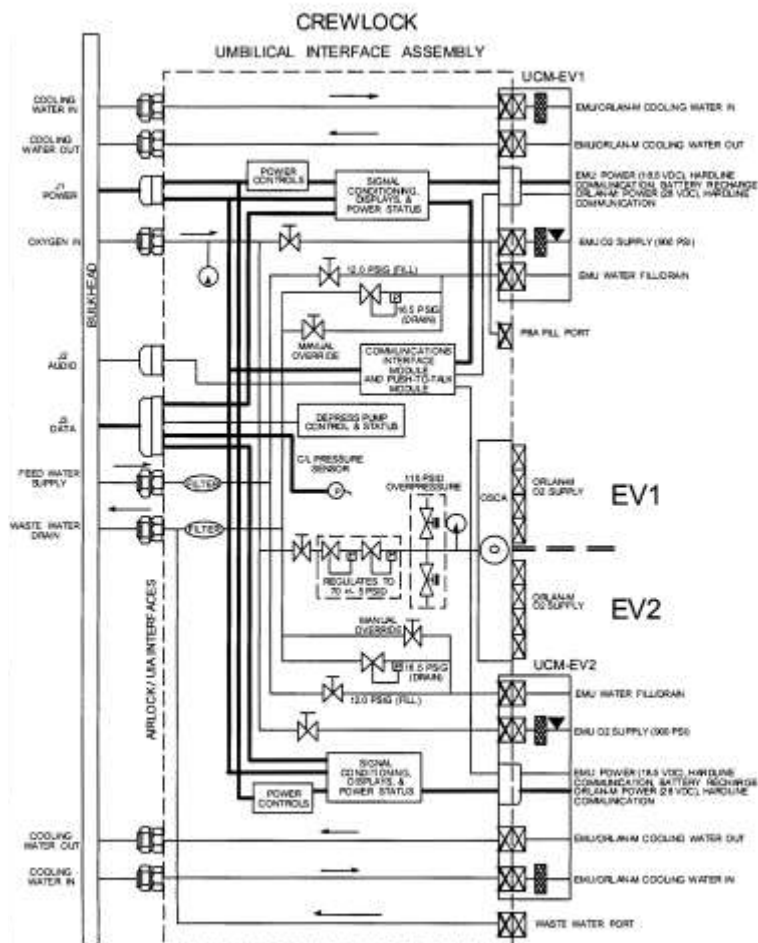
The crewmembers interface with the UIA via the front panel shown in Figure G.13, which includes user controls, interface and data displays, and electrical and fluid interfaces.

The UIA feed water loop is used to replenish the EMU feed water reserves when required. The EMU will deplete its reserves while performing EVAs and will also be routinely dumped and filled as a part of preventative maintenance. The UIA is the only means of filling and draining the EMU feed water tanks and its continued operation is necessary to sustain the performance of

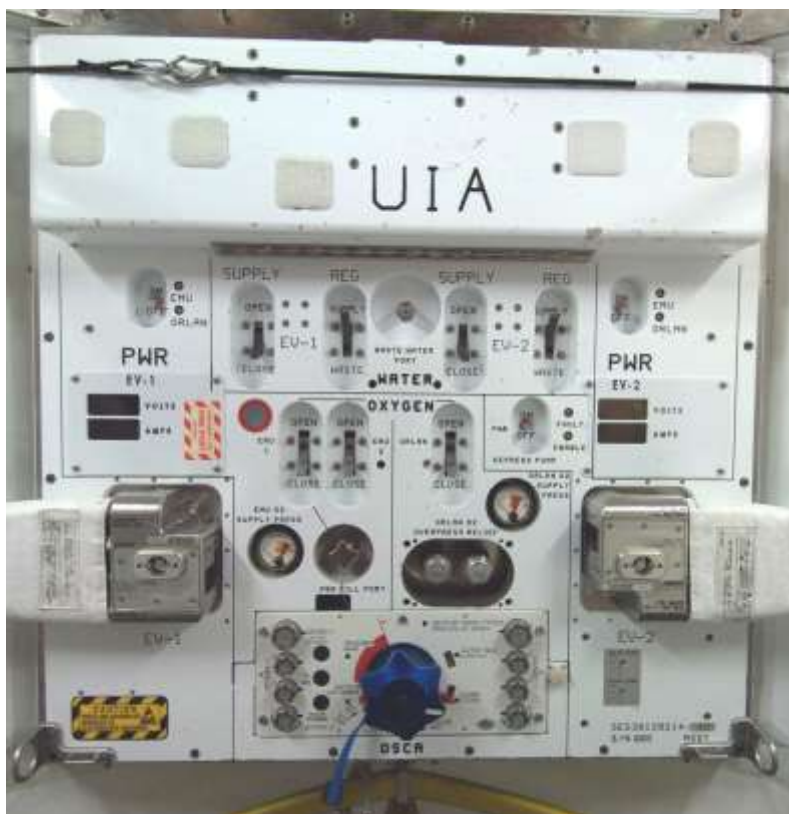
EVAs. The feed water loop contains two Gamah connectors, two BFAs, one on the fill side and one on the drain side, 4 manual isolation valves, two backpressure regulators, and 3 QDs.

The cooling and transport water loop consist of four lines that act as passthroughs between the IEU and the Airlock Isolation Heat Exchanger, and include four Gamah connectors and four QDs. It is used to provide and interface and passthrough for the EMU transport water loop to interact with the Airlock Isolation Heat Exchanger, which cools the water from the EMU and then returns it to provide cooling to the crewmember. It is used during ingress, egress, and pre-breathe activities associated with EVAs and can supply transport water flow for two EMUs, via two IEU umbilicals, simultaneously.

The UIA electronics circuits primarily act as passthroughs for the transfer of power and communications between the EMU(s) and the PSA while also providing operator status and control over those functions. They also provide power, control, and status of the airlock depress pump. The ability to provide power prior to EVA allows a greater EVA duration by saving battery charge which would otherwise be needed to power pre-breathe activities.



**Figure G.12**      **UIA System Block Diagram**



**Figure G.13 Umbilical Interface Assembly Panel**

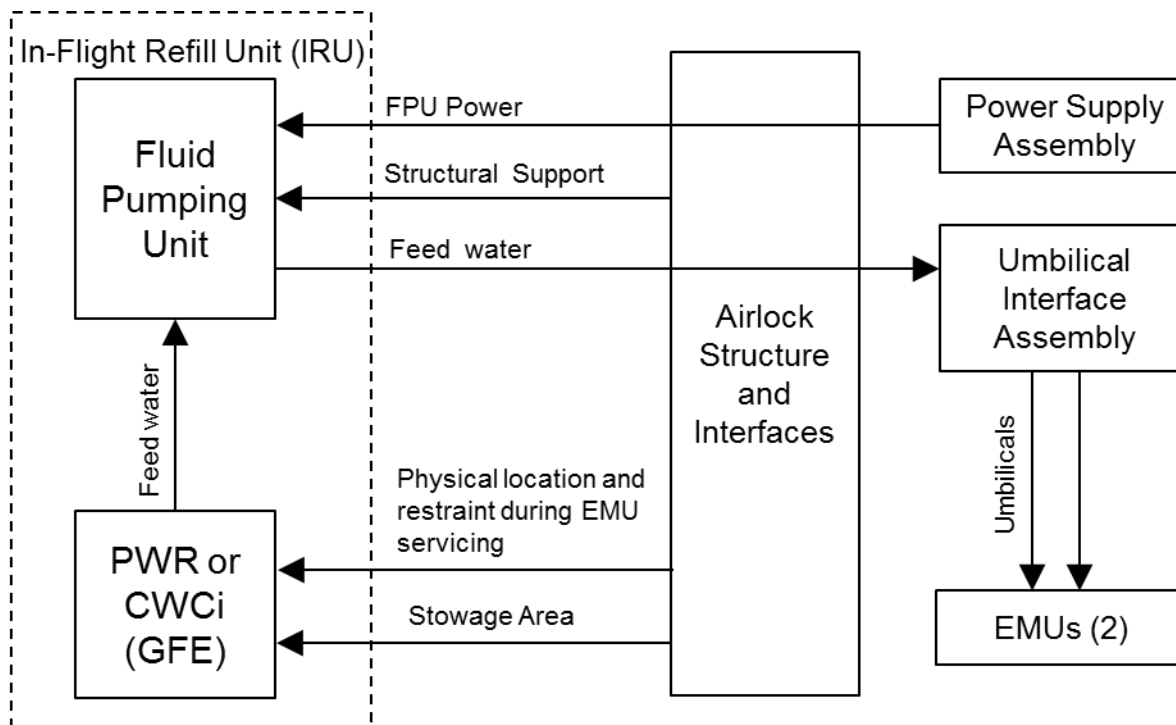
## **G.5 FPU – FLUID PUMPING UNIT**

The Fluid Pumping Unit (FPU) is supplied to the ISS to recharge EMU feed water.

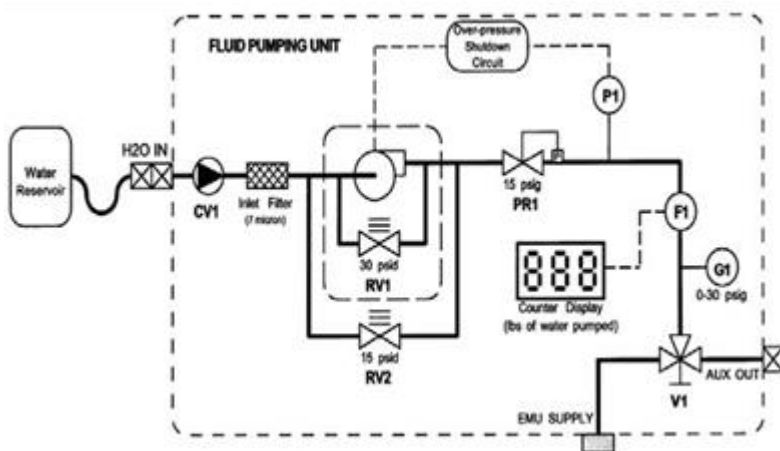
The FPU is an On-Orbit Replacement Unit (ORU) that serves to recharge EMU feed water and, if needed, to transfer water between water reservoirs via an 'Aux Out' port on the front panel. As part of the Inflight Refill Unit (IRU), the FPU recharges the EMU feed water bladders through the UIA as depicted in Figure G.14.

The FPU system consists of a check valve, a 7 micron filter, a pump assembly, a transducer regulator assembly, a flow meter assembly, a counter display, a proportional relief valve, a pressure gauge, and a 3 way switching valve.

As shown in Figure G.15, the FPU system provides a feed water path from either a Payload Water Reservoir (PWR), or from a Contingency Water Container - Iodine (CWCi), to either the EMU supply output, or the Aux Out port, as selected by the hand valve V1. Figure G.16 provides a front panel view of the hand valve used to select the output water flow path.



**Figure G.14 In-Flight Refill Unit (IRU) Interface Diagram**



**Figure G.15 FPU System Block Diagram**



**FIGURE G.16 FPU Front Panel with Hand Valve**