

EVA Console Handbook

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EVA, Robotics,
and Crew Systems
Operations Division



EVA Group

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EVA Console Handbook

ISS EVA Operations

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PREFACE

This document has been prepared by the Extravehicular Activity (EVA) Systems Group under the authority of the EVA and Crew Systems Operations Branch, EVA, Robotics, and Crew Systems Operations Division, Lyndon B. Johnson Space Center (JSC), National Aeronautics and Space Administration (NASA).

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Questions concerning the technical content of this document should be directed to Adele Luta, (281) 483-2507, DX35.

PURPOSE

The EVA Console Handbook provides a single authoritative source of primary information for use by EVA flight control personnel. For additional information, the reader should refer to training manuals and other documents referenced in this handbook.

SCOPE

Information in this handbook is not flight-specific. It addresses systems and procedures used for EVA operations on the International Space Station (ISS).

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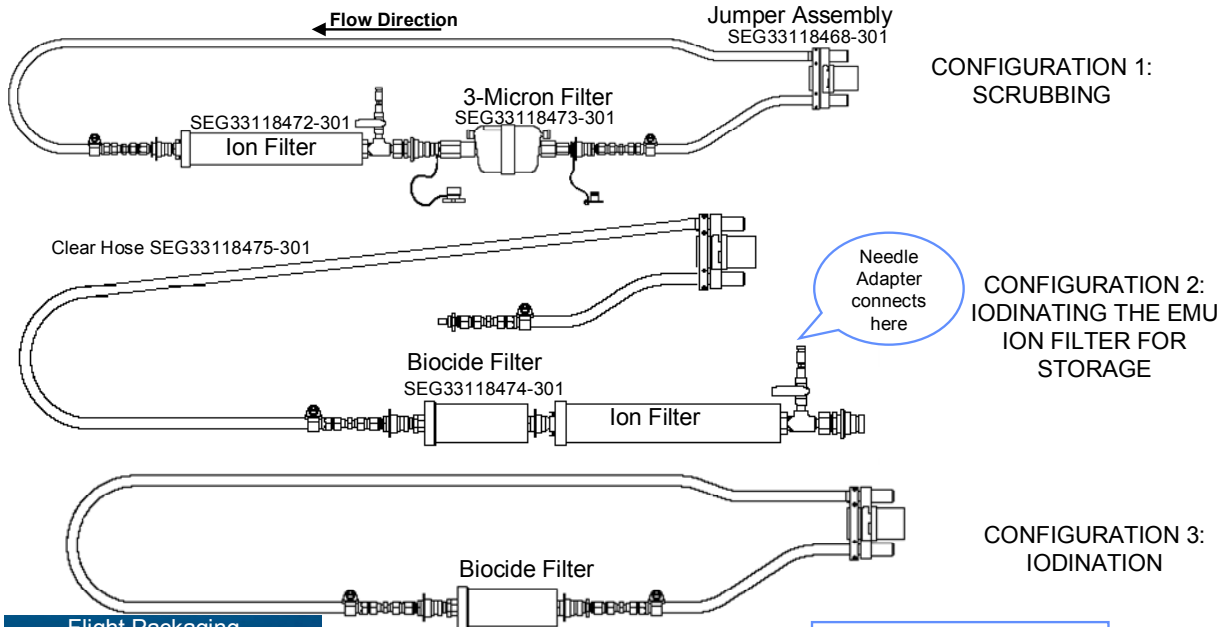
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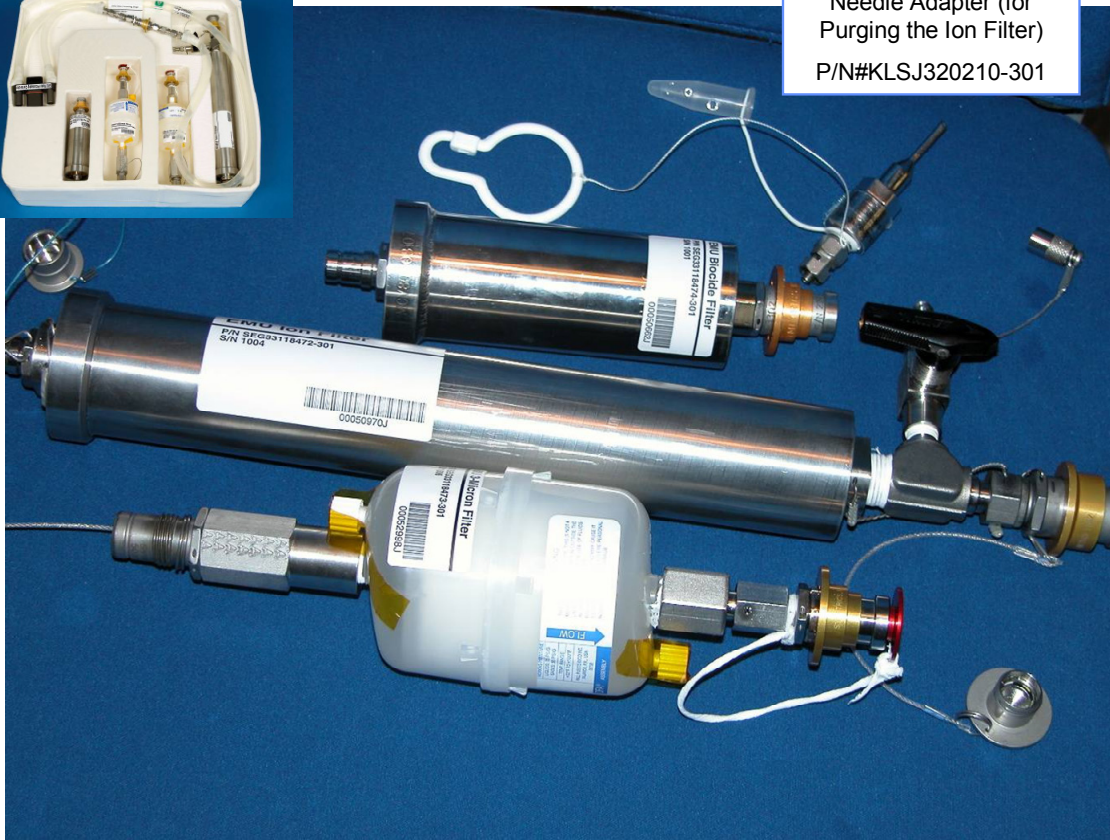
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3.6-14	0.25 gram hydrazine brought into cabin (One hydrazine removal canister)	3.6-17
3.6-15	0.25 gram hydrazine brought into cabin (Two hydrazine removal canisters)	3.6-17

ISS AIRLOCK SYSTEMS	Reference only
ELEMENT AL	EMU Water Processing Kit
	PAGE 1

Airlock Coolant Loop Recovery Kit SJK33118469



Needle Adapter (for
Purging the Ion Filter)
P/N#KLSJ320210-301



ISS AIRLOCK SYSTEMS Reference only

ELEMENT AL PAGE 2

EMU Water Processing Kit

PRE-EVA SERIES SCRUB

Event	Jumper Config	Airlock Config	Flow Duration	Time Constraint
Scrub	Ion/3-mircon filters	EMU with SCU	≥1:00	≤ 4 week before 1 st EVA

POST EVA SERIES SCRUB

Event	Jumper Config	Airlock Config	Flow Duration	Time Constraint
Scrub	Ion/3-micron filters	EMU with SCU	≥1:00	≤ 2 weeks after Last EVA

POST EVA SERIES IODINATION (WITH LTL < 70 F)

Events (require both)	Jumper Config	Airlock Config	Flow Duration	Time Constraint
Loop Biocide	Biocide filter	EMU with SCU	1:30	≤ 2 weeks after Last EVA
Suit Biocide	Biocide filter	EMU alone	0:30	≤ 2 weeks after Last EVA

POST EVA SERIES IODINATION (WITH LTL ≥ 70 F)

Event	Jumper Config	Airlock Config	Flow Duration	Time Constraint
Loop Biocide	Biocide filter	EMU with SCU	2:00	≤ 2 weeks after Last EVA

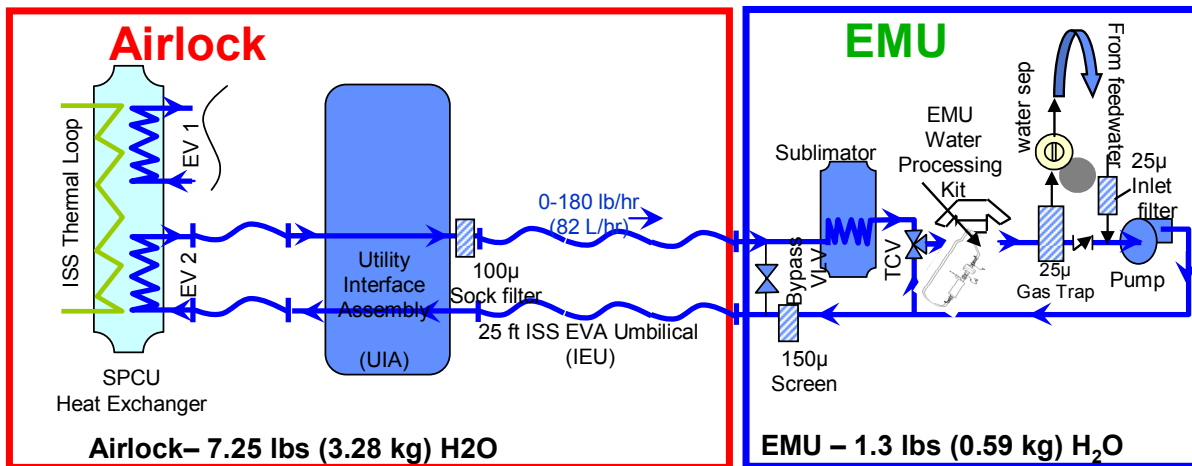
EMU 90-DAY MAINTENANCE (ON BATTERY)

Events (both required)	Jumper Config	Airlock Config	Flow Duration
Scrub	Ion/3-micron filters	EMU alone	0:30
Suit Biocide	Biocide filter	EMU alone	0:30

EMU 90-DAY MAINTENANCE (ON SCU)

Events (both required)	Jumper Config	Airlock Config	Flow Duration
Scrub	Ion/3-micron filters	EMU with SCU	1:00
Loop Biocide	Biocide filter	EMU with SCU	2:00

- LOSS OF FLOW CONTINGENCY:**
1. Push Pump Priming Vlv, cycle TCV
 2. Swap out filters
 3. Use 1.528 COOLING LOOP FLUSH procedure



Airlock Water Flow Path showing EMU Water Processing Kit

ISS AIRLOCK SYSTEMS		Reference only	
ELEMENT AL	EMU Water Processing Kit		PAGE 3
<u>HARDWARE LIMITED LIFE:</u>			
ION FILTER: 8 uses with SCU (60 uses w/o SCU) or 2 years after first use			
3-MICRON FILTER: 4 uses or 2 years			
BIOCIDES FILTER: 100 uses with SCU (1500 uses w/o SCU)			
<u>OPERATIONAL INFO:</u>			
<p>The diagram shows a horizontal timeline with four main intervals marked by brackets above the line:</p> <ul style="list-style-type: none"> ≤ 4 Weeks: From the start to a point labeled "Begin EVA Series". ≤ 8 Weeks: From "Begin EVA Series" to a point labeled "End EVA Series". Below this interval, it says "All EVA's executed here". ≤ 2 Weeks: From "End EVA Series" to a point before "Maintenance". Storage, max 180 days: From the point before "Maintenance" to the end of the timeline. <p>At the start, there is a blue diamond icon. At the "Begin EVA Series" point, there is a blue diamond icon. At the "End EVA Series" point, there is a blue diamond icon. At the point before "Maintenance", there is a yellow diamond icon. At the "Maintenance" point, there is a blue diamond icon. At the end of the timeline, there is a yellow diamond icon.</p>			
<p>◆ Denotes use of the EMU Ion Filter AND EMU 3-Micron Filter (Scrubbing)</p> <p>◇ Denotes use of the EMU Biocide Filter (for re-iodinating)</p>			
EVA SERIES			
<ul style="list-style-type: none"> • Max 6 EVAs • Max 2 weeks between EVAs • Max 8 weeks from 1st to last EVA 			
<p>Scrub=Using Ion and 3mic filters in series to remove precipitates/biomass and ionic contaminants respectively; required <4wks pre first EVA in a series and <2wks post last EVA of that series; also required at EMU 180 day maintenance intervals (if suits unused for 180 days).</p>			
<p>Iodination=Using the Biocide filter to iodinate the water system to control microbial growth; required <2wks post last EVA or at EMU 180 day maintenance intervals;</p> <ol style="list-style-type: none"> 1. If LTL temp<70F then 2 step method= EMU+Loop Biocide for 1:30 then EMU alone Biocide for 30min. 2. If LTL temp>70F then do one step method= EMU+Loop Biocide for 2:00 hr. 			
<p>ALCLR White Paper Requirements are to Scrub within 4wks of first EVA, perform the series of EVAs, then do a Scrub and Iodination within 2 wks of the last EVA. A Maintenance Scrub and Iodination should be performed within 180 days if an EMU is unused during that interval. Post Scrubbing, Ion filter will be iodinated for storage. TCV cycling during Scrubbing assures all channels in EMU coolant loop are flushed out. Ion/3mic Filters operational range is 50F to 80F at 40-160 lbs/hr (low end assures 5 volume exchanges, high end precludes ineffective scrubbing) and Biocide filter at 50F to 90F at minimum 80 lbs/hr (assures 10 volume exchanges).</p>			
Logistics Tracking			
Ion, 3micron, and Biocide filter usage is tracked on the EVA Logistics Tracking database on the V: drive.			
<u>REFERENCE INFO:</u>			
•ISS EMU Coolant Loop Recovery Kit CARD Rev B, February 2007 JSC 62294B			
•Airlock Coolant Loop Recovery (ALCLR) Unit Operational White Paper-John F. Lewis, EMU/Airlock Coolant Loop Tiger Team Lead, April 20, 2005			
•Approved EVA CR# EVA-00164-R1 (updates to Operational White Paper w/ scrubber and filter extensions)			
•ISSSH JSC-36027 Rev C PCN-1			
•Logistics Tracking R3.XLS V:\EVA\Generic Systems Items\Flight Support\Logistics Tracking Database			

1.1 ISS EVA WATER SYSTEMS

1.1.1 System Description

Joint Airlock EVA water systems provide capability for cooling water supply, water dumping, and water transport in support of EVA unsuited and suited activities. EVA operations where Joint Airlock water systems are used include EMU Checkouts, EVA Prep/Post, and EMU Maintenance activities. There is not a standalone water supply system dedicated to EVA Systems. Iodinated water is provided from the Shuttle Orbiter Repackage Galley (SORG or Shuttle Galley) until arrival of the Water Processing Assembly (WPA) currently targeted for ULF2. Iodinated water is currently transferred with Payload Water Reservoirs (PWRs).

1.1.2 EMU Water Recharge

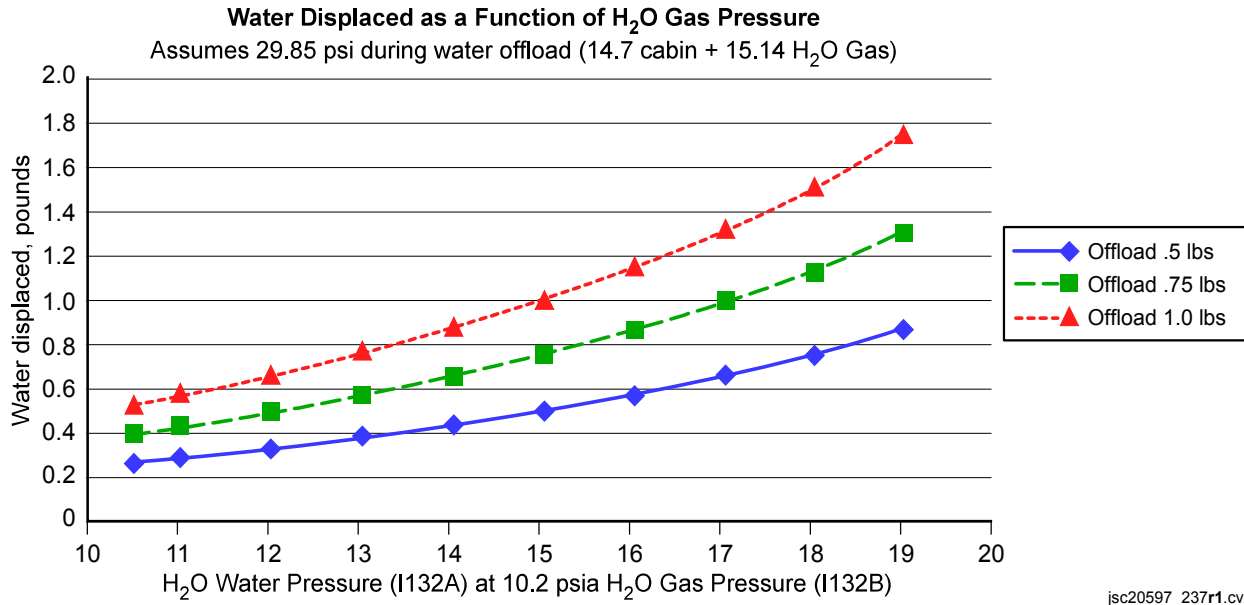
EMU water recharge should be performed after an EVA to recharge partially depleted tanks. If an EMU has not been used for >180 days, a 4-lb minimum dump is done, and then a recharge is required. If an EMU has not been used for >365 days, a full water tank dump is done, then recharge is required. If the EMU has seen 14 EVAs, or if it is determined that there is a gas bubble displacement in the feedwater tanks >0.85 lb of water, a full water tank dump is performed, and then recharge is required. In all cases, after the recharge is completed, an ullage dump is performed, dumping ~0.5 lb of water out of the feedwater tanks for each EMU to allow for condensate collection during pre-breathe and minimize the chance of cracking the feedwater relief valve. Historical data on EMU Waste Water dumps can be found in Section 1.1.11, Historical Data Addendum, at the end of the Water Section.

EMU Feedwater Tank Gas Bubble Inclusion

It may be possible for gas to have been transferred into the EMU feedwater tanks during water recharge operations due to entrained gas in the PWR supply water. This gas would more than likely manifest itself at an Airlock pressure of 10.2 psia during EVA Prep operations with the suit radios on (EVA telemetry being sent to the ground). The H₂O Water Pressure (WP) would be higher than the H₂O Gas Pressure (GP). Nominally, they both would track each other at ~15.1.

Shown in Figure 1.1-1 is a graph depicting the water displaced as a function of the H₂O GP. To use this graph, the operator must know the following two things:

1. The amount of water offloaded at a cabin pressure of 14.7 during the ullage dump. (The historical assumption was that about 0.5 lb of water dumped over the 30-second ullage dump; although, some Space Station Airlock Test Article (SSATA) data shows 0.78 lb of water for a 30-second dump). The operator may assume a worst-case ullage dump of 1.0 lb and use the topmost curve in the graph for conservative assumption.
2. The EMU H₂O WP reading while at 10.2 psia cabin pressure and O₂ ACT-OFF.



**Figure 1.1-1. EMU water tank gas bubble correlation
(from FEMU-R-003)**

As an example, if the 10.2 psia H₂O WP reading is indicating 14 psi, follow a straight line vertically from 14 on the horizontal axis to the upper curve (conservative 1.0-lb ullage dump assumption), then move across to the left to determine the equivalent water displaced in lb of water. A displacement of greater than 0.85 lb means that the 6.5-hour EVA time will not be met (based on 1 lb/hr water usage), an assessment should be made as to whether the EVA can be shortened, whether estimated water usage (cold vs. hot EVA) allows for margin, etc. The following calculations have been used in these assumptions (assumes 0.5-lb ullage dump):

$$8.35 \text{ lb (main-tankage min)} - 6.5 \text{ lb (1 lb/hr for 6.5 EVA)} - 0.5 \text{ lb (30-min margin at 1 lb/hr)} - 0.5 \text{ lb (ullage dump)} = 0.85 \text{ lb}$$

1.1.3 EMU Water Dump

EMU water dumps are performed as part of servicing operations before and after EVAs. The United States Operational Segment (USOS)/Airlock is required to accept EMU waste water, and the Node 3/WPA (launch ULF2) is required to process EMU waste water, as documented in SSP-41000, SSP-41162, and the Airlock Prime Item Development Specification (PIDS) (684-10142). These requirements are not applicable to the Russian segment and the SRV-K (Russian Water Processor), and neither is certified nor tested for processing iodinated water.

Because implementation of the WPA installation is not planned until ULF2, dumping of water was performed by flowing EMU waste water to the Lab Condensate Tank, which was then processed by the SRV-K. After the Russian segment started having problems with the SRV-K in 2004, it was decided to stop dumping iodinated EMU waste water into the US Lab condensate tank to avoid subsequent transfer of this water to the Russian water processor. An alternate method of dumping water from the EMUs was required to maintain EVA capability.

This alternative method for dumping water from the EMUs was implemented post 12A.1. This first required disconnecting the Waste Water Line under the UIA cover at the bulkhead gamma fitting, then putting a 0.5-in gamma cap and plug on both open sides of the line shown in Figure 1.1-2.

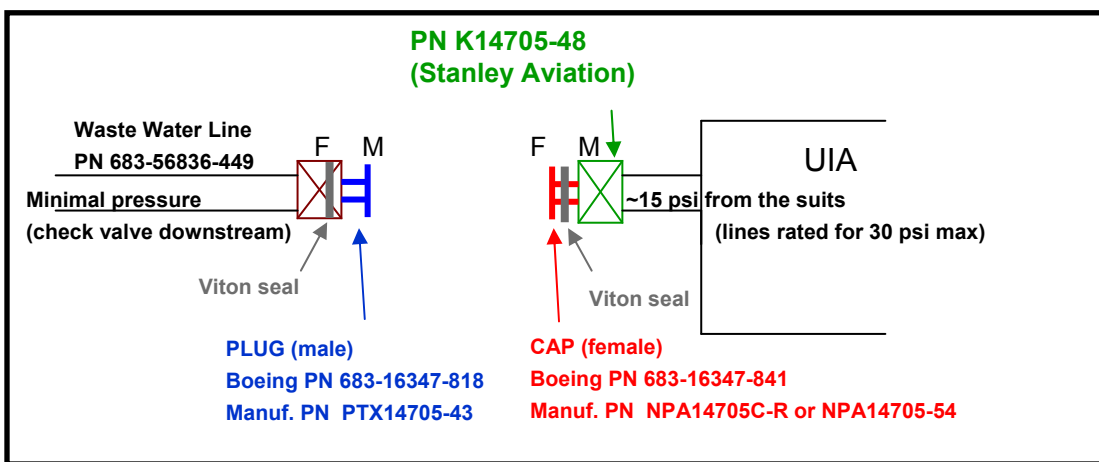


Figure 1.1-2. UIA Waste Water Line Cap and Plug installation

In this new configuration, dumping to the Lab Condensate Tank is no longer possible. The point of disconnect of the Waste Water Line was made under the UIA cover, and the current water flow path for the Drain Line from the UIA is shown in Figure 1.1-3. A big picture overview of the EMU Waste Water Line disconnect at the UIA is shown in Figure 1.1-4.

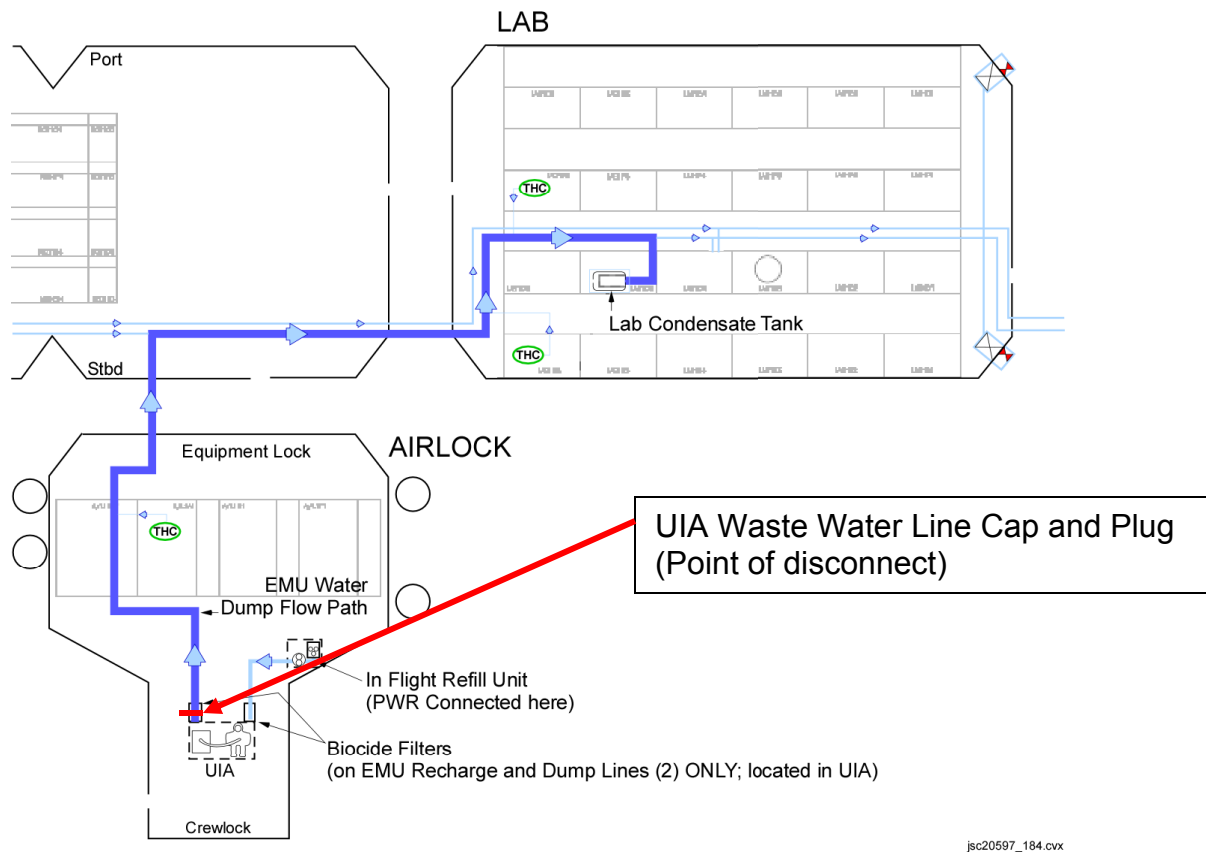


Figure 1.1-4. Big picture overview of UIA Waste Water Line disconnect

To dump EMU waste water, a CWC is connected to the UIA Waste Water Port via a R/Y QD - Blue/Blue Hose - R/Y QD shown below in Figure 1.1-5.

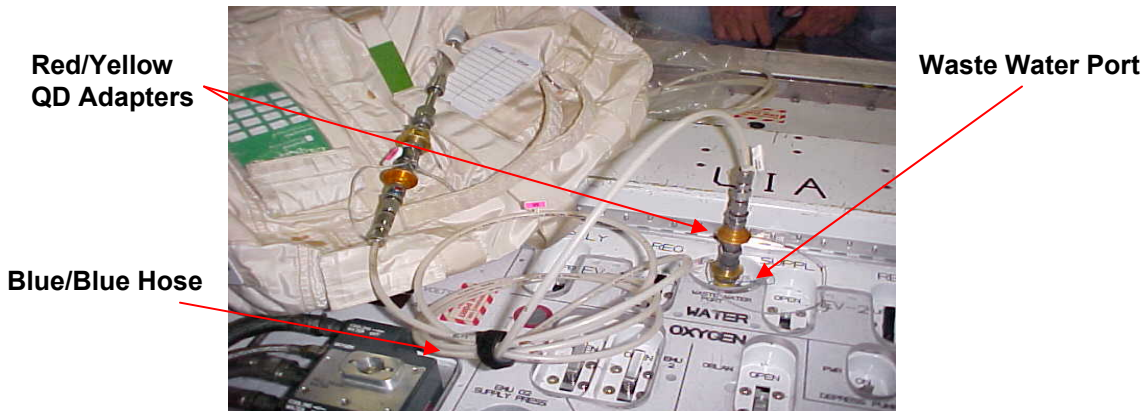


Figure 1.1-5. Current EMU Water Dump configuration

The rest of the process for dumping water out of the EMU is the same as described for dumping into the lab condensate tank. For more details relating to EMU waste water dumps into a CWC, reference the ISS EVA Systems Checklist Procedures 1.506 EMU Water Recharge Post UIA Cap and Plug or 1.508 EMU Water Maintenance Dump and Fill Post UIA Cap and Plug.

The CWC is currently not certified to go to vacuum and must be removed from the airlock prior to depress operations. The CWC is nominally stowed in the Node. The Blue/Blue Hose and Red/Yellow QD Adapters are nominally stowed connected as one assembly in the Lab (reference the ISS Inventory Management System for current stowage location).

Alternatively, if a CWC is not available for use during the dump, a waste PWR may be used in its place. The Blue/Blue Hose connects directly to the PWR; therefore, a Red/Yellow QD Adapter is not needed at this junction.

Once the WPA is installed and the waste water line under the UIA cover is reconfigured, we will be able to perform nominal EMU waste water dumps, as originally intended. For more information on this, refer to Section 1.1.11, Historical Data Addendum.

1.1.4 Water Maintenance

Background

Maintenance is performed on Airlock water systems to prevent water contamination, due to microbial growth and ionic particulates, and to control subsequent introduction of contaminants into the EMUs. During the time between STS-107 and STS-114, two of three EMUs on orbit experienced failures of their coolant pumps. An effort was launched to determine the causes for these failures. The presence of corrosive particulates in the EMU cooling loop has shown that the ISS thermal loop heat

exchanger has a corrosion problem. The impacts to EMU operations are contamination and the potential to overpressurize the EMU system should the higher pressure LTL breakthrough to the EMU cooling lines at the heat exchanger. Subsequently, the heat exchanger was changed out on orbit to mitigate this potential breakthrough but the need was determined to require coolant loop scrubbing and iodination to maintain the water system.

The EMU Water Processing Kit was developed to address this need. The following information describes the necessary activities needed to perform these maintenance activities and the required hardware.

1.1.4.1 EMU Water Processing Kit

The EMU Water Processing Kit (also known as the Airlock Coolant Loop Recovery kit or ALCLR) was developed to address the need to maintain the Airlock coolant system. The kit is designed to be installed at the Multiple Water Connector (MWC) of the EMU. The kit uses activated carbon, ion exchange resin, filtration, and iodination to control particulate formation. Two configurations are used: scrubbing is shown in Figure 1.1-6, and iodination is shown in Figure 1.1-7. The scrubbing configuration incorporates an ion filter that uses activated carbon to remove organic contaminants and an ion exchange resin to remove ionic contaminants. It also uses a 3-micron filter to remove particulate contaminants. The iodination uses an ion exchange resin to iodinate the coolant loops to ~4 ppm iodine.

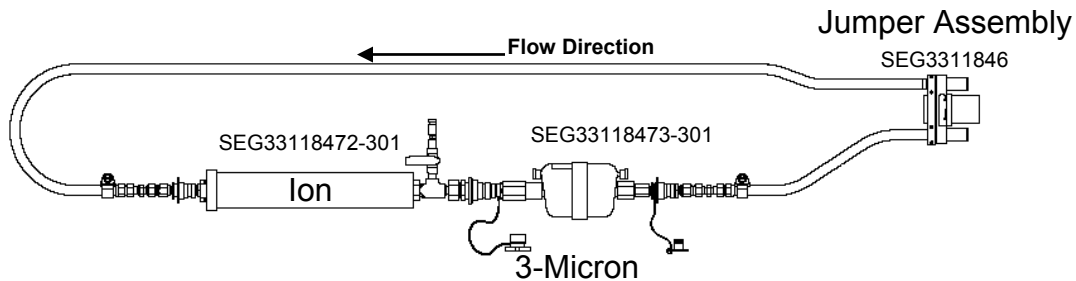


Figure 1.1-6. Scrubbing configuration

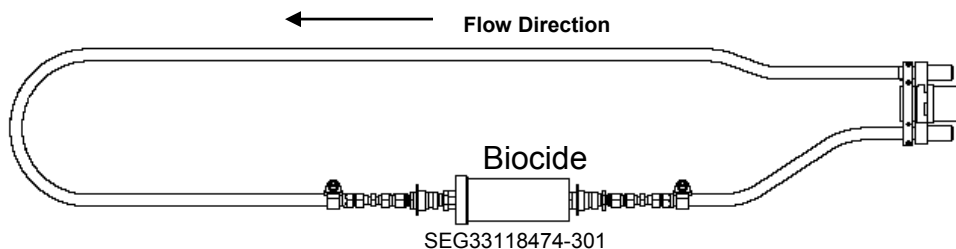


Figure 1.1-7. Iodination configuration

Figure 1.1-8 shows the three filters used in the kit and Figure 1.1-9 shows the EMU Water Processing Jumper Assembly. The kit filters consist of a biocide filter, ion filter, and 3-micron filter (as shown top to bottom, respectively).



Figure 1.1-8. Biocide filter, ion filter, 3-micron filter (top to bottom)



Figure 1.1-9. EMU water processing jumper

The following information provides some technical data for the biocide filter, ion filter, and 3-micron filter. Photos have been provided for each filter. (Refer to Figure 1.1-10, Figure 1.1-11, and Figure 1.1-12.)

Biocide Filter



Figure 1.1-10. EMU biocide filter

- A. 100 uses with SCU (1500 uses w/o SCU)
- B. 1 use w/SCU = ~4L, good for ~2270L of water iodination ==> ~567 uses w/SCU
1 use w/oSCU
- c. Ops Nom Name: EMU Biocide Filter
- d. P/N: SEG33118474-301
- e. Current Cert Name: MCV (Microbial Check Valve, prepared for flight by USA)
- f. Description: Ion exchange resin cartridge capable of adding iodine to a concentration of 1 to 4 ppm
- g. Labels:
 - Combo Label w/ Ops Nom name, P/N, S/N, and barcode
 - Label can be written on, over existing information or in blank space near S/N, to denote “used”

- h. Cleanliness:
- Virtually Clean (VC) external, 300 internal (no particles bigger than 300 microns)
 - 150-micron polypropylene screens on inlet/outlet basically keep MCV at 150, but MCV reqt is 300
- i. Pressure:
- ICD-4-1006-0C-0) max operating pressure at 22 psi above local ambient
- j. Operational = 2270L or ~567 uses w/ SCU...I need the volume assumption w/o SCU to calculate that (or you can)
- Shelf-life = unlimited
- k. Connections:
- Inlet: 1/4-inch M Parker Symmetrics QD
 - Outlet: 1/4-inch F Parker Symmetrics QD

When the EMU biocide filter is used to iodinate the entire cooling system (airlock plus EMU), capacity is subsequently reduced on the Biocide filter.

Based on EMU testing the biocide filter installed in the ALCLR iodinate the EMU/Airlock coolant loop within 1.5 hours and be able to do that 100 times. The Biocide Filter also can be configured to iodinate just the EMU within 30 minutes.

For use of the ALCLR Biocide Filter to iodinate the EMU/Airlock coolant loop, the SCU should be connected. For just iodinating the EMU, the SCU should not be connected. In either case, the Temperature Control Valve (TCV) should be set to "Full Cold" to get the best mix of all of the water in coolant loop. Sometime during the scrub, the TCV should be cycled once to "Full Hot" momentarily and back to "Full Cold" to ensure that all channels in the EMU coolant loop are iodinated.

The minimum flow rate through the biocide filter is 80 lb/hr. The limit at the low flow end is to assure that there are at least 10 volume exchanges so that the iodine has sufficient resupply to make up for lost iodine due to the initial microbial kill. The restriction of the biocide filter sets the flow.

Since the possible temperature range of the SCU coolant temperature is dependant on ISS Integrated Thermal Control System (ITCS) set points, the temperature range that the biocide filter is certified to operate in is from 50° to 90° F.

Ion Filter



Figure 1.1-11. Ion filter

- A. 8 uses with Service and Cooling Umbilical (SCU) (60 uses w/o SCU) or 2 years after first use
- B. Ops Nom Name – EMU Ion Filter
- C. Part Number (P/N) – SEG33118472-301
- D. Current Cert Name – ACTEX

The Ion filter has an exchange resin and activated carbon cartridge capable of removing ionic and organic contamination down to an ionic concentration of 5 mS/cm (micro siemens/cm) or less, and an organic concentration of 5.0 parts per million (ppm) or less.

- E. Labels – The label includes the Operations (Ops) Nomenclature (Nom) name, P/N, Serial Number (S/N), and barcode. The label can be written on, over existing information or in the blank space near the S/N, to denote “used.”
- F. Cleanliness
 - 1. VC (visually clean) external, 500 internal (no particles bigger than 500 microns)
 - 2. Activated charcoal particulates limit cleanliness, 2.5m filter will always be downstream, which meets particulate standards of £150
- G. Pressure – Max operating pressure at 22 psi above ambient (ICD-4-1006-0C-0)

H. Operational and Shelf-Life

1. No less than 16,000ml of water flow (~8 EMU suit/loops of water)
2. 5 years based on expiration date of the ion exchange resin

I. Connections

1. Inlet: 1/4-inch Male Parker Symmetrics QD
2. Outlet: 3/8-inch Female Parker Symmetrics QD

3-Micron Filter



Figure 1.1-12. Micron filter

A. 4 uses or 2 years

The 3-micron filter is currently certified for four uses until more on-orbit data is obtained and tested on the ground.

B. Ops Nom Name – EMU 3-Micron Filter

C. P/N –SEG33118473-301

D. Current Cert Name – Microbial Removal Assembly; similar to 0.2m filter

E. Description – The 2.5-micron polypropylene filter (capsule and media) reduces particulate concentration to less than 3 microns in size.

- F. Labels – The label includes the Ops Nom name, P/N, S/N, and barcode. The label can be written on, over existing information or in the blank space near the S/N, to denote “used.”
- G. Cleanliness
 - 1. VC external, 150 A internal (no particles bigger than 150 microns)
 - 2. 2.5m filter meets or exceeds particulate ratings equal to 150 standards
 - 3. Adapters and QDs mated to filter are cleaned to 150 A
- H. Pressure – Max operating pressure is 22 psi above local ambient (ICD-4-1006-0C-0)
- I. Operational and Shelf-Life
 - 1. No less than 4,000mL of water flow (~1 EMU suit/loops of water)
 - 2. 2 years
- J. Connections
 - 1. Inlet: 3/8-inch Male Parker Symmetrics QD
 - 2. Outlet: 1/4-inch Female Parker Symmetrics QD

1.1.4.2 Operational Scenario

Pre EVA Series Events

The operational scenario of the ALCLR starts with the beginning of an EVA series. An EVA series can be one to six EVAs with less than 2 weeks between EVAs and a maximum time between the first and last EVA of 8 weeks. To keep any particulates that may have formed during the EMU/Airlock down time, both loops should be scrubbed using the ion filter and particulate filter in series.

Event	ALCLR configuration	Airlock configuration	Flow duration (h:mm)	Time constraint
Scrub	Ion/particulate filters	EMU with SCU	≥1:00	≤ 4 weeks before 1 st EVA

Post EVA Series Events

After the EVA series, the loops and suits that were used for the EVAs need to be cleaned with the ion filter and particulate filter in series to remove all contaminants that were formed during the EVAs. This is to assure that the gas trap and pump area do not fail due to solids formed from residual contaminants. After the suits and loops are scrubbed, they are iodinated using the biocide filter to provide a residual biocide for microbial growth control. Since the biocide filter releases a higher concentration of biocidal iodine at warmer water temperatures, there are two approaches to iodinating to

assure that the EMU has the highest level of iodine possible to optimize microbial control. If the Low Temperature Loop (LTL) is below 70° F in the Airlock, then a two-step method is required. If the LTL is above 70° F, then a single-step method could be performed. Typically, the LTL is reconfigured for the iodination phase to meet the requirements of the iodination occurring in the “warm” zone (>70° F) reducing overhead and saving crew time. Also, the ALCLR ion filter should be iodinated by flowing 150 ml of iodinated water through it to prevent microbial growth from occurring when it is stored for over 2 weeks.

Max time between EVAs in a series with no scrub is < 2 weeks.

Scrub

Event	ALCLR configuration	Airlock configuration	Flow duration (h:mm)	Time constraint
Scrub	Ion/particulate filters	EMU with SCU	≥1:00	≤ 2 weeks after last EVA

Iodinate with “cold” LTL Option

Event	ALCLR configuration	Airlock configuration	Flow duration (h:mm)	Time constraint
Loop biocide	Biocide filter	EMU with SCU	1:30	≤ 2 weeks after Last EVA
Suit biocide	Biocide filter	EMU alone	0:30	≤ 2 weeks after Last EVA

Iodinate with “warm” LTL Option

Event	ALCLR configuration	Airlock configuration	Flow duration (h:mm)	Time constraint
Loop biocide	Biocide filter	EMU with SCU	2:00	< 2 weeks after Last EVA

Maintenance

The EMUs should be scrubbed and reiodinated if an EMU sits dormant for more than 90 days from last checkout (including the first checkout on orbit). This can either be done with the SCU connected or disconnected. The advantage of having the SCU connected is not requiring battery charging. The advantage of not having the SCU connected is shorter scrubs and more uses of ion filter. We currently do scrubs with the SCU connected. This takes a little longer but ensures the whole system is treated.

Maximum EMU stagnation time is 90 days.

SCU Disconnected

Event	ALCLR configuration	Airlock configuration	Flow duration (h:mm)
Scrub	Ion/particulate filters	EMU alone	0:30
Suit biocide	Biocide filter	EMU alone	0:30

SCU Connected

Event	ALCLR configuration	Airlock configuration	Flow duration (h:mm)
Scrub	Ion/particulate filters	EMU with SCU	1:00
Loop biocide	Biocide filter	EMU with SCU	2:00

Operational Workarounds

If, for any reason the ALCLR hardware would not be available to scrub or iodinate the suits and loops, then the following should be performed:

Event	Workaround	Airlock Configuration	Flush quantity	Time constraint
Pre-EVA flush	PWR flush	EMU w/ SCU	10 lb of PWR per loop	< 4 weeks before 1 st EVA
Post-EVA flush	PWR flush	EMU alone	5 lb of PWR per EMU	≤ 2 weeks after Last EVA

Scrubber/Filter Operational Constraints

Number of uses (Pre-EVA, Post-EVA, or maintenance)

Unit	Uses with SCU connected	Uses EMU alone
Ion filter	8	60*
Biocide filter	100	1500*
3-Micron Filter	4	4

*15 EMU alone uses = 1 EMU with SCU connected

On-orbit life

Unit	Before first use	After first use
Ion filter	Unlimited	2 years
Biocide filter	Unlimited	Unlimited
3-Micron filter	2 years	n/a
Adapter	2 years from manufacture	-

System History – EMU Cooling Loop Maintenance (Orbit Data)

Figure 1.1-13 shows RTPLOT Airlock data obtained in the MCC in preparation for United States (US) EVA 4. The data shows a Fan ON time of 8:30 to initiate the scrubbing and a Fan OFF at 9:34 for scrubbing termination. During the scrubbing phase, the LTL provides cooling, which allows for the filters to capture contaminants more readily. Once the LTL is deconfigured (cooling disabled) from scrubbing operations, it is reconfigured for the iodination phase in order to meet the requirements of the iodination occurring in the “warm” zone (>70F). Biocide filters provide better iodination at warmer temperatures. It also allows for the single-step method to be performed, saving crew time. A minimum of 2 hours of iodination is shown completed at 12:05 with the LTL reconfigured shortly after. More detailed plots of this data may be obtained from the EVA Systems console log entries for Inc 12 for November 9, 2005.

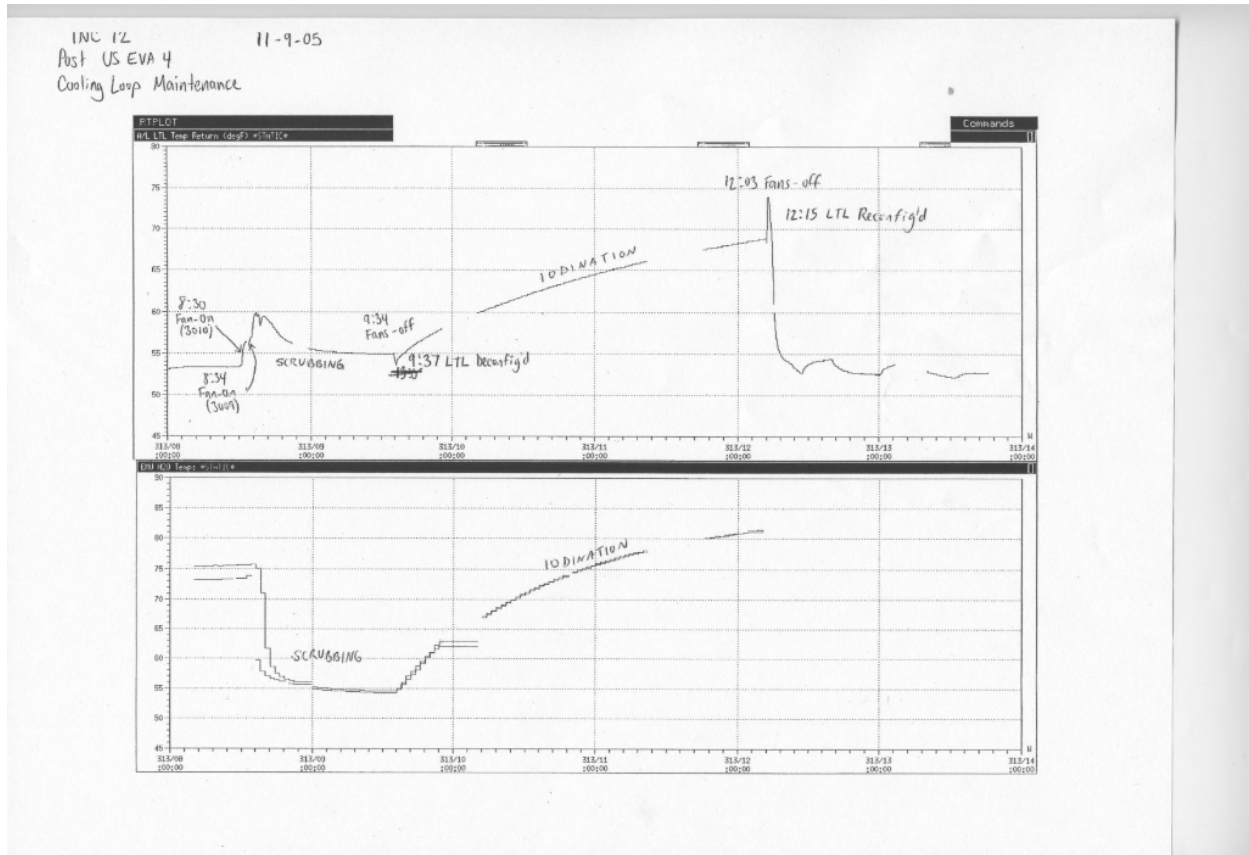


Figure 1.1-13. Pre-US EVA 4 LTL data during scrub and iodination

(A/L LTL Temps(top graph, deg F) & EMU Water Temps(lower graph, deg F) as functions of time)

1.1.4.3 EMU Water Processing Kit Stowage

The first EMU water processing kit was flown up on STS-114. The kit was manifested, as shown in Figure 1.1-14. A kit was flown containing jumpers to be used on two EMUs during servicing operations. The kit is stowed in CTB bags with foam containing appropriately sized cutouts for each component. Figure 1.1-14 shows each CTB containing two 3-micron filters, 1 ion filter, 1 biocide filter, and one EMU water processing jumper.

Each EMU water processing kit subcomponent contains a serial number that is tracked by Mission Operations Directorate (MOD) EVA personnel in the Logistics Tracking Database. This tracking information is used to prevent components from exceeding their design use cycles. Once the initial STS-114 filters are returned on STS-121, an analysis is performed to determine if a life extension is feasible for these filters. This eases future resupply logistics and prevents shortages on orbit. More details on logistics tracking of this kit are provided in Section 1.1.10, Logistics Tracking.



Figure 1.1-14. STS-114 EMU water processing kit

1.1.5 Water Flow Paths

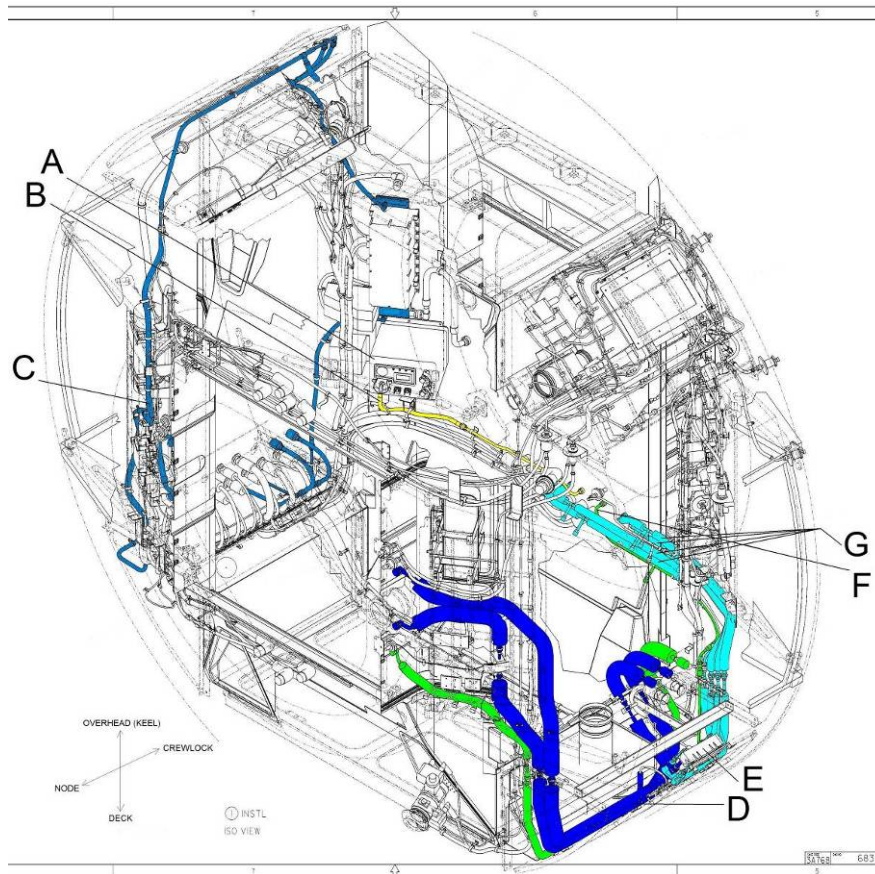


Figure 1.1-15. Airlock port view showing cooling flow paths

- A. In-Flight Refill Unit (IRU)
- B. IRU Water (EMU Water Recharging)
- C. MTL Cooling Lines
- D. LTL Cooling Lines
- E. SPCU Heat Exchanger
- F. EMU Waste Water (to lab condensate tank)
- G. EMU Cooling Water Lines (water out and return lines shown)

Figure 1.1-15 is a Port view of the Airlock showing the various ISS EVA Water Systems flow paths. The Moderate Temperature Loop (MTL), LTL, IRU water lines, EMU cooling lines, and EMU waste water lines have been colored in for clarity. The drawing shows the lines terminating at the Umbilical Interface Assembly (UIA) connection point and at the Airlock to Node interface with the lines leading up to the US Lab condensate tank omitted for brevity.

The lines in yellow routed from the IRU are the water recharge lines. These lines carry fluid from the PWR to the EMUs. Only the portion leading up to the UIA connections is shown.

Figure 1.1-16 shows one simplified EMU cooling loop and includes the EMU Water Processing Kit installed.

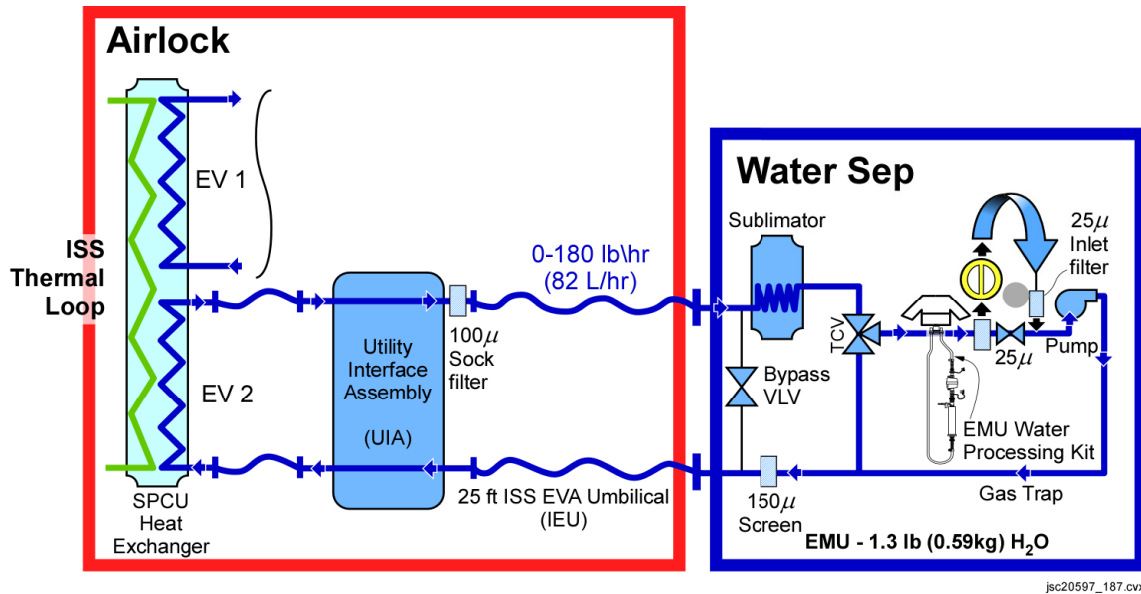
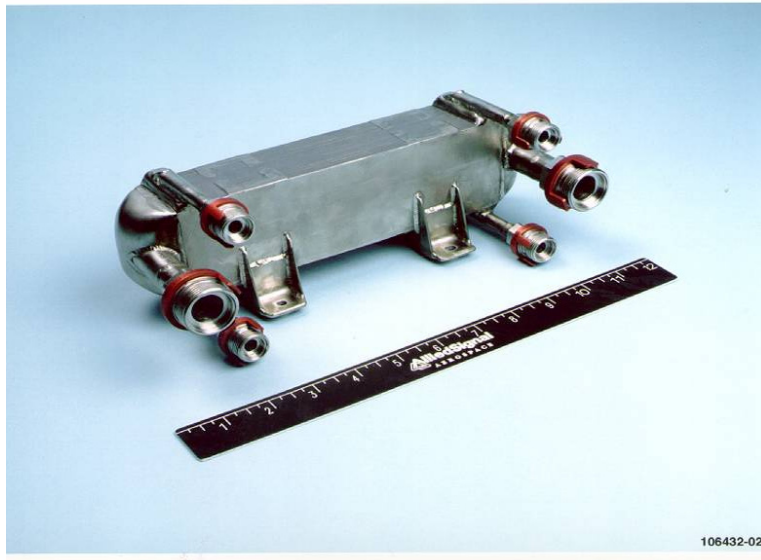


Figure 1.1-16. Simplified EMU coolant loop

1.1.6 EMU Cooling

The EMU cooling loops provide heat removal for the suits by rejecting heat into the LTL via the Service and Performance Checkout Unit (SPCU) Airlock heat exchanger (shown below in Figure 1.1-17). The SPCU heat exchanger may serve one or two EMUs simultaneously. Flow through the respective EMU cooling loops is provided by the EMU pump at approximately 240 lb/hr (chamber data has shown approximately 180 lb/hr with the EMU Water Processing Kit).

Figure 1.1-16 shows one EMU cooling loop for simplicity. Starting at the EMU pump, water flows past the UIA toward the SPCU heat exchanger. The heat exchanger contains a brazed, plate and fin, counterflow core and can handle 2,000 BTU per EMU. Both EMU circuits flow in parallel paths counter to the flow of the ITCS circuit. Flow returns past the UIA, though the SCU and into the EMUs to provide cooling for the crewmember at the Liquid Cooling and Ventilation Garment (LCVG).



**Figure 1.1-17. SPCU Airlock heat exchanger
(PN 2351350)**

Performance Data:

• Heat Transfer Capacity, BTU/hr	2,000 ⁽¹⁾
• Hot-Side Flow Rate, lb/hr	240 ⁽¹⁾
• Cold-Side Flow Rate, lb/hr	300
• Hot-Side Inlet Temperature, deg F	56
• Cold-Side Inlet Temperature, deg F	42
• Effectiveness Cold	0.95 ^(2,3)
• Hot-Side Pressure Drop (@ 240 lb/hr), psi	0.75
• Cold-Side Pressure Drop (@ 300 lb/hr), psi	0.5
• Dry Weight, lb	7.0
• Max Dimensions, inches	11.5(L)X5.1(W)X4.5(H)

NOTES:

- (1) Per EMU Loop
- (2) Effectiveness (Cold) = $(T_{in} - T_{out})_{cold} / (T_{hot} - T_{cold})_{IN}$.
- (3) Simultaneous EMU Loop Operation

During suited operations in the Airlock, ventilation loop condensate for each EMU is introduced at a rate of approximately 0.2 lb/hr (approximately 1.5 lb per EVA). This condensate contains microbes, biological materials, and salts from the crewmember. Excess condensate is returned to the EMU water tanks. The amount of condensate introduced into the system varies, depending on the amount of time spent in the suit with the SCU connected, and usually is determined by the type of Prebreathe Protocol used for the mission.

1.1.7 IRU and PWR

The IRU (Ops Nom), also known as the Fluid Pumping Unit (FPU), is part of the Airlock Service and Performance Checkout Equipment (SPCE) hardware and is used to move water from a PWR into the EMU water tanks. The IRU is designed to interface with the PWR via a QD and accepts up to two PWRs to allow for transfer of water from one PWR to another.

1.1.7.1 IRU

The IRU (Figure 1.1-18) is installed in AL1F2 and is used to pump water from a PWR into the EMUs via Airlock plumbing through the UIA and SCU. The IRU allows fluid from the connected PWR to enter the UIA at a rate of 120 lbm/hr.

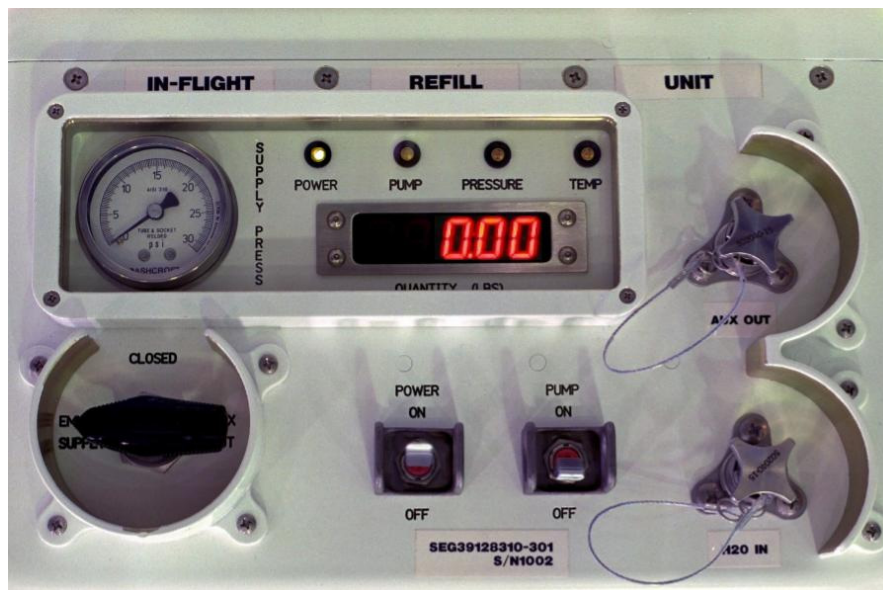


Figure 1.1-18. In-Flight refill unit

Power up of the IRU begins at the PSA IRU/Utility Power switch. Due to power loading constraints, crew should always contact Mission Control Center-Houston (MMC-H) when turning on the IRU if other operations are drawing power from the Utility Power Outlet (approximately 6 A max combined power draw from all users). For additional technical specs, reference the IRU section of this console handbook.

Once the IRU is powered up, a PWR is connected at the H2O IN port. Water is then pumped to the EMU or to another PWR through the AUX OUT port, depending on the setting of the IRU rotary valve.

Water may be transferred to another PWR to consolidate PWRs or if a PWR has a leak in it. Figure 1.1-19 shows the IRU/PWR configuration for a PWR consolidation. Note that the PWR on the bottom has had its zipper opened for ease of view of the water bladder within the restraint bag.



Figure 1.1-19. PWR consolidation

When water is transferred from one PWR to another, the expiration date of the water in the newly filled bag is equivalent to the expiration date of the oldest water. Therefore, if one bag is going to expire in 6 months, and the other in 2 months, the new expiration date of the combined PWR water is 2 months. Furthermore, if a PWR is to be dumped and refilled, the expiration clock of the PWR is reset to 1070 days only if its water quantity has gone below 5 lb of water. More information on PWR water expiration may be obtained in Section 1.1.10, Logistics Tracking.

During water transfer from the source PWR, SSATA testing has shown that there is no issue in the event that the PWR should run dry. Operationally, crew turns the pump off and swaps out for a new PWR.

1.1.7.2 PWR

The PWR is a soft container used for a variety of fluid collection and stowage applications on shuttle and ISS systems. Two primary applications of the PWR have been identified during the development of PWR hardware: the transport to orbit and short term storage of Internal Active Thermal Control System (IATCS) resupply fluid; and the storage and transfer of high-purity iodinated potable water for the charging of EMUs. PWRs specified for EMU use are specified as EMU PWRs and are not used for IATCS applications, and the reverse also applies.

Several life extensions have been given to PWR water based on analysis. Currently, PWR water is acceptable for use in the EMU if it is less than 1070 days old. Analysis has shown that pH levels for 1070-day-old water is 5.44 (slightly acidic) and has no detrimental affect on sublimator performance. There is currently little to no water left in storage older than 1070 that may be tested to extend the on orbit life of PWR water.

PWRs are launched dry and filled on orbit. They are filled using the Shuttle Orbiter Repackage Galley (SORG also known as the Shuttle Galley) with a supply pressure of 15 to 20 psig to about 22 lb of water (~3.3 gal) in about 40 minutes, as shown in Figure 1.1-20.



Figure 1.1-20. PWR refill using the orbiter galley

PWRs have a nominal capacity of ~10 liters (22 lb) of water and can therefore recharge two completely drained EMUs. Although all nominal operations are at ambient pressure, the PWR is certified to withstand a limited pressure condition. All PWRs are certified clean for potable water containment. After a PWR is used on orbit and returns to the ground, a new bladder is installed prior to acceptance testing and re-flight.

PWR Degassing

Prior to refilling an EMU, crew inspects the PWR for gas bubbles. To prevent gas from being pumped into the EMU water tanks, a degassing technique has been developed to flush most of the gas out of the bag prior to EMU filling. Two 11-inch Russian bungees are used to squeeze the bags, as shown in Figure 1.1-21.

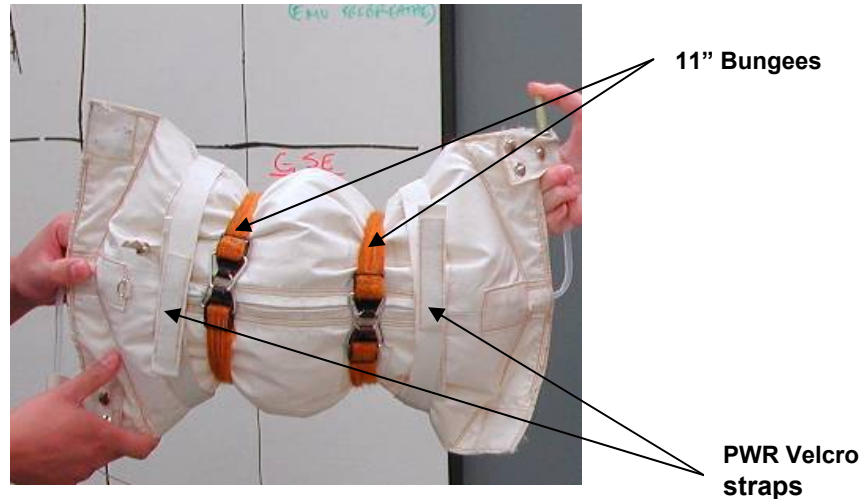


Figure 1.1-21. PWR with bungees

To get the gas out of the bag, the ground servicing port is used. The PWR de-gas tool was developed to allow for depressing of the poppet located in the ground servicing port, as shown in Figure 1.1-22.

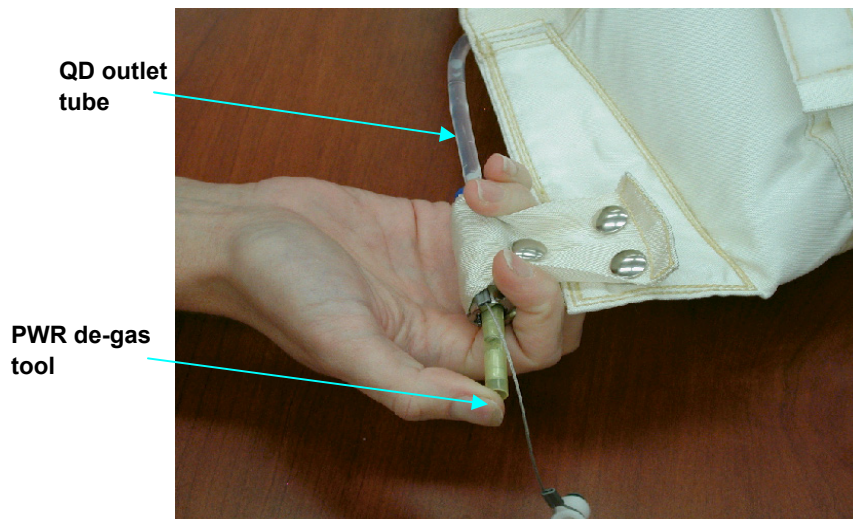


Figure 1.1-22. Insertion of de-gas tool

The tool contains a “V” cut at the bottom that makes contact with the outlet port to allow the gas to escape. Once pressure is applied to the bag and an outlet for the gas to escape is available, the crew must force the water away from the outlet opening. Should crew depress the outlet poppet prior to rotating the bag, water flows out of the bag. Therefore, the water needs to be moved out of the way of the outlet poppet. To do this, the bag is rotated about the crewmembers axis of rotation with the outlet opening closer to the crewmember than the rest of the bag. Crew holds a towel near the outlet to catch any free water droplets that might escape. (Refer to Figure 1.1-23.)

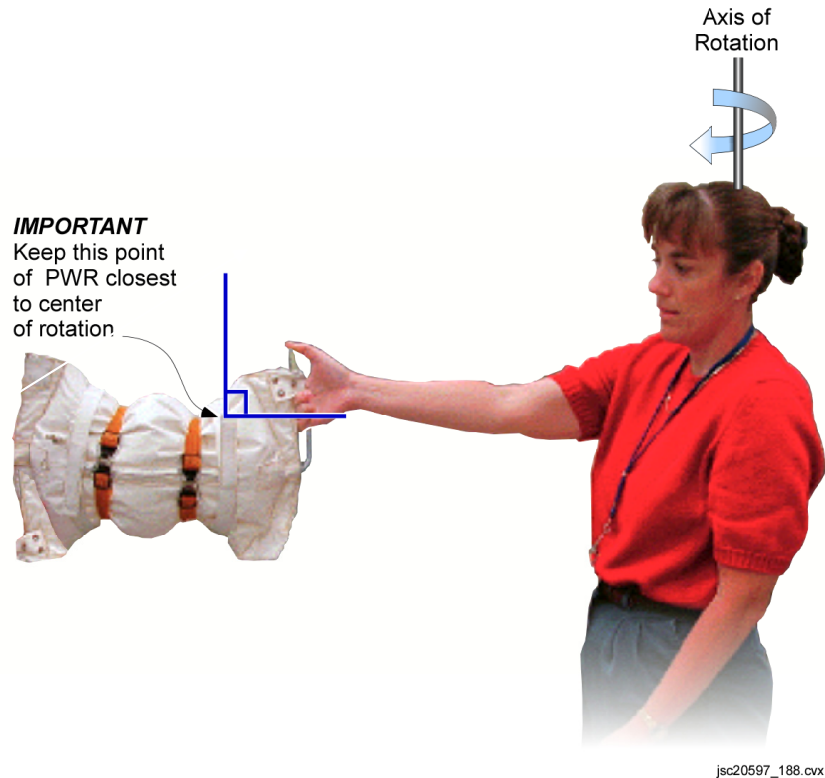


Figure 1.1-23. Position for rotation of PWR

As the bag is rotated, the water moves away from the crewmember and, thus, away from the outlet opening. Only then does the crewmember depress the outlet poppet to allow the bungees to squeeze the gas out of the bag. A negligible amount of water may also flow out of the bag during degassing and is captured into a towel.

A more detailed description of PWR degassing may be obtained by referencing the ISS EVA Systems Checklist Procedure, Payload Water Reservoir De-gas. Operators may also reference on orbit-video footage of Expedition 9 crewmember Mike Fincke performing PWR degassing in the US Lab.

1.1.8 CWC Description

The CWC is a soft container used for a variety of fluid collection and stowage applications on shuttle and ISS systems. (Refer to Figure 1.1-24.) The primary application of the CWC is as a container for the transport and resupply of potable water from the shuttle to the ISS, as was similarly done for the Mir Program. For this application, orbiter fuel cell water is processed through the Galley Iodine Removal Assembly (GIRA) where silver (biocide) and minerals (for taste) are injected into the CWC as it is filled on the orbiter middeck. Another important application is for the collection and stowage of humidity condensate on the ISS. In addition, there are several contingency uses to collect condensates, wastewater, and other unique fluids such as EMU wastewater. Thus, the CWC inner lining is shown to be compatible with a number of different fluids. Fluid compatibility over time will also be proven, to show that

various fluids can be stowed in CWCs for months at a time without the degradation of either the fluid or CWC itself.

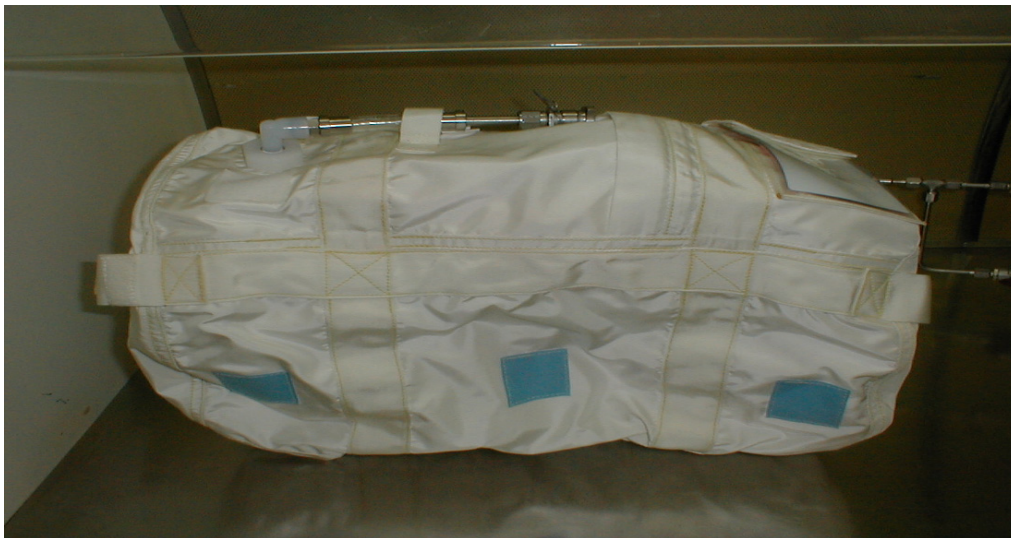


Figure 1.1-24. CWC (-305 flight configuration)

CWCs have a maximum capacity of 120 lb of water. However, operational constraints limit the filling of CWCs to 95 lb to protect against overpressurization. This constraint also serves to limit the weight in Orbiter Volume G or H, which is where CWCs would be stowed in the event of rapid safing for an emergency landing. CWCs are also certified to land full (95 lb) in any appropriately sized Multipurpose Logistics Module (MPLM) Resupply Stowage Rack (RSR) location. Although all nominal operations are at ambient pressure, the CWC will be certified to withstand a limited pressure condition.

The CWC consists of an outer restraint and an inner bladder. The restraint is primarily made from Nomex fabric and Nomex reinforced webbing, and is designed to provide protection against inadvertent external bumps, structurally contain any internal pressure forces, and contain various crew interface features such as handles, pockets, and labeling. The bladder is made from a thin, clear material, Combitherm VPCXX-140, chosen by the National Aeronautics and Space Administration (NASA) for its compatibility with a large number of different fluids. Combitherm is a multilayered material with polyethylene as the outer most layers. To aid in the proper seating of the bladder with the restraint and to minimize unnecessary bladder crimping and crinkling, the bladder is anchored to the restraint in several places.

The primary fluid interface of the CWC is a 3/8-inch male QD fitting. From this port, all filling and emptying on orbit takes place. A service port is located on the underside of the CWC and is used for ground servicing only. It remains plugged while on orbit. All certified CWCs are cleaned and disinfected for potable water containment for their initial use. After a CWC is used once, all future fills with this unit must be with nonpotable water only, since the potability cannot be guaranteed without reprocessing on the ground.

1.1.9 UIA

The UIA in the Crewlock provides the capability to connect EMU suits to the ISS for power, data, communication, suit cooling, and O₂ during EVA prep for egress and Airlock ingress following an EVA (or for conserving EMU consumables). It also provides these capabilities during Intravehicular (IV) operations for EMU maintenance and checkout activities. Water is supplied to the UIA from the IRU for EMU water recharging activities. When charging EMUs, the UIA Supply valve is placed in the OPEN position and Regulator is set to SUPPLY for each EMU. Water flows through a biocide filter as it moves from the PWR to the EMU and is, therefore, iodinated. Two biocide filters are located under the UIA cover with the second one located on the waste water line to iodinate water that is dumped from the suits. More technical information relating to the UIA may be found in the UIA section of this console handbook.

UIA Condensation Concerns – When the UIA is configured to allow flow through the Liquid Cooling Ventilation Garments (LCVGs), required cooling is provided to the suited Extravehicular (EV) crewmembers. This coolant flow path is isolated physically from the Airlock ITCS LTL with heat rejection accomplished in the SPCE Heat Exchanger (HX). The EMU Primary Life Support System (PLSS) contains a pump that circulates the water through the LCVGs based on comfort settings used by the EV crewmember. When the UIA was installed in the Crewlock, there is plumbing that is part of the UIA that is not insulated. This discovery was made at a point in time of the outfitting schedule that it would have caused a significant mission slip to correct it. It has not been determined when this will be corrected. Analysis was performed to determine the best way to deal with this operationally. For now, the Airlock CCAA setting is set lower when the EMUs are connected flowing water and additional personnel in the Airlock is limited. Due to restricted access, there is no way to reach behind the UIA and towel off the area.

1.1.10 Logistics Tracking

EVA Water Systems logistics are tracked using the V: drive logistics tracking database. During orbit operations, console operators log information such as PWR drain quantities, PWR fill quantities, CWC fill quantities, ALCLR events, etc. More information on EVA Water Systems logistics tracking can be found in JSC-20597, Volume 1, EVA Console Handbook, Section 4.6, EMU Logistics Tracking Database.

1.1.11 Historical Data Addendum

A. EMU Waste Water Dump Data

Table 1.1-1 shows water usage data from STS-82 and STS-104 and is provided here for reference to show potential EMU water recharge amounts. During an EVA, there is no direct insight into the water usage rate of an EMU. For LiOH-based EVAs, a usage rate of 0.8 lb/hr is used as a conservative value. For Metox, 1.0 lb/hr is assumed for calculations. The operator should reference the EMU Consumables User Guide and EMU Consumables Spreadsheet for more information regarding water usage calculations.

Table 1.1-1. Sample water usage data from STS-82 EVAs

STS-82

EVA	EVA time	Met rate (Avg)	TK C qty (%)	H ₂ O lb refill (2 EMUs)	H ₂ O lb refill (per EMU, w/ 1lb ullage)	Usage rate (lb/hr)	% Used of primary tanks (7.47 lb)
1	6:42	758/800	5.2	8.666	3.407	0.508	45.6
2	7:27	760/800	5.1	8.5	3.324	0.443	44.5
3	7:11	732/782	5.6	9.333	3.74	0.521	50.1
4	6:34	743/690	4.6	7.666	2.907	0.447	38.9
5	5:17	751/695	3.3	5.5	1.824	0.345	24.4

STS-104

EVA	EVA Time	Met Rate (Avg)	TK C Qty (%)	H ₂ O lb refill (2 EMUs)	H ₂ O lb refill (per EMU, w/ ullage)	Usage Rate (lb/hr)	% Used of primary tanks (7.47 lb)
1	5:59	???/???	4.6	7.6	2.8	0.468	37.3
2	6:29	744/668	4.4	7.25	2.6	0.401	34.7
3*	3:55	957/797	N/A	12.8	3.9	0.996	52.0

* EVA 3 was the first out of the ISS Joint Airlock and the first to use METOX

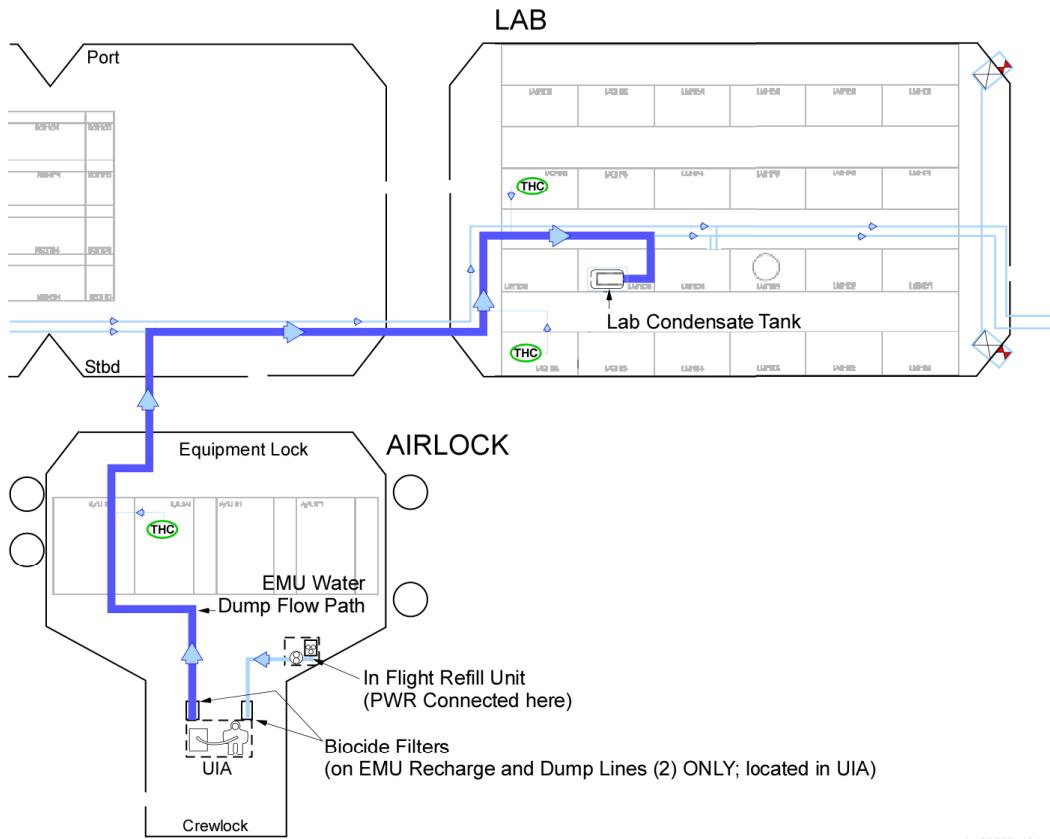
During water dump after fill, a dump rate of 0.9257 lb/min was used in the above table based on data (420 cc/min) taken from STS-82 V1103.01 (Airlock Functional) test. Data during STS-104 indicates 1.0 lb/min dump also for Joint Airlock.

Since we did not perform a feedwater recharge on orbit on STS-96, we had a rare occasion to find out the actual water used during the EVA. Using the preflight water charge data and the postflight water drain performed at USA FCE/EVA, the actual water usage was 2.69 lb for EV1 (on Remote Manipulator System (RMS)) and 5.43 lb for EV2 (free-floater).

The average metabolic rate for EV1 was approximately 615 BTU/hr, and the average metabolic rate for EV2 was approximately 875 BTU/hr.

B. Intended Nominal Water Dumping Scenario

Figure 1.1-25 depicts the waste water lines used by the EMU and the Common Cabin Air Assembly (CCAA) to pump water into the lab condensate tank (labeled as EMU Water Dump Flow Path) and may be used for reference. As designed, the complete flow path to the lab condensate tank is used any time the EMUs water tanks are dumped as part of the nominal ullage dump after water recharging activities.



jsc20597_184.cvx

Figure 1.1-25. EMU water dump and fill flow paths

Table 1.1-2 and Table 1.1-3 show EMU Water dump history from 2002 through 2004. In some cases, water was processed by the SRV-K; while in others, the water was vented overboard.

**Table 1.1-2. EMU waste water dump history
(from ISS ECLSS water mini-TIM August 2005)**

Date	Quantity EMU wastewater (lb)	Quantity Lab Condensate Tank (lb)	Tank Offload Date	CWC Serial Number	Flush, Process, or Vent
JUL-21-2001	2.62	102	27-Jul-01	1009	Vented
FEB-21-2002	1.3	83	22-Feb-02	1022	Vented
APR-11-2002	unk	47	16-Apr-02	503XX	Vented
APR-13-2002	1.1	65	16-Apr-02		
APR-14-2002	1.25	78	16-Apr-02		
APR-16-2002	unk	89	16-Apr-02		
JUN-9-2002	1.35	65	1-Jul-02	1004	Processed
JUN-11-2002	1.63				
JUN-13-2002	0.9				
AUG-17-2002	0.82	40.24	21-Aug-02	1004	Processed
AUG-30-2002	1.58	50.89	2-Sep-02	1022	Processed
OCT-10-2002	1.43	26	18-Oct-02	1004	Processed
OCT-12-2002	1.17	30	18-Oct-02		
OCT-14-2002	1.54	40	18-Oct-02		
NOV-27-2002	1.49	54.4	10-Dec-02	1022	Processed
NOV-29-2002	1.12				
NOV-29-2002	1.09				
JAN-15-2003	unk	43	22-Jan-03	none	Vented
APR-9-2003	1.25	21.62	28-May-03	1027	Processed
Fall-2004	0.5	TBD	TBD	TBD	Flushed

Table 1.1-3. EMU waste water dump history showing mission-specific data

EMU FEEDWATER ULLAGE DUMPS TO LAB CONDENSATE TANK

POST EVA

AVAILABLE DATA POINTS:

	TOTAL (lb)	PER EMU (lb)
8A	1.5	0.75
	1.23	0.615
	1.24	0.62
UF2	1.35	0.675
	1.63	0.815
	0.9	0.45
9A	1.42	0.71
	1.33	0.665
	1.51	0.755
11A	1.49	0.745
	1.12	0.56
	1.09	0.545
INC 6	1.25	0.625
AVERAGE	1.31	0.66
MEDIAN	1.33	0.67

1.1.12 Related Documentation References

JSC-20597, Volume 1, EVA Console Handbook

JSC-60417/CTSD-SS-2728 FEMU-R-003 Rev L-2, EMU On-Orbit Operation, Maintenance, Testing, Storage, and Tracking Requirements and Constraints, January 15, 2008

ALCLR Design White Paper, John F. Lewis, EMU/Airlock Coolant Loop Tiger Team Lead, NASA JSC EC6, April 20, 2005

JSC-39375B Project Technical Requirements Specification for the Contingency Water Container, April 25, 2001

EMUM 1034-1070 day PWR water acceptability, March 22, 2004

EMUM 1038-Gas Bubble SEMU 3011 during ISS 8 midterm checkout, March 29, 2004

ISS AR 000257, High Residual Water Pressure

“Feedwater Gas Bubble” presentation from Colin Campbell, April 5, 2004

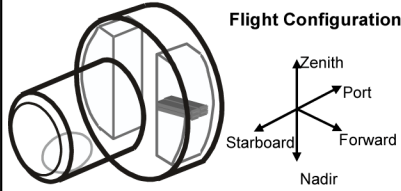
JSC-62294 ISS EMU Airlock Cooling Loop Recovery Kit CARD

EMU Water Dumping presentation to ISS ECLSS Mini TIM, Laurie Peterson-ISS ECLS Subsystem Manager, August 12, 2005

DX35 EVA Systems Logistics Tracking Database

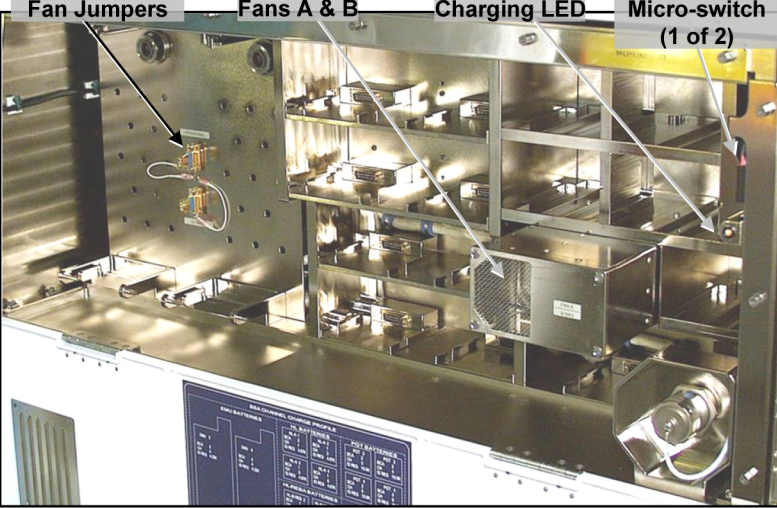
DX35 EVA Consumables Spreadsheet User Guide

ISS AIRLOCK SYSTEMS		Reference only	
ELEMENT AL	Battery Storage Assy & Battery Charger Assy		PAGE 1



Flight Configuration

Zenith
Port
Starboard
Forward
Nadir



Fan Jumpers Fans A & B Charging LED Micro-switch (1 of 2)

AL1F1 - Avionics Rack
BCA: SEG39128212-301
BCM: SEG39128256
BC1: sn1001 (type -301)
BC2: sn1003 (type -301)
BC3: sn1006 (type -303)
BC4: sn1007 (type -303)
Spares: None on-board
BSA: SEG39128213
sn1002 (type -601)
Spares: None on-board

BSA SLOT ASSIGNMENTS (similar to BSA Door Placard SDG33113132)

EMU Batteries		HL-A Batteries		PGT Batteries	
EMU 1 BC 4 CH 1 ID 02 EMU SUIT	EMU 2 BC 3 CH 1 ID 02 EMU SUIT	HL-A1 BC 2 CH 1 ID 03 HL-A	HL-A2 BC 1 CH 3 ID 03 HL-A	PGT 2 BC 2 CH 3 ID 06 PGT	PGT 3 BC 2 CH 4 ID 06 PGT
EMU 3 BC 3 CH 4 ID 01 EMU BSA		HL-A3 BC 1 CH 5 ID 03 HL-A	HL-A4 BC 1 CH 6 ID 03 HL-A	PGT 4 BC 2 CH 5 ID 06 PGT	PGT 5 BC 2 CH 6 ID 06 PGT
		HL-B Batteries		PGT 1 BC 1 CH 1 ID 09 PGT	
EMU 4 BC 4 CH 4 ID 01 EMU BSA		HL-B/EMPTY2 BC 1 CH 2 ID 04 HL-B or 10 HL-B EMPTY	HL-B/EMPTY3 BC 1 CH 4 ID 04 HL-B or 10 HL-B EMPTY	FAN A FAN B	
		HL-B/EMPTY4 BC 3 CH 3 ID 04 HL-B or 10 HL-B EMPTY	HL-B/EMPTY5 BC 4 CH 3 ID 04 HL-B or 10 HL-B EMPTY	HL-B/EMPTY1 BC 2 CH 2 ID 07 HL-B or 11 HL-B EMPTY	AUX.CHG.PORT 1) BC3, CH2 2) BC4, CH2 3) BC3, CH5 4) BC4, CH5 5) BC3, CH6 6) BC4, CH6

CHARGE TIMING SEQUENCE

MAX HOURS	BC1	BC2	BC3	BC4
	PGT 1	HL-A1	HL-B4	HL-B5
2				
3				
4				
5				
6				
7				
8				
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POWER PATH (POST 13A)

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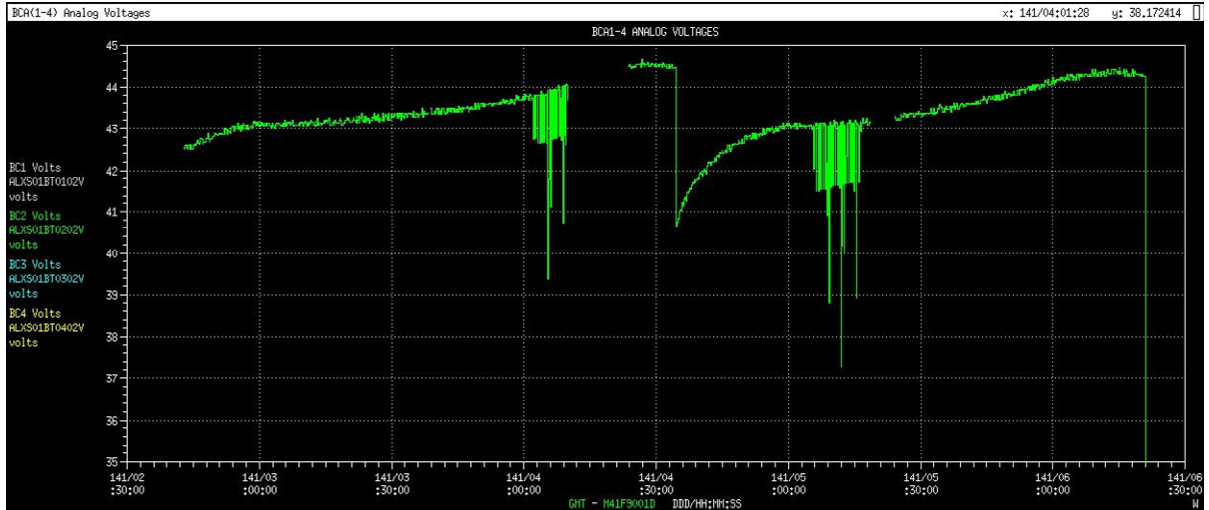
    Solar Array: Channel 1A -or- Channel 4A
    DCSU: 1A: RBI 6 -or- 4A: RBI 6
    (Direct Current Switching Unit)
    SARJ: Starboard -or- Port
    (Solar Array Rotary Joint)
    MBSU: 1: RBI 3 -or- 4: RBI 3
    (Main Bus Switching Unit)
    DDCU: LA1A -or- LA4A
    (DC-to-DC Converter Unit)
    RPCM LA- 1A4A-F: RPC3
    RPCM AL- 1A4A-B:
        RPC 3 -> BC 1
        RPC 4 -> BC 2
        RPC 5 -> BC 3
        RPC 6 -> BC 4
    
```


ISS AIRLOCK SYSTEMS									
Reference only									PAGE
ELEMENT	Battery Stowage Assy & Battery Charger Assy								3
BCA CHARGE AND DISCHARGE PARAMETERS FOR VARIOUS BATTERY TYPES									
	Charge Amps (& Alt Charge)	Charge Volts (OCV)	Charge Type / Cutoff Type	Charge Time-Out* HH:MM	Dis-charge Amps	Dis-charge Cutoff Voltage (OCV)	Amp Hours	Minimum Amp Hours	COMMENTS
-301 type									BOLD = Parameter used by charger as a control.
-303 type									
-305 type									
10 HL-B Empty	0.0A	0.0V	ReFLEX / Voltage Maximum Curve	00:00	0.0A	0.0V	0.0AH	0.0AH	Obviously, not a real battery type. ¹ FIX: The -303,-301 chargers intermittently would not proceed past these channels due to slight positive V bias / noise.
11 HL-B Empty	0.0A	0.0V		00:00	0.0A	0.0V	0.0AH	0.0AH	
	1.00A	18.0V		4:00	1.0A	15.0V¹	3.4AH	2.5AH	
01 EMU BSA	1.55A	21.56V	Constant Current / Voltage Cutoff	22:00	1.50A	15.95V	46.0AH	26.6AH	² FIX: Parameters modified on-board via OCA 05-1339 to get a complete maintenance recharge of a fully discharged EMU ICB.
		21.78V²		30:00²	1.50A				
		21.78V		30:00	3.0A				
03 HL-A 04 HL-B 07 HL-B	1.00A³	18.0V	ReFLEX / Voltage Maximum Curve	4:00	1.0A	15.0V	3.4AH	2.5AH	³ On -301 chargers, for unknown reasons, charge current is actually around 1.3A.
06 PGT 09 PGT	0.55A⁴	36.0V	ReFLEX / Voltage Maximum Curve	4:15	0.5A	30.0V	1.9AH	1.0AH	⁴ On -301 chargers, for unknown reasons, charge current is actually around 0.7A.
					0.5A				
					1.0A				
08 REBA-30	1.00A	36.0V	ReFLEX / Voltage Maximum Curve	4:15	0.5A	30.0V	3.60AH	2.5AH	While REBA is a 12V system when in use, the battery cell strings are reconfigured when the REBA jumper cable is separated for charging. For the 30-cell channel, the 3 10-cell strings are thereby placed in series, resulting in the higher voltage.
					0.5A				
					1.5A				
05 REBA-10	1.00A	12.0V	ReFLEX / Voltage Maximum Curve	4:15	0.5A	10V	3.60AH	2.5AH	
					0.5A				
					1.5A				
02 EMU SUIT	1.55A	21.56V	Constant Current / Voltage Cutoff	22:00	1.5A	15.95V	46.0AH	26.6AH	In-suit charging has not been reinstated since a grounding sneak circuit exists when both umbilicals are connected to EMUs (IFI-TBS)

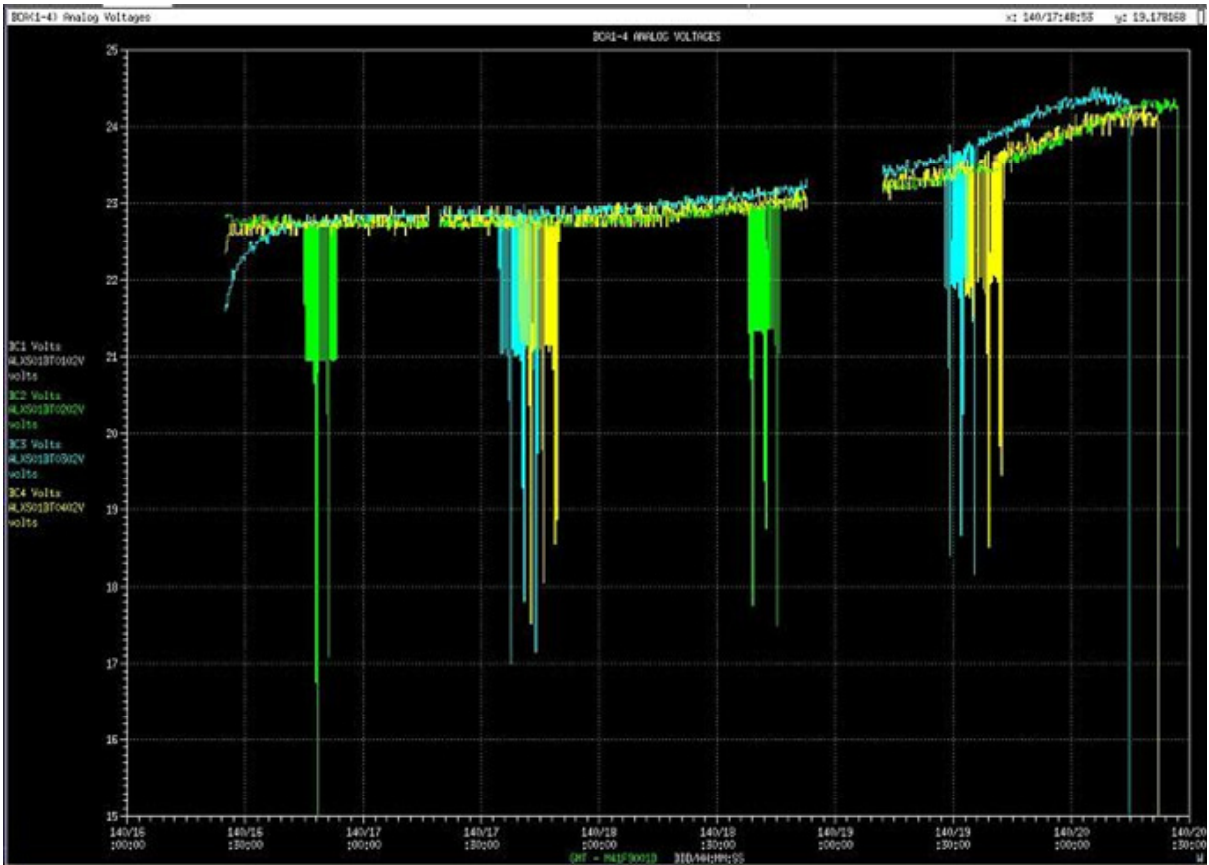
* Actual maximum charge time is 3 minutes longer due to the initial Alt Charge performed at the start of every charge sequence.
For battery specific voltage profiles during charge and discharge, see details in the BCA Systems Brief.

ISS AIRLOCK SYSTEMS		Reference only	
ELEMENT AL	Battery Stowage Assy & Battery Charger Assy		PAGE 4
Known Issues (IFIs, ARs, Chits)			
Document	Signature	Workaround	
DURING CHARGING			
	BCA unable to topower some EMU batteries	Condition EMU battery by performing majority of EMU C/O on battery power	
	Some EHIP batteries do not lock in BSA		
	CREW sees pages skipped when cycling through channel history (i.e. slow display response.)	Train crew to cycle DATA switch when hourglass is not displayed or use PCS to more quickly view data.	
IFI-0929 IFI-1644	HL battery sn1038 reads 0V on BSA slots (BC1:Ch4 and BC2:Ch2); these slots incapable of recognizing/ charging this battery.	Battery was installed in other slots with good voltage indications; battery has subsequently been returned, but no root cause was identified.	
IFI-0500 IFI-0619	In-suit Charge terminated early and UIA amperage indicated amperage on both umbilicals although one charger had stopped.	In-suit EMU Battery Charging no longer allowed.	
IFI-1211	CREW sees no voltage reading on front panel display when EMU batteries start charging.	Verify nominal charge current. Use MCC or PCS analog voltage data, or wait for panel Volt data to update (EMU OCV will update ~2 minutes)	
IFI-0918 IFI-1137 IFI-1876	Charger randomly stops charge and issues "STOP SW TOGGLED" (caused by noise on the command lines within charger)	Have crew restart charge with switch or use other charger. Noise is reduced in -303 charger and if UIA PWR switches are OFF.	
-301 Chargers Only			
IFI-1494	BCM sn1001(BC1) display permanently garbled and frequent erroneous "STOP"	BC is considered failed for all operations. Power cycle did not fix. Likely due excessive noise & lockup of display circuitry	
IFI-0770	Charge inexplicably stops and data shows "No History" on all channels.	Restart charge with switch. Signature of a power interrupt, but data rate too slow to catch.	
	High charge current indication on BCM display for EMU In-suit charge.	UIA modified to show charge current, providing verification of in-suit battery recharge current	
	At startup, CREW sees BCM display garbled / blank or "look at" message displayed.	Power off UIA prior to powering on BCA	
IFI-1494 IFI-0701 IFI-0476	CREW sees temporary or locked 'Garbling' of data on front panel display -OR- are immediately returned to Main display	Functionality not affected. Cycling 'history' sw may correct. Else, use MCC or PCS data, and eventual Power cycle	
DURING DISCHARGING			
IFI-0842	When using an SSC to perform maintenance, charger becomes unresponsive (no comm w / SSC, STOP switch doesn't change BC's display)		
IFI-1181	Crew sent command to start discharge, SSC display indicates discharging, but analog voltage Delayed discharge startup		
-301 Chargers Only			
IFI-1478	BC2 RPC tripped (AL1A4A B RPC4) at the end of the battery's discharge	BC shall not be used for discharging. Upgrades in -305 type will reduce the amps spike used to test if battery is still connected.	
TELEMETRY ONLY ISSUES			
	MDM card LLA13, CH3 (BC3 Current Monitor) Alarm msg toggled on and off		
	MDM card LLA13, CH5 (BC4 Voltage Monitor) Alarm msg toggled on and off		
	MDM card LLA13, CH6 (BC4 Current Monitor) Alarm msg toggled on and off		
IFI-1883	Unpowered BC's 'False' Serial Data: wrong data stream is intermittently populated erroneously with data from another (powered) charger.		
	Analog Data periodic "Noise": data sampling speed usually syncs up to (dis-)charging (loaded) voltage, but slowly will phase into showing battery OCV temporarily.		
IFI-0771	False Amps when PSA being used: While BCs are powered off, Analog Amps indicate ~0.25-0.3amps		
IFI-0500	In-suit EMU Battery Charging no longer allowed. Charge terminated early and UIA amperage indicated amperage on both umbilicals although one charger had stopped.		
IFI-0489	Empty EMU In-suit and PGT battery slots resulted in "Short Circuit error", and HL-empty slots received "Time-out error", rather than the expected "Battery Circuit open" message.		
IFI-0487	FIXED		
Ops Notes & History			
<ol style="list-style-type: none"> Previous ORU: Pre-7A testing identified many intermittent issues related to electrically noisy signal within -301 type chargers. Two upgraded spares (-303 type) were prepositioned on-board. Inc-4 performed IFM of the BC3 and BC4 positions via IFM procedure 4.2.803 AIRLOCK BATTERY CHARGER MODULE (BCM) R&R AL1F1 Charge Resumption after BSA Door Opened: charging resumes at a random channel, & the 'Over-Temp' message will continue to be displayed for all channels not yet charged. Firmware Table parameters updated by Crew: (1) Inc-5 crew updated the charge cutoff voltage and Max charge time for EMU ICBs per OCA05-1339 and -1381A (2) Inc-8 crew modified the 'anlz' feature to allow automated charge-discharge maintenance cycle per OCA08-0627. Don't stow batteries in the BSA: there appears to be a parasitic load on batteries stowed connected for a couple months, even when the BCAs are off. (several batteries found to be below 1V.) Non-maintained NiMH batteries & Over-Temp: Batteries which have not been used in ~6 months may end with an Over-Temp, Time-Out, Low-slope, Wrong Batt/Hi Imp. The Charger will re-initiate recharge automatically on only those batteries which receive an Over-Temp Error. If no other batteries are present or will / can be charged in that charger's sequence, this will cause an endless charge (charge then Over-Temp). This results in voltage swings and degradation of battery life. The crew must shut down the charger manually or worst case RPCs should be opened. 			
References			
<ol style="list-style-type: none"> 			

Battery Charge Profile - Normal PGT



Battery Charge Profile - Normal HL



ISS AIRLOCK SYSTEMS		Reference only	
ELEMENT AL	Battery Stowage Assy & Battery Charger Assy		PAGE 6
Hazard Number	Hazard Description:	Operational Control:	
	Fire due to overheating of electrical components/batteries	Any heat generated in the BSA is dissipated through the rack structure. There are no operational temperature concerns with the BCA/BSA, during normal operation. If the coldplate were to fail, the worst-case temperature would be in the BCA DC/DC Converter.	
	Fire due to battery rupture	The crew procedures will ensure that the crew scrolls through the BCA display to check that the battery to be charged matches the profile. The data is also monitored by the ground via the MDM. The crew will be trained on all corrective actions taken once	
	Loss of habitat environment due to presence of toxic electrolyte from venting or leakage of batteries	Crew procedures for battery electrolyte clean up exist. The crew will also be trained to look for electrolyte before removing any battery.	

1.2 BATTERY CHARGER ASSEMBLY (BCA)

1.2.1 Quick Look Reference Data

Table 1.2-1 shows the specifications of the Battery Charger Assembly (BCA) and Battery Charge Module (BCM) sub-assemblies.

Table 1.2-1 . Battery charger assembly reference data

Description	Specification	Comments
On-Orbit Replaceable Unit (ORU)		
ORU procedure	4.2.803 AIRLOCK BATTERY CHARGER MODULE (BCM) R&R A/L1F1	Owner: Operations Support Officer (OSO)
Part number: BCM	SEG39128256	Refer to Section 1.2.6 Failure and Design History regarding dash number differences
BC 1	-305	<i>Changed out during STS-124</i>
BC 2	-305	<i>Changed out during STS-124</i>
BC 3	-303	Changed out during Expedition 4
BC 4	-303	Changed out during Expedition 4
Anticipated Configuration:		<i>-306 Chargers are anticipated to be launched late 2009 or 2010</i>
BC 1	-305	
BC 2	-305	
BC 3	-306	
BC 4	-306	
Flight units (qty):	7	Includes the qualification unit (sn1002)
Dimensions: BCM	8.1 in. W x 3.98 in. H x 15.45 in. D	Dimensions do not include protrusions from panel surface plane (i.e., handholds, tether rings, switches, etc.). Main body width not including flanges is 6.8 inches
Weight (dry): BCM	12.7 lb	Source: Manifest Documents (Tools EVA Support Equipment List (ESEL))
Interfaces		
Cooling: Cold plate (single)	Medium Temp Loop (MTL)	Charge: Minimal waste heat generated at the charger's location. Dischrg: TBS
Power Supply: Power Bus (BCA) A/L RPCM	LA1A4A F RPC 3 AL1A4A B -120 V	Shares power bus with Metox, ORCA and Airlock Shell heaters

Table 1.2–1. Battery charger assembly reference data (continued)

Description	Specification	Comments
BC 1 BC 2 BC 3 BC 4	RPC 3: 3.5A max RPC 4: 3.5A max RPC 5: 3.5A max RPC 6: 3.5A max	
Power Output:	Output dependent on battery charge profile	Refer to the (Battery Stowage Assembly) BSA/BCA zap card for battery charge profiles
Battery Type:		Refer to the BSA/BCA zap card for BSA locations. Refer to Table 1.2–2 for charge sequence
BC 1 BC 2 BC 3 BC 4	1 PGT + 5 HL 2 HL + 4 PGT 1 In-suit + 3 Aux Port + 1HL + 1EMU (same as BC3)	Batteries using Aux Port: REBA - uses all Aux Channels (2,5,6) on a BCM
Remote Port Operations:	(via Laptop connection)	Provides direct interface to the Christie (Commercial Off The Shelf) COTS firmware via Christie COTS software
BCM-PCS Interface Cable REMOTE.EXE <i>TD-700</i>	SEG33112927 Length: ~ 8ft Christie DOS-based executable software communicates with -303 BCM in PCS Mode <i>Christie Windows-based software communicates with -305 BCM</i>	A pin out adapter between the BCM REMOTE port and ISS Windows-based Laptop serial communications port; a unique cable due to the Remote connector on BCM. Software allows control of the hardware without the panel switches (i.e., start/stop charge, start/stop discharge, etc.). Also allows a Parameter Table to be modified one parameter at a time. Refer to Section 1.2.4 <i>Allows upload and download of battery parameter tables. BCM must be in PCS MODE to transfer tables from BCM to computer and in DOWNLOAD mode to receive tables from the computer</i>

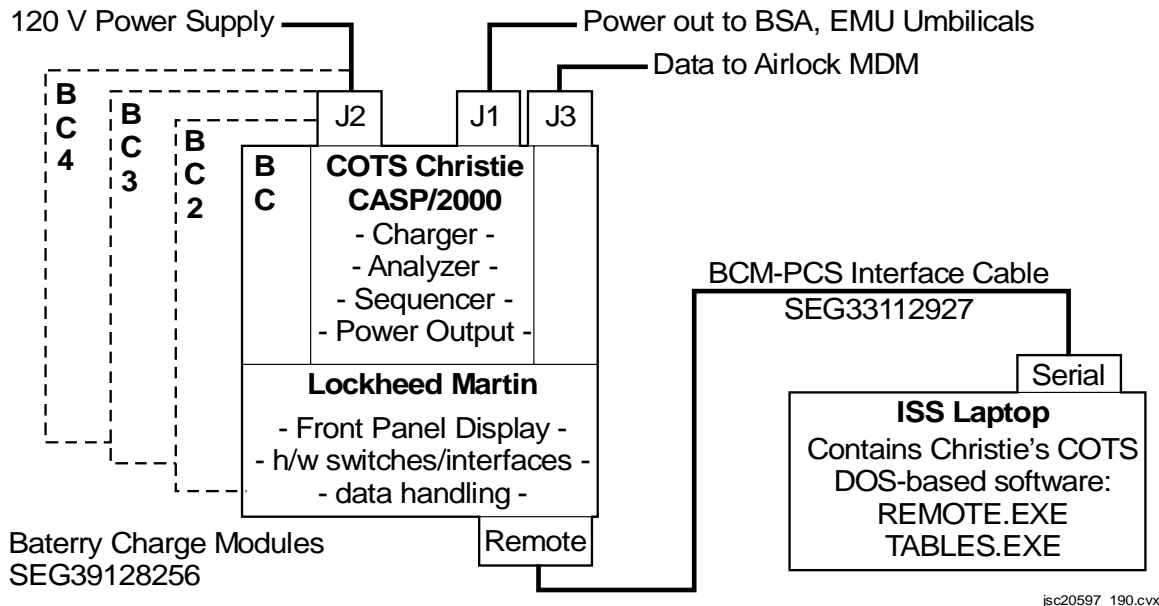


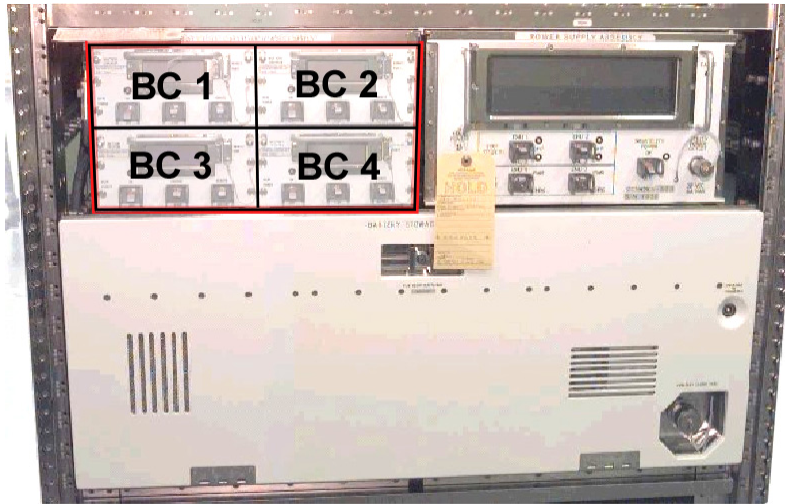
Figure 1.2-1. General BCA hardware/software architecture

1.2.2.2 Location and Structure

The BCA is mounted in the Avionics Rack located station forward (A/L1F1) in the equipment lock. The BCA is located to the left of the Power Supply Assembly (PSA) and above the BSA. The BCA is composed of four independent BCM subassemblies, each with its own crew interface switches and display. To gain better visibility and access to the switches and displays, the crewmember can rotate the EMU Don Doff Assembly that is normally located directly in front of the panels.

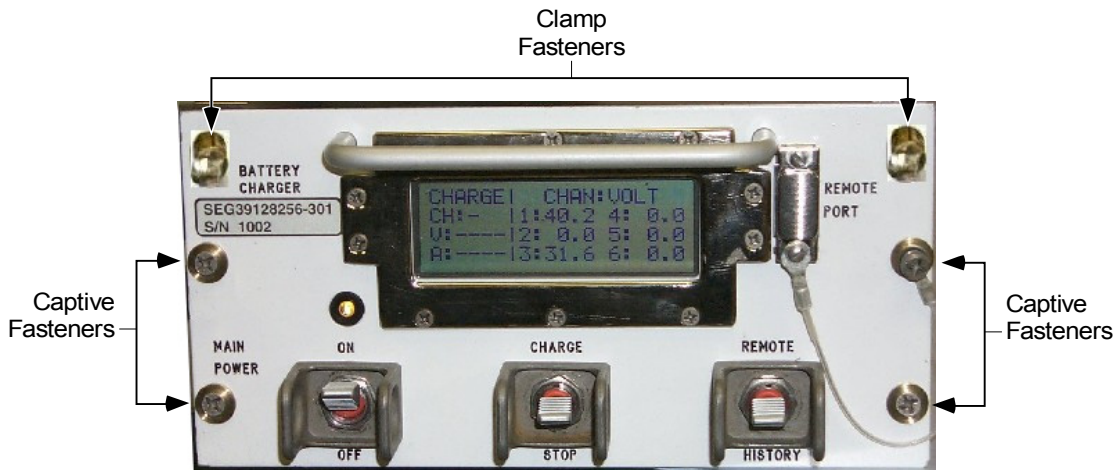
As with most other items in the Joint Airlock, the BCMs are Orbital Replacement Units (ORUs) that can be changed out one at a time as needed. The procedure, 4.2.803 AIRLOCK BATTERY CHARGER MODULE (BCM) R&R A/L1F1, is owned by OSO and is located in the In-Flight Maintenance Checklist. Due to anomalies found during integrated ground testing, BC 3 and 4 were changed out during EXP 4 to reduce noise in the charge and data circuits and to improve reliability for EMU battery charging. Due to later on-orbit failures on BCM sn1001, and a desire to allow the switches to initiate maintenance discharges, *BCs 1 and 2 were replaced with -305 units during STS-124.*

The -305 version chargers allow discharge cycle initiation without the connection of a laptop computer. Additionally, several charging parameters have been updated. *Just prior to launch, a potential failure mode was uncovered that increases the likelihood that the -305 displays will fail.*



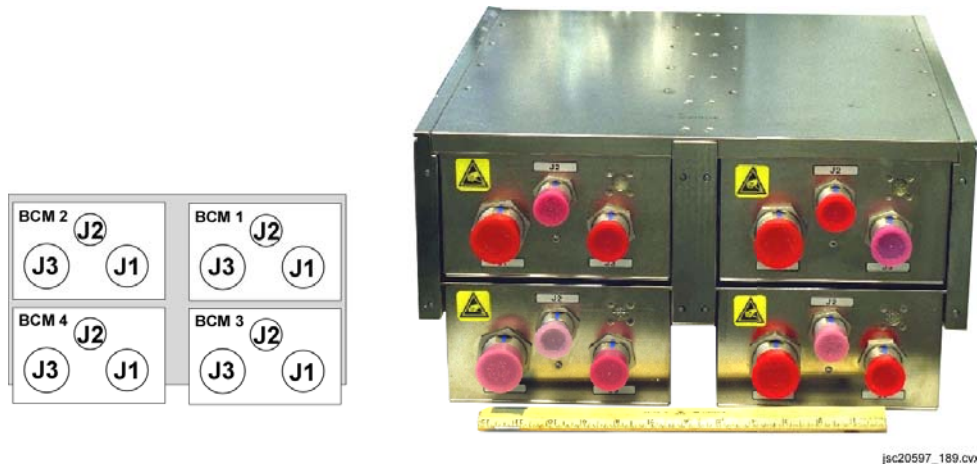
jsc20597_192.cvx

Figure 1.2-2. BCM Locations on avionics rack lower section (BCAs, PSA, BSA)



jsc20597_191.cvx

Figure 1.2-3. BCM Housing with structural and user interfaces



**Figure 1.2-4. BCM electrical interface
(Rear View)**

1.2.2.3 Power

Power is supplied to the BCA by the Joint Airlock Remote Power Control Module (RPCM), which receives power off the LA1A4A F RPC 3 power bus. Each of the four BCM subassemblies, BC1, BC2, BC3, and BC4, receive 120 V from the RPCM AL1A4A_B using RPC 3, 4, 5, and 6, respectively (refer to the zap card for the post-13A power path). The power from these RPCs is wired through each BCMs J2 connector. The power consumption of the BCA should not exceed 220 W under peak load conditions. The RPCs are normally left closed since no power is drawn until the BCMs MAIN PWR switches are taken to ON.

The BCA supplies the power required to recharge batteries installed in the BSA or connected to the auxiliary port. The four BCs are controlled independently, allowing them to be activated at different times. Each BC is capable of charging six independent channels in series following a single charge initiation event. Each BC channel is hardwired to a specific location (mostly in the BSA) and cannot be modified on orbit. This wiring defines the sequence in which the batteries will be charged as shown in Table 1.2–2. Once the charge function is initiated, each channel that has a battery connected is charged in sequence, with the charger automatically moving to the next channel when a battery's charge completion criteria is met or a charge error has occurred.

The BCA also interfaces with the EMU Umbilical via the PSA to supply a 5-amp current to the Umbilical Interface Assembly (UIA) for EMU in-suit battery recharge. The PSA is a passive interface; a relay to allow the BCA to charge the EMU battery is in the suit. The PSA does not need to be powered to charge the EMU battery, but it is required to read volts and amps via the UIA, if desired. *It was found that a sneak circuit existed, causing in-suit charging to terminate early. In-suit charging is no longer considered an option.*

Table 1.2-2. Battery charger channel sequence

	BC 1	BC 2	BC 3	BC 4
Channel 1	PGT 1	HL-A 1	EMU 2 (in-suit)	EMU 1 (in-suit)
Channel 2	HL-B/EMPTY 2	HL-B/EMPTY 1	ACP 1 (REBA)	ACP 2 (REBA)
Channel 3	HL-A 2	PGT 2	HL-B/EMPTY 4	HL-B/EMPTY 5
Channel 4	HL-B/EMPTY 3	PGT 3	EMU 3	EMU 4
Channel 5	HL-A 3	PGT 4	ACP 3 (REBA)	ACP 4 (REBA)
Channel 6	HL-A 4	PGT 5	ACP 5 (REBA)	ACP 6 (REBA)

1.2.2.4 Data

Output analog and serial data signals are provided to the Airlock MDM for transmission to Mission Control Center (MCC) for ground monitoring of BCA performance. Analog voltage and amperage data is provided to the MDM directly from the associated sensors. This same data is available to the crew via the ISS Portable Computer System (PCS) laptop computers. Much of the serial data is also available to the crew via the panels display on each BCM (see Section 1.2.1, Sensors and Telemetry Types).

1.2.2.5 Thermal

The BCA interfaces with the avionics rack cold plate for cooling. This cold plate removes heat from the BCA at a rate of no less than 330 BTU/hr to maintain a temperature of no greater than 73° F. Cooling is supplied via the Moderate Temperature Loop (MTL).

The BCA is designed to operate within specification during exposure to an operating temperature range of +55° F to +109° F and after exposure to a nonoperating temperature range of +40° F to +150° F. The BCA is required to operate at the relative humidity of the airlock (25-70 percent), and is required to operate after, but not during, equipment lock exposure to vacuum.

1.2.2.6 User Interfaces

The front panel of the BCA (Figure 1.2-3) provides the interface for the user to power the various recharge channels and to obtain status information. This panel contains three switches, a Liquid Crystal Display (LCD), a remote port, and a main power Light Emitting Diode (LED). Each of these items is discussed in detail in Section 1.2.3,

On-Orbit Operational Details. The remote port connection can be used to update and/or adjust the battery charge Parameter Tables, including voltage and amperage for each battery's charging profile. A Parameter Table update is executed on the ISS Windows-based laptop using COTS software (Christie Inc.). The remote port can also be used to discharge batteries using the ISS Windows-based laptop and battery discharge software *for the -303 BCMS*.

1.2.3 On-Orbit Operational Details

Note that the COTS Christie CASP/2000 charger, housed inside each BCM, is capable of many more operations than just those accessed via the front panel switches. While all these functions are accessible and can be initiated via laptop connection to the REMOTE port, not all functions have been certified by the International Space Station (ISS) Program. This section limits its discussions to those operations that are performed on-orbit via published Systems Operations Data File (SODF) procedures.

1.2.3.1 SODF Procedures

Nominal BCA Procedures: The following nominal procedures in the ISS EVA SYS checklist are used to perform battery charging and maintenance using the BCA.

- 1.605 BSA BATTERY RECHARGE
- 1.610 EMU BATTERY MAINTENANCE USING SSC IN DOS MODE
- 1.615 DISCHARGE EMU BATTERY USING SSC IN DOS MODE

Alternate Battery Maintenance Procedures: If the BCA were to malfunction to the point it were unusable, the following alternate hardware/procedures in the ISS EVA SYS checklist could be used for EVA battery charging and maintenance:

- 1.620 IN-SUIT EMU BATTERY DISCHARGE USING FAN
- 1.625 EMU BATTERY RECHARGE FROM PSA UTILITY OUTLET
- 1.630 HELMET LIGHT/PGT BATTERY RECHARGE FROM PSA UTILITY OUTLET
- 1.635 REBA RECHARGE FROM PSA UTILITY OUTLET

BCM Parameter Modification: On-orbit modification of Charge and Discharge parameters with the BCMS can be performed using the following procedure in the ISS EVA SYS checklist:

- 1.645 BCA SOFTWARE DOWNLOAD
- 1.655 PARAMETER UPDATE FOR -305 BCMS*

If only a single parameter needs to be changed *on a -303 BCM*, the following Orbiter Communications Adapter (OCA) procedure can be modified for each specific case:

- 05-1381A BCA TIME-OUT PARAMETER MODIFICATION (Note: Uses REMOTE.EXE program)

1.2.3.2 Switches

The MAIN POWER switch enables power to the Battery Charger (BC) when placed in the ON position. If the unit is receiving power from its Remote Power Controller (RPC), the LED above the power switch is illuminated and the pixel test sequence is activated.

Once the BC is powered, its firmware prepares data provided from the Christie charger in preparation for intermittent (~ every 2 minutes) collection by the Airlock MDM. An “hour-glass” symbol appears in the upper right corner of the LCD while data is being collected by the Airlock MDM. All switch inputs are buffered during this period (15 to 40 seconds); therefore, it is best to avoid switch inputs until the “hour-glass” clears.

The MODE switch (CHARGE/OFF/STOP) is used to initiate or terminate battery charging. This switch is a three-position momentary switch with a center null position. Momentarily depressing the MODE switch to the STOP position stops the charge. To restart the charge, the MODE switch is simply returned to the CHARGE position and released. Additional inputs to the CHARGE position are ignored if the system is currently charging a battery. Additionally, on the -305 versions of the chargers, this switch is used to initiate discharge and maintenance modes that have been selected using the DATA switch.

The DATA switch (REMOTE/OFF/HISTORY) is a three-position switch, spring-loaded to return to the center inactive position. The HISTORY position allows the user to toggle through the display to obtain charge status and history for each of the six BC channels. The HISTORY switch tells the firmware to report channel, battery type, charge history, charge time, and status of the current channel. In the REMOTE position, this switch enables the remote port for download of data for control by the Christie software on an ISS Windows-based laptop. The download mode is achieved by taking the DATA switch to REMOTE with a quick single toggle of the switch (up to 3 seconds). The remote mode for control by an ISS Windows-based laptop is achieved by toggling the switch twice or holding the switch in the REMOTE position until PCS Mode is displayed on the LCD. The -305 version chargers allow access to Discharge, Charge-Discharge, and Charge-Discharge-Charge modes by toggling the DATA switch to the REMOTE position additional times.

1.2.3.3 Panel Displays during Charging

The LCD mounted on the control panel provides for direct monitoring of battery Open Circuit Voltages (OCVs), of power (volts and amps) being supplied by the BCA to the different channels and of battery charge time. In addition, the display provides insight into the mode of operation for each channel and the health of the BCA itself via use of the History position of the DATA switch. Error messages are also displayed on the LCD, as needed. All data presented on the display is controlled by the BCM firmware. It is collected from the Christie charger in the form of 63-byte serial data table, the same table that is also downloaded by the Airlock MDM.

Example of a Charge Sequence

During the first 5 seconds of the BC power-up sequence, the LCD performs a self-test during which all pixels are illuminated.

After the initial power up self-test is complete, the LCD displays the OCV for each battery connected to that BC's channels (Figure 1.2-5). At this time, "No History" would be available from the charger, as that information is purged when the charger is powered off.

CHARGE	CHAN:VOLT	
CH: -	1: 0.0	4: 19.2
V: - - - -	2: 0.0	5: 0.0
A: - - - -	3: 11.5	6: 0.0

**Figure 1.2-5. Battery charger LCD
(not charging – initial power up)**

When the MODE switch is toggled to the CHARGE position, the BC default display shows which channel is being charged, along with the associated voltage, and amperage on the left side of the display. The display also shows the OCV of the batteries in the other channels, as shown in Figure 1.2-6. The charger will move on in sequence to subsequent channels when the battery's charge completion criterion is met or an error is encountered. The data on this display is updated on the order of every second, with one exception, EMU battery charging. During EMU battery charging, the EMU battery voltage data is only updated at best every 2 minutes, and can occasionally be as old as 10 minutes (see Table 1.2-6 Data oddities on panel displays.)

CHARGE	CHAN:VOLT	
CH:4	1: 0.0	4: --
V: 19.0	2: 0.0	5: 0.0
A: 1.55	3: 22.5	6: 0.0

**Figure 1.2-6. Battery charger LCD
(during charge)**

Before, during, or after a charge sequence, depressing the DATA switch to the HISTORY position cycles through the status of each of the six BC channels. Each time the switch is depressed the next channel is displayed, as shown in Figure 1.2-7, and cycles back around to channel 1 after having displayed all six channels. The data on these History pages is updated at best every 2 minutes, but can occasionally be as old as 10 minutes.

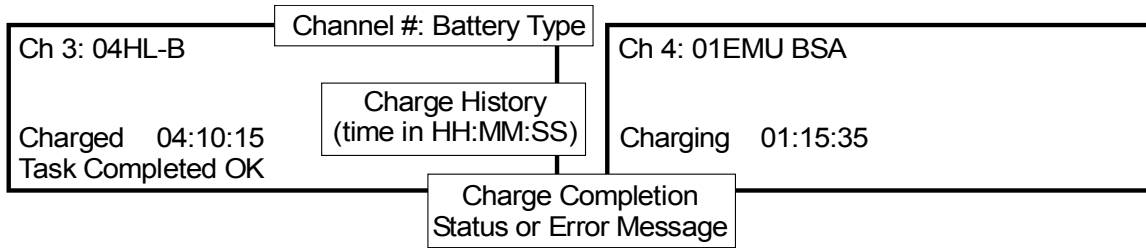


Figure 1.2-7. Battery charger LCD (viewing history)

After 20 seconds, or when the MODE switch is toggled to the STOP position, the BC display returns to the previous default. If all six channels have completed charge or have at least received an attempted charge, the default display cycles with an additional screen (Figure 1.2-8) showing “Look At,” with a listing of all channels that DID NOT receive a “Task Completed OK” Completion status, and “Charged,” with a listing of all those that did.



Figure 1.2-8. Battery charger LCD (all channels complete)

Although all channels are complete, the BC cycles through the channels looking for new batteries that have been added since the charge was initiated. The BSA door can be opened, and batteries can be swapped out during a charge. When the BSA door is again closed, charging of the new batteries starts, as long as the STOP switch was not activated during the swap sequence. Similarly, if the Service and Cooling Umbilical (SCU) was connected to the suit (and the UIA was configured for an in-suit battery charge) after charging was initiated on BC3, the in-suit battery would not be charged until channels 2 through 6 are finished. At this time, in-suit EMU Battery charging starts. This is applicable also to batteries subsequently connected to the Auxiliary Port.

The History Data display for any channels in the “Look at” list should be reviewed by the Flight Control Team to determine if action should be taken. The history data displayed depends on the status of the battery, as shown in Table 1.2–3.

Table 1.2-3. Data displayed by BCM history display

Message	Charge history line	
"Charging HH:MM:SS"	Battery on selected channel is presently charging	
"Charged HH:MM:SS"	Battery on selected channel has finished its charge attempt or the charge has been terminated by the user or a Temperature Cut-Off (TCO) event	
"No History"	No charge has been attempted on and thus no information has been collected for the selected channel, subsequent to one of the following events: <ol style="list-style-type: none"> 1. Power up of the BC 2. Watchdog / CASP CPU reset (no other indication is provided) 3. New battery connected (history kept at battery disconnection) 	
Charge Completion Panel Message/ CASP Code	Charge completion status	Workaround
"Task completed Ok" Ok!	Task was completed normally	N/A
"Stop switch toggled" St*	Charge terminated by user with the STOP switch/ command, <i>or</i> Charge terminated by noise on the firmware circuits causing a false "STOP" command (-301)	Toggle CHARGE switch to restart charge
"Amp-hour tested Ok" Ah!	Calculated amp-hours exceeded the "Min Amp Hour" in the Parameter Table	Only possible if a CASP "Analyze" task initiated (i.e., maintenance sequence). No workaround required.

Table 1.2–3. Data displayed by BCM history display (continued)

Charge Completion Panel Message/ CASP Code	Charge completion status	Workaround
<p>"Batt over-temp error"</p> <p>Ot*</p> <p>(see Section 1.2.3.4 for more details.)</p>	<p>Excessive battery temperature during charge (NOTE: The EMU Increased Capacity Batteries (ICBs) do not provide a thermister output and therefore does not allow TCO monitoring by the BCMs)</p> <p><i>or</i></p> <p><i>If indicated on all four chargers</i>, on channels which have not yet completed charge, BSA door latch switch is indicating an open door</p>	<p>For actual TCO indication:</p> <ol style="list-style-type: none"> 1. If voltage and current were OK when error code was received, leave in charge mode, wait for battery to cool. Charge will resume automatically. 2. If voltage and current were excessive, battery likely bad. 3. If TCO circuit were failed, typically will instead issue a "short circuit error" for that channel. (TBD) <p>For BSA door latch indication:</p> <ol style="list-style-type: none"> 4. It may indicate problem with the TCO circuitry in BSA or UIA (EMU); if indication seen when charge initiated, perform 1.670 BSA FAN SWAP
<p>"Incomplete data" (displayed instead of HISTORY page)</p>	<p>When requesting the HISTORY Page, the BCM firmware was not able to communicate with the charger after several automated attempts</p>	<p>Cycle power</p>
<p>A 'Completion Status'¹ of any of the following will cause that channel to be included in the 'Look at' list:</p>		
<p>"Batt circuit open"</p> <p>Op*</p>	<p>Battery circuit appears to be open; either the battery, a cable, or a connector has a broken connection.</p> <p><i>or</i></p> <p>No battery is installed, although the channel's battery type (ID resistor) was recognized</p>	<ol style="list-style-type: none"> 1. Install/reinstall battery in slot 2. If in charge mode, it will start charge when it gets back to that channel 3. If STOP switch had been toggled, toggle CHARGE switch

Table 1.2–3. Data displayed by BCM history display (continued)

Charge Completion Panel Message/ CASP Code	Charge completion status	Workaround
"Wrong batt or Hi-imp" Ra*	Battery failed the rail test. Wrong battery could be installed or battery has high internal impedance <i>or</i> If battery has been setting around charged for extended durations, battery may have passivation (see work around for Low-slope error)	<ol style="list-style-type: none"> 1. Verify ID resistor has recognized properly by toggling through HISTORY 2. If not recognized properly, reload Parameter Table 3. If ID resistor is correct, try a different slot 4. If no joy, battery is probably bad
"Low-slope error" Ls*	<p>The rate at which the battery voltage is increasing is below acceptable limits; battery is not accepting a charge</p> <p>This may be a nominal if:</p> <ol style="list-style-type: none"> (1) the battery was charged nominally within the past couple days (i.e., top-off) <i>or</i> (2) has been setting around charged for extended durations, causing battery passivation 	<p>If passivation is likely:</p> <ol style="list-style-type: none"> 1. Repeat standard charge attempt. This automatically performs a 3-minute alt charge prior to performing the Low-slope test. 2. If that still does not work, the battery may require maintenance (discharge); the battery should charge correctly the next cycle
"Amp-hour test error" Ah*	Calculated amp-hours were less than the "Min Amp Hour" in the Parameter Table	<p>Only displayed if a CASP "Analyze" task initiated (i.e., maintenance sequence). REVIEW DATA.</p> <ol style="list-style-type: none"> 1. Battery may have been already had partial charge. 2. Battery capacity may be low and does not hold a charge. 3. The Parameter Table may be wrong

Table 1.2–3. Data displayed by BCM history display (continued)

Charge Completion Panel Message/ CASP Code	Charge completion status	Workaround
<p>“Power error”</p> <p>Pr*</p>	<p>Charger tried to exceed 350 watts during charge or 65 watts during discharge. This error should be N/A for the BCA because it is limited to a 100 watt charge (50 V or 3 amps) and (TBD) watts discharge</p>	<p>Only displayed if BCA is used as a power supply; we do not support this mode.</p> <ol style="list-style-type: none"> 1. Verify that the ID resistor has been recognized using the HISTORY switch. 2. If it is not recognized correctly, reload Parameter Tables. 3. If message is received for the external connector, also verify the ID resistor is correct for the attached battery
<p>“Reverse polarity error”</p> <p>Rp*</p>	<p>Reverse polarity of battery voltage</p>	<ol style="list-style-type: none"> 1. Battery is connected backwards (not possible for batteries installed in BSA). 2. Maybe possible if external port cable wired incorrectly. 3. You may get this message erroneously instead of the “battery circuit open” if charge started without a battery. It happened at Huntsville while trying to start a charge for the EMU battery at the UIA with a simulated load and TCO signal
<p>“Short circuit error”</p> <p>Sh*</p>	<p>Short-circuit sensed in the cable or battery</p>	<ol style="list-style-type: none"> 1. Should indicate the battery is shorted (bad) and has no voltage. 2. You will get this erroneously (particularly on CH 1) when charge is started but no battery in a BSA slot. It does not occur erroneously if batteries are in the slots

Table 1.2–3. Data displayed by BCM history display (concluded)

Charge Completion Panel Message/ CASP Code	Charge completion status	Workaround
"Time-out error" Ti*	Charge terminated by time limit set in Parameter Table	<ol style="list-style-type: none"> 1. The battery is bad and not accepting a charge. Do not use the battery. 2. The charge current may be low and causing the battery to charge slower. Check serial data to verify current. If it is low, start the charge again and look for proper termination
"External- temp error" Xt*	Over-temp cut-off in discharge booster (N/A)	The BCA does not use a discharge booster. This error should never occur. Cycle power

¹ flow charts and descriptions of the tests, measurements and decisions that the CASP firmware uses when reporting errors can be referenced in the CASP Flowcharts fax dated Oct. 28, 1999.

The same data displayed on the panel, as well as additional data from the Christie charger, can be viewed by the crew on a PCS laptop. As this additional data is in a very similar format to what is available to the Flight Control Team via MDM downlink data, it is described in Section 1.2.4, Performance Monitoring.

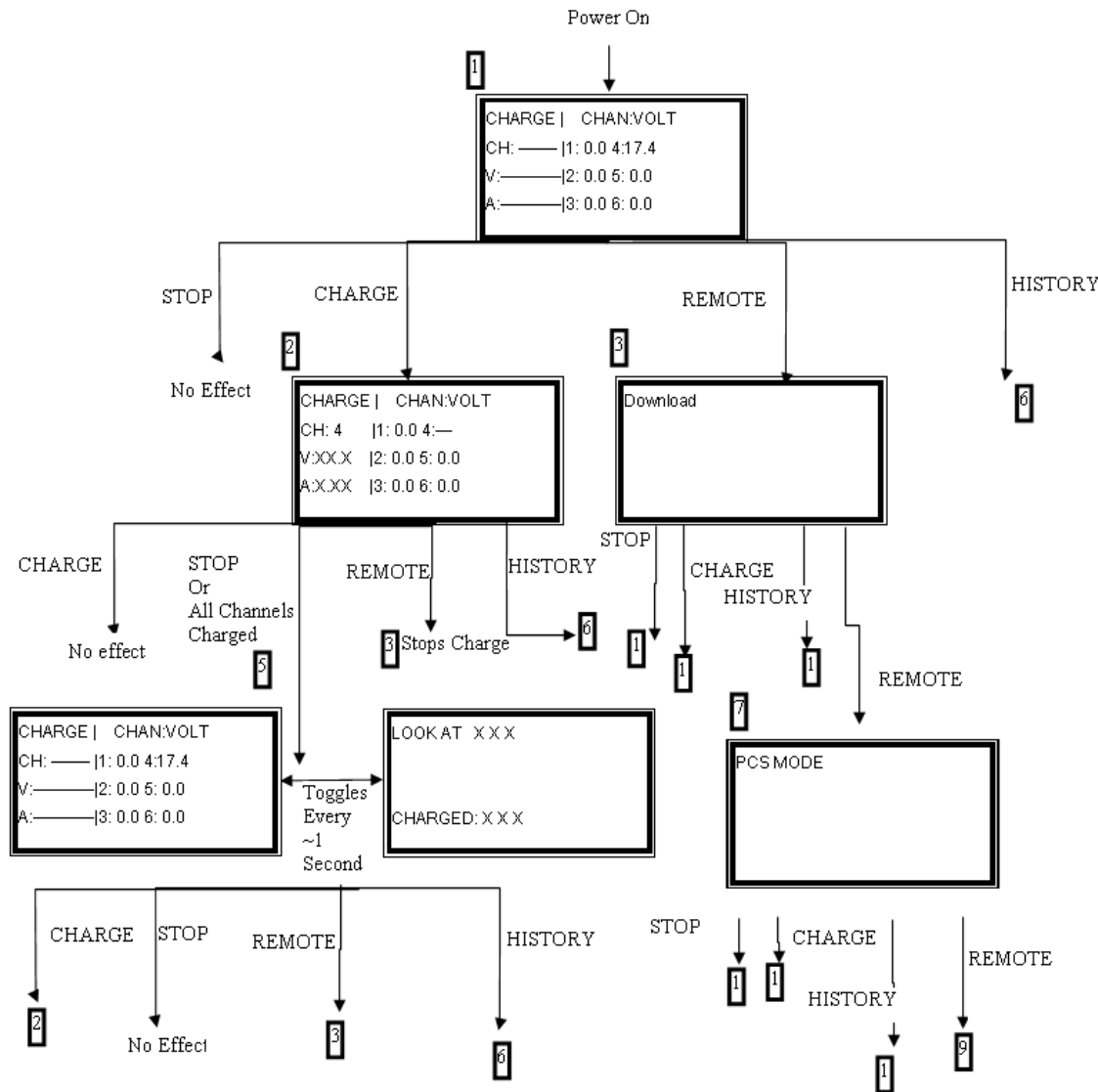
Data Oddities on Panel Displays

Table 1.2-4 lists known panel display oddities. These do not affect the function of the charger, just the displaying of the data, therefore are considered a “known” annoyance versus an actual failure.

Table 1.2-4. Data oddities on panel displays

Oddity description	Details	Workaround
History display blank or garbled at powerup or after STOP switch used (-301)	Refer to Table 1.2-17 Malfunction summary table. Fixed in -303 and subsequent BCM versions	1. Cycle BCM power. <i>or</i> 2. Crew monitor data on PCS; MDM data also available to Flight Controllers in MCC-H
EMU battery voltage data delayed up to 10 minutes from actual charge start (-all)	The EMU battery voltage during charge is read from the Christie charger rather than the sensor pick-offs as all other battery Volt/Amp readings are. The Christie data are collected every 2 minutes, when the hour-glass is displayed on the front panel. Therefore, depending on the relative timing of the collection, the EMU battery voltage can update relatively slow. This was designed specifically for monitoring EMU Battery charging, to avoid showing the 2-volt sensor bias high (line loss) caused by the BCM sensors being upstream of the actual voltage supplied at the battery terminal. Since the EMU battery requires a voltage cut-off at an actual voltage of ~22 V (as measured by the Christie during its open-circuit check), the pick-off would read ~24 V indicated. This would look like an over-charge to anyone unaware of the charge bias; the bias is not present during the OCV check	N/A

The -305 BCM has a more complex flow of operations, which can be initiated using only the frontpanel switches. The flow chart in Figure 1.2-9 below documents the flow of operations. Note that at the time of this publication not all potential switch throws had been tested at all points in the operational sequence.



Additional Notes:

- During charge, voltage displayed as 0.0
- Time displayed for charge reverts to 2 sec after charge complete
- Noted that the battery emulator for an ICB was getting a Task Complete Ok message after only a few minutes. Would have expected some kind of error message since an ICB shouldn't charge nearly this quickly

Figure 1.2-9. -305 BCM operations flowchart

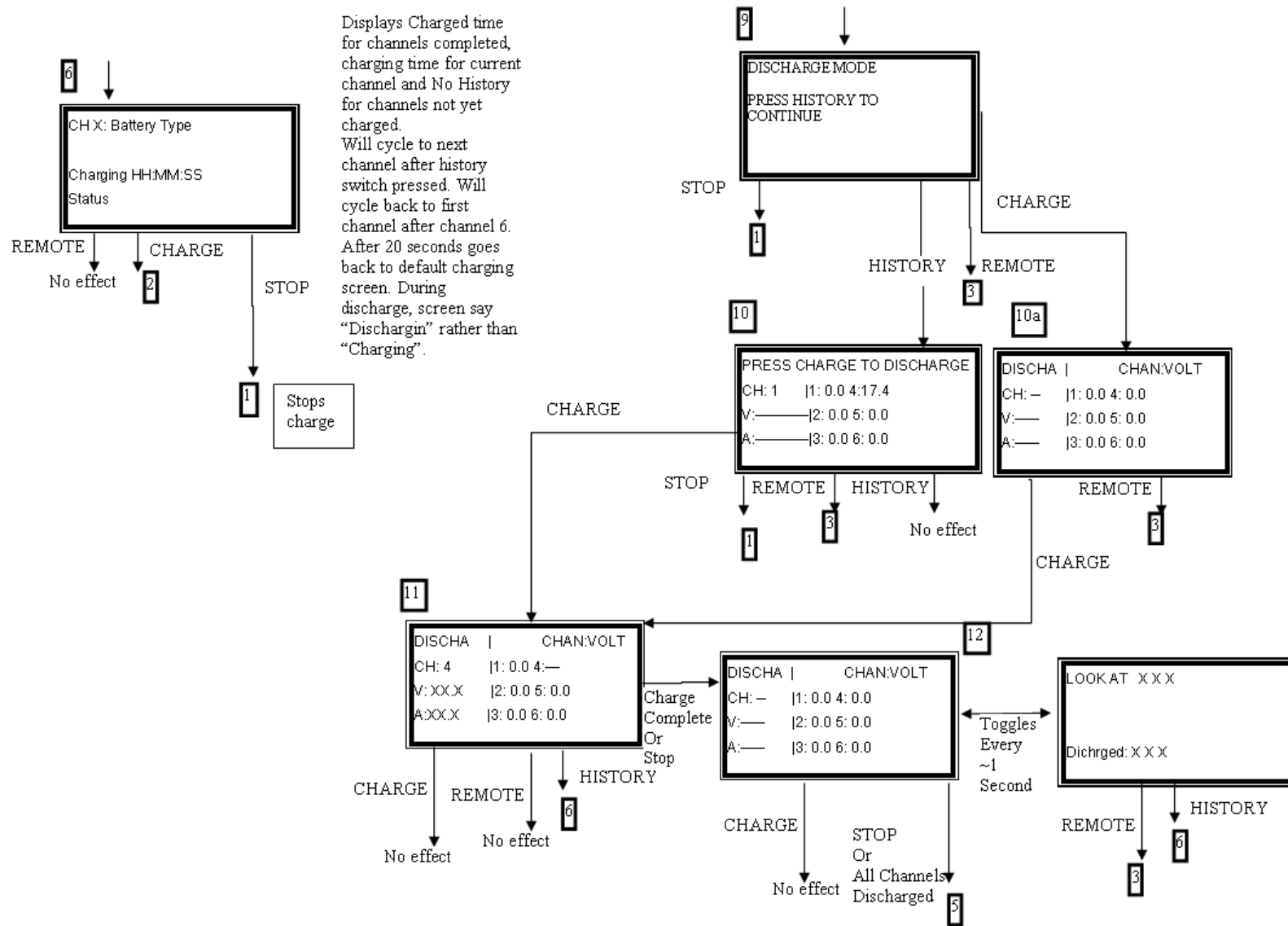


Figure 1.2-9. -305 BCM operations flowchart (continued)

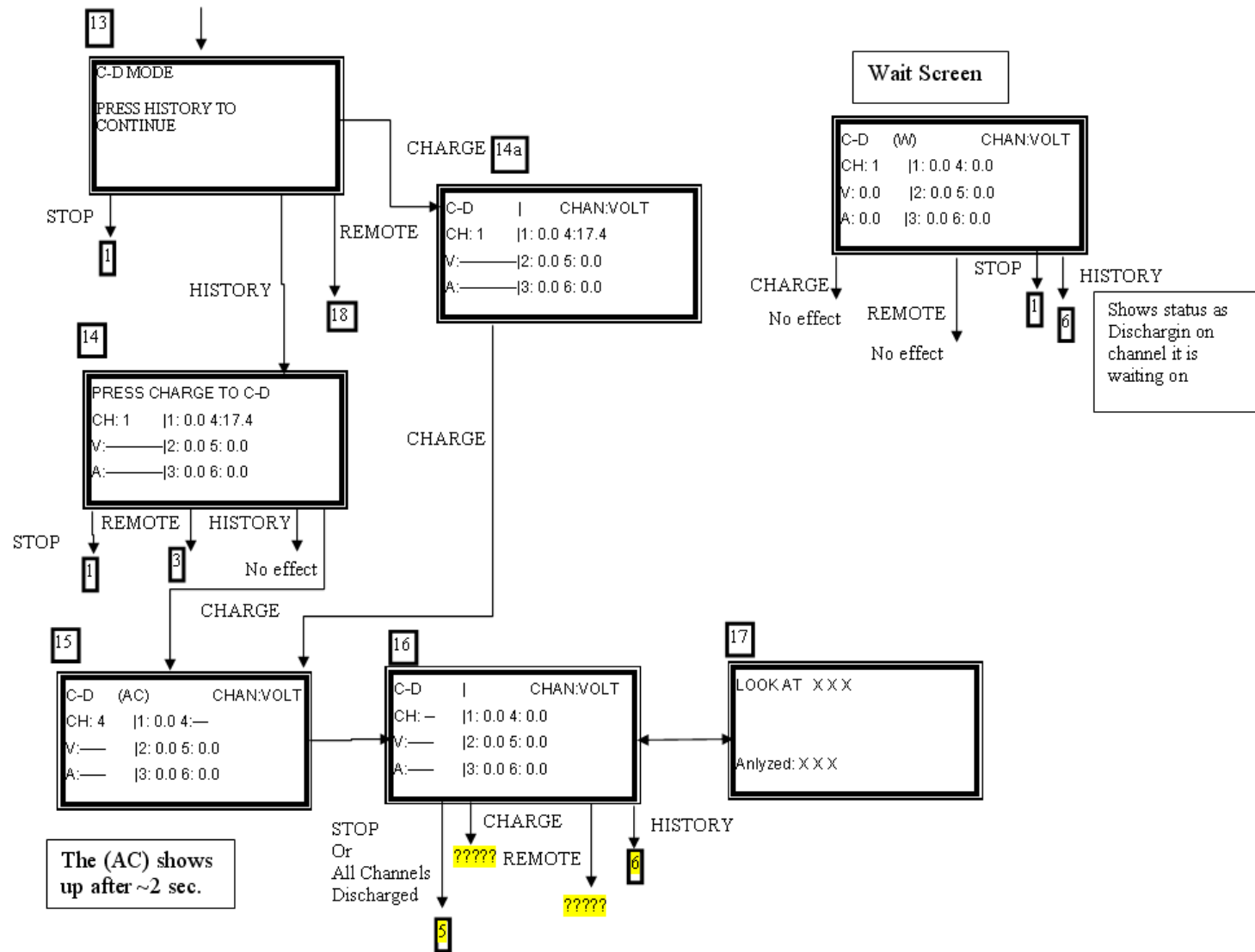


Figure 1.2-9. -305 BCM operations flowchart (continued)

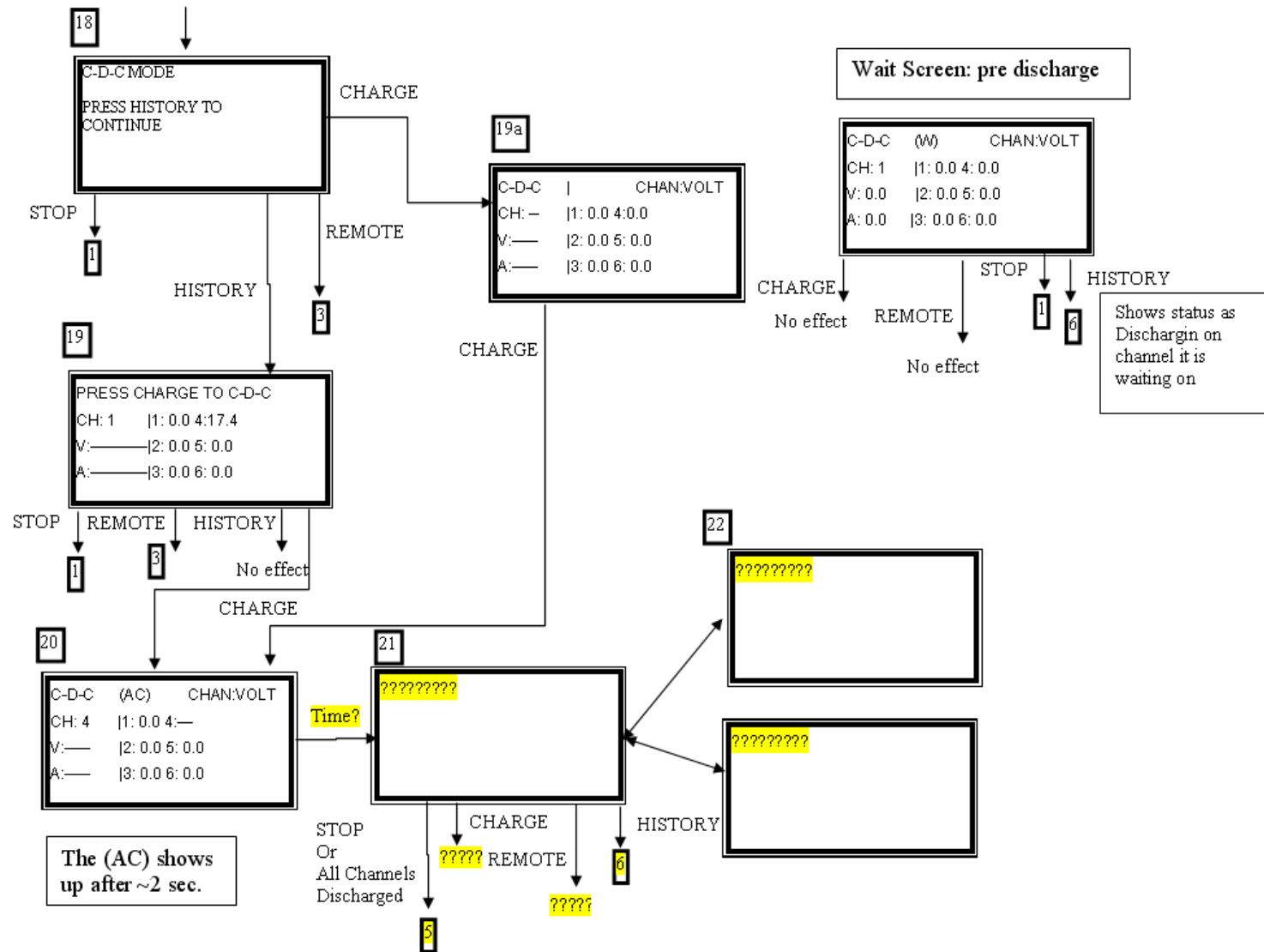


Figure 1.2-9. -305 BCM operations flowchart (concluded)

1.2.3.4 Temperature Cut-Off Circuitry and the BSA Door

During charging, the BCM continues from one channel to the next channel and begins charging unless the channel's TCO has been tripped as indicated by a Completion Status of "Batt over-temp error" for that channel. In this case, or if a TCO is activated after the channel begins charging, the BC pauses until the temperature decreases to within an admissible range. Table 1.2-5 lists the TCO specifications for each battery type.

Table 1.2-5. Battery temperature cut-off specifications

Battery type	TCO temperature	Thermister resistance	Comment
EMU ICB	n/a	(no Thermister)	
Helmet light	> 140 +/- 10 deg. F	< 2500 +/- 100Ω	Only 1 of 3 thermisters monitored; across battery pins 9 and10
PGT		< 1268 +/- 20Ω	Monitored across battery pins 3 & 5
REBA		< 2500 +/- 100Ω	Only 1 of 2 thermisters monitored; across battery pins 9 and10

BSA Door

As a hazard control for crew exposure to potentially explosive batteries during charging, the BSA door position is monitored by the BCM software. If the door is opened during charging, charging will be temporarily stopped on all batteries located in the BSA. The door has two magnetic latches, one on each side, that indicate whether the door is open or closed. Only one of the two redundant latches is monitored by the battery chargers, depending on which of the fan jumpers is currently active.

If the BSA door is open during charging, all BSA channels that have not completed charging indicate a "Batt over-temp error." This is because, for ease of implementation, the door latches are wired to trip the standard TCO circuitry programmed within the Christie charger by sending all TCO-monitored BSA line resistances low. EMU batteries in a suit continue to charge even with the door open, and the LED is illuminated. Refer to Section 1.3 for more information on the BSA circuitry.

1.2.3.5 Battery Maintenance Discharges

During the initial design and development of the BCMs, battery hardware providers did not identify a need to perform on-orbit, EVA battery maintenance. However, when the reality of ISS operations began to stretch the limits of the engineering community's understanding of the effects of extended charged stand-time, the program decided to certify and fly the Christie's COTS, DOS-based software i.e., the REMOTE and TABLES applications. While this allows access to all of the CASP/2000 features, the certification was to allow discharges to be performed if necessary for battery health, and to allow the Parameter Tables to be updated as new or modified batteries were

developed for the program. While the software was not considered user-friendly enough for crew use under normal circumstances, it was considered a good compromise given the short lead time available prior to the BCA's launch on ISS Flight 7A. Rather than going completely without the discharge maintenance functionality, it was believed that it would not be required often and only during Stage operations.

On-orbit maintenance requirements for the EMU Increased Capacity Battery (ICB) are officially documented in the FEMU-R-003. EMU ICB maintenance requirements were first implemented during ISS Expedition-5 in response to an EMU battery that failed to supply the expected Amp-hour capacity during a UF-2 Assembly EVA.

The -305 version of the charger provides the ability to enter the following maintenance modes directly from the front panel, without attaching a laptop:

- Discharge
- Charge-Discharge
- Charge-Discharge-Charge

When these modes are selected, the BCM will move through each channel performing the first operation of the mode on each channel. For the modes with multiple operations, the BCM will then cycle through each channel performing the next operation. The BCM will always wait at least 2 hours after a charge operation before performing another action on a battery and at least 4 hours after a discharge operation.

SSATA Test Data – Discharge

The Space Station Atmosphere Test Article (SSATA) discharge test was conducted to verify the on-orbit capability to discharge ICBs to 16 V. Prior to delivery to the SSATA, two ICBs were discharged to 16.0 V dc and then recharged to 3 amp-hours of capacity at USA. The test consisted of discharging, in the BSA, the two ICBs to 16 V using the BCM. An ISS Windows-based laptop was used to interface with the BCM via the remote port to perform the discharge. A digital multi-meter was used to test the voltage at the battery and compare to the data supplied by the Christie charger. Table 1.2-6 lists the final numbers at discharge termination.

Table 1.2-6. SSATA test data - discharge

ICB s/n	Christie voltage (OCV)	Battery voltage (DMM)	Delta voltage	Discharge time (HH:MM)	Capacity (Amp-hrs) @ 1.55A	Comments
2015	16.0	15.95	0.08	02:25	3.6	The voltage fell off quickly at the end and did not set to the minimum voltage on the Digital Multimeter (DMM)
2016	16.12	15.88	0.07	01:59	3.0	The min voltage record on the DMM was set prior to the voltage falling off

ICB s/n 2015 SSATA Discharge Test

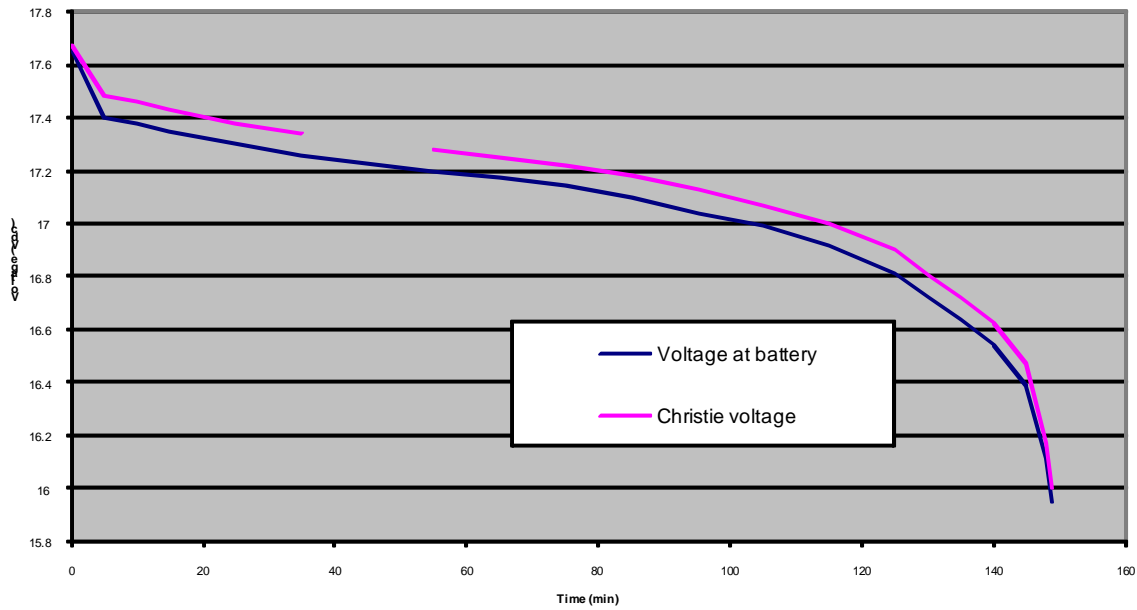


Figure 1.2-10. ICB S/N 2015 discharge

ICB s/n 2016 SSATA Discharge Test

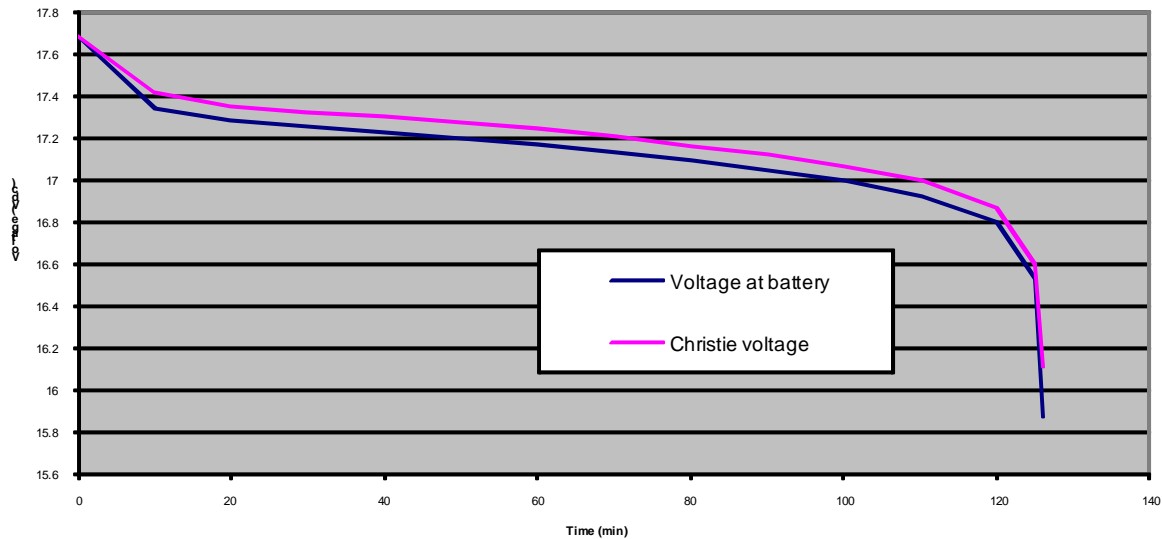


Figure 1.2-11. ICB S/N 2016 discharge

1.2.4 Performance Monitoring

This section contains information regarding interpretation of the data supplied from the BCMs. While the focus is on the data displayed on the MCC-H Dec-Alpha Workstation, it also applies to the data available to the crew via the ISS PCS laptop. The new Status and Task states that have been added in the -305 version of the charger will result in !ERR being displayed on the PCS (ref. ISS SCR 37037).

1.2.4.1 Sensors and Telemetry Types

There are two types of telemetry available from the BCMs: (1) analog sensors that indicate the power output (voltage and current) being provided by each BC, and (2) the CASP/2000 internal microprocessors data (Serial Data, see Section 1.2.4.2) that is used to control charger tasks and provide a status of their results. All BCM data is located in HK2.

Table 1.2-7. BCM sensor specifications

Parameter	Sensor output level	Sensor range	Specified accuracy	Number of data bits	Resolution
Volts - Analog	0 – 5 V	0 – 50 V			
- Serial					
Amps - Analog	0 – ±5 V	0 – ±5 A			
- Serial					

Sensor Calibrations and Scaling

The analog sensor data is calibrated and scaled by the MDM to supply the Standard Out in appropriate engineering units (V or A); therefore, the display applications do not perform any calculations, and the data is displayed exactly as it is received from the MDM.

The serial data volt and amp readings as sent to the MDM on the BCA RS-485 serial port is calibrated but not scaled to place the decimal point (see Table 1.2–9 Raw Serial Data Example). However, the original ICD improperly identified this in the Standard In/Standard Out for the MDM. The result was that the MDM performed the calibration multiplication when it needed to perform the scaling. Therefore, the MDM Standard Out was not in engineering units as delivered for ISS Flight 7A. The display software, therefore, was required to divide voltages by 600 and current data by 500. This correction was implemented for our Manual Select Keyboard (MSK) View displays on the MCC-H Workstations, but not for the crew’s PCS displays. The MDM Standard Out will be corrected with the Command and Control (C&C) MDM revision for ISS Flight 15A.

When it is desired to know the voltage at a battery’s terminal, note that significant voltage biases exist for both the analog and serial data any time a relatively large current is flowing. This is due to the voltage (line) loss associated with the resistance in the electrical circuits between the batteries, where the sensor would ideally be located, and the remotely located sensors within the BCM. The size and sign of the bias varies with the current; small when the currents small, larger when it is higher, as demonstrated in the Table 1.2–8. Note that the bias does not affect the readings used by the charger to terminate a charge. Christie’s firmware turns off the current for 15 to 20 ms every second to take the OCV reading used for voltage cutoff determinations.

Table 1.2-8. Examples of voltage transducer bias due to non-ideal location

Case description	Indicated voltage	Line resistance* x line current	Calculated voltage @ battery term	On-orbit data suggests an actual bias of:
		= Approx. Bias		
OCV on EMU battery in BSA	20.3 V	1.28Ω x 0.00A	20.3 V	(± 0.05 V per xducer spec.)
		~ 0.0 V		
Charge voltage on EMU battery in BSA	24.0 V	1.28Ω x -1.55A	22.0 V	- 1.7 V
		~ -2.0 V		
Discharge voltage on EMU battery in BSA	14.3 V	1.28Ω x +1.55A	16.3 V	+1.7 V
		~ +2.0 V		
Charge voltage on EMU battery in suit	24.0 V	2.14Ω x -1.55A	20.7 V	
		= -3.3 V		

* Line resistances were calculated based on the solid state component specified resistances, wiring gages and line lengths. While not actually measured, limited test and on-orbit data suggest correct order of magnitude.

Analog Sensors

The analog sensors located within each BCM are standard ISS sensors providing BCM voltage and current output data directly to the Airlock MDM via Analog-to-Digital (A/D) converters. These sensors are monitored directly by the MDM as any other standard ISS sensors would be with the values being updated every 10 seconds. The sensors are not used by the charger in any way; they are not used to control the charge, nor are their data displayed on the BCM front panel. Their data is only available from the MDM via the ISS PCS laptop and MCC-H displays.

Note that due to the location of the sensors, only data related to the active channel is displayed. Also, during discharge maintenance, only the voltage sensors provide analog data; no currents (i.e. amps) are seen, since the discharge current from the batteries flow through a separate circuit from the charge circuit on which the amperage sensors are located.

This data is also plotted for monitoring in RTPlot. The BSA/BCA zap card contains examples of both charge and discharge voltage plots. Note the apparent noise seen at regular intervals. This is actually the sampling by the MDM matching up with the times when the charger stops the (dis-)charge to take an OCV reading of the battery. Since the charger performs this for 15 to 20 ms every second, how often it shows up in the analog data depends on how often the two synchronize due to the two occurring on just slightly different frequencies (~1Hz).

1.2.4.2 BCA Serial Data

Firmware

The “bca2.C” firmware program provides charger status information via the MDM RS-485 serial data link for MCC monitoring. Note that the firmware also maintains the front panel displays, processes input commands from the panel switches, and initiates download and remote operations between the Christie charger and the ISS Windows-based laptop. For more information on firmware and logic flowcharts, reference drawing number SKG39134917 BCA Firmware Program Documentation.

MDM Download functions

A command received every 10 seconds from the MDM system causes the system firmware to activate the RS-485 serial port and download a 63-byte table containing charge history and electrical information. However, since some of the data in the 63-byte table is collected less frequently or may not be down loaded due to checksum errors, the data can be significantly older than 10 seconds.

The MDM communication's health with this RS-485 serial port can be monitored via the Serial Status display (Figure 1.2-12).

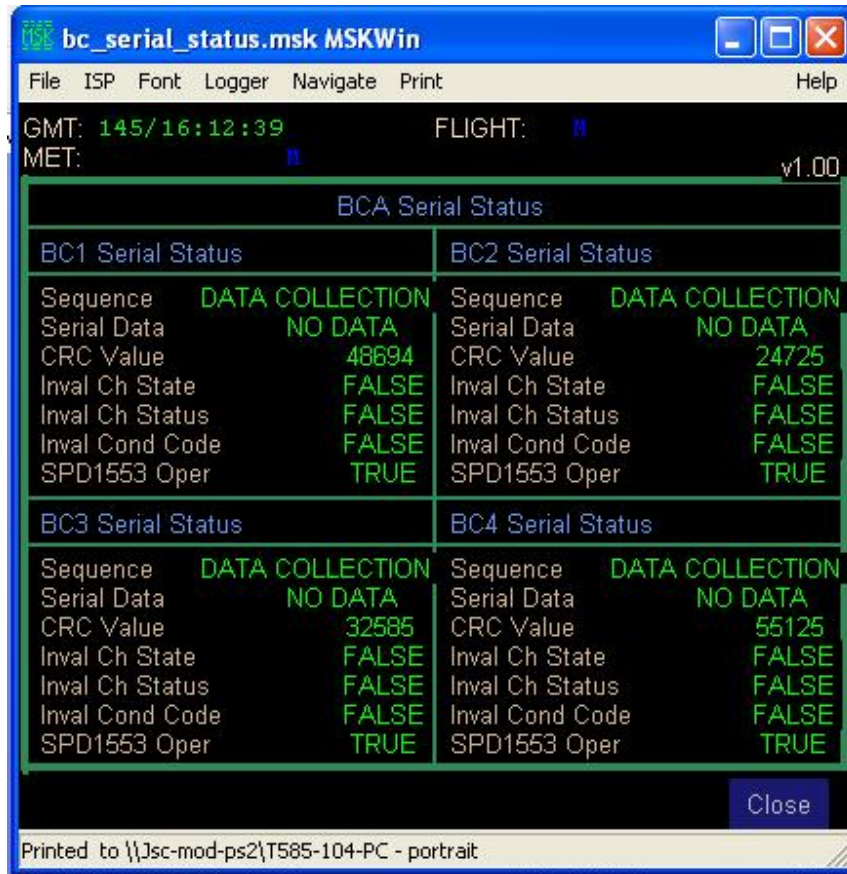


Figure 1.2-12. Serial status display

Serial Data Format and Parameter Sample Rate

Serial data transmitted between the BCM and the MDM is in the RS485 format. The parameter order of this data stream is defined in Figure 1.2-11. All bytes are sent as code numbers that are then decoded by the various displaying software (i.e., PCS Displays, BCM firmware for the front panel). The first 61 data bytes of this 63-byte table are collected by the BCM firmware at one of two sample rates, dependent on the parameter (byte). The BCM firmware computes a checksum for the downloaded data using an algorithm (CRC-16) and transmits the result in the last two bytes of the table.

Several times per second, sensor data is picked off from the transducers monitored by the Christie circuitry. This is done via the A/D converter to provide frequent voltage and amperage data (bytes 26 to 49) to the front panel default display. This is the case for all battery types, except for the EMU battery voltage when an EMU battery is charging (see Table 1.2-4 Data Oddities on Panel Displays).

The remainder of the table, and EMU battery voltages during charging, is collected every 2 minutes, i.e. just after each 12th download of the table by the MDM. This data, e.g. status/history information, is generated by the Christie firmware and is collected in the 63-byte table by the BCM firmware. This buffering process takes 15 to 40 seconds, during which an hour-glass is displayed on the front panel and commands from the front

panel switches are not passed from the BCM firmware to the Christie charger. Therefore, this data is not collected more often. Also, if the BCM is placed in the PCS Mode or Download Mode the BCM firmware does not collect the data.

Due to the differences in sampling rate, seemingly conflicting data is displayed for a couple minutes, or worst case up to 10 minutes. For example, when a charge completes the volt and amp data indicate this first by the amps dropping to zero; however, since the status/history data is not updated as quickly or as reliably, it can still indicate charging on the serial data display and the front panel history page.

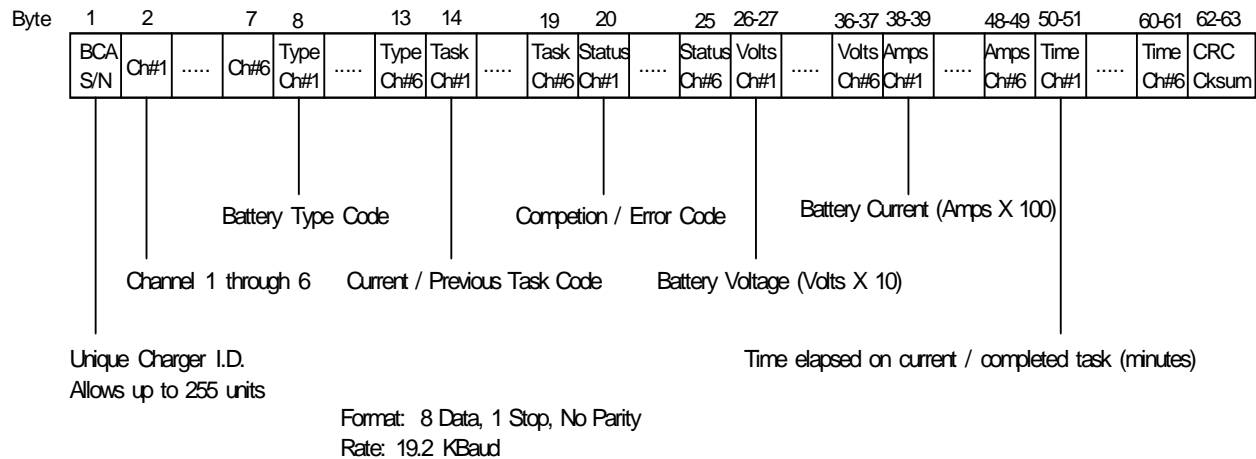


Figure 1.2-13. BCM serial data packet definition

EXAMPLE OF RAW SERIAL DATA: The following table shows a fictitious example of the raw serial data codes as would be received by the Airlock MDM from a BCM:

Table 1.2-9. Raw serial data example

Data Type	Byte(s)	Raw Serial Data						
BCM S/N	1	3						
Channel	2-7	1	2	3	4	5	6	
Type	8-13	1	6	0	0	0	0	
Task	14-19	1	2	0	0	0	0	
Status	20-25	2	1	0	0	0	0	
Volts *	26-37	205	414	0	0	0	0	
Amps *	38-49	0	55	0	0	0	0	
Time *	50-61	1020	12	0	0	0	0	
Ck. Sum *	62-63	b7dd						

* These data types require two bytes per data point.

Interpretation: This data is from BC serial number 1003 and shows data for an EMU battery on channel 1 and a PGT battery on channel 2. The EMU battery has been charged using a constant current charge and has completed its normal charging cycle

of 1020 minutes (17 hours). The voltage of the EMU is 20.5 volts. The PGT battery is now reflex charging at 41.4 volts and 0.55 amps after 12 minutes. The charger does not recognize any battery type or ID resistor connected to channels 3 to 6. Information regarding the codes and their meanings are contained in the following sections.

1.2.4.3 Summary of Charger Programmability

The Christie CASP/2000 is capable of performing various kinds of maintenance on any rechargeable battery type. It is programmable via various types of tables stored within the firmware of the unit. The user provides battery-unique information and the desired profile parameters for each battery type in a particular Parameter Table. Each Parameter Table is associated to particular ID resistance(s) sensed on the output circuit of each of the charger’s six channels. The ID resistor can be physically located in the battery, in an adaptor cable connected in the channel, or, as in most of our applications, in the BSA connection circuits; the resistors were placed in the BSA since the EVA batteries were already in use and did not contain resistors when they were manufactured. The tables can be updated (one BCM at a time) to support new batteries or to refine maintenance profiles by placing the BCM in Download Mode via the REMOTE switch, connecting the REMOTE port to an ISS Windows-based laptop and using the TABLES.EXE program located on the laptop (refer to 1.645 BCA SOFTWARE DOWNLOAD) *for the -303 BCMs and using the TD-700 software for the -305 BCMs (refer to 1.655 PARAMETER UPDATE FOR -305 BCMs)*. If only a couple parameters require changing *for the -303 BCMs*, they can be changed one at a time using the REMOTE.EXE program, as was performed on Expedition 5.

Table 1.2–10 summarizes the table types and what information they contain; the specifics regarding the tables that the BCM’s use and the contents of each are in the follow sections.

Table 1.2-10. Charger table types

Table type	Table ID no./range	Description of table contents
Battery type table	100-131	Maps an ID resistor to a battery name (e.g. EMU BSA) and Parameter Table no.
Parameter Table	000-031	Identifies the characteristics for each battery, maps to a Cell Type Table no., and defines the (dis-)charge and charge termination methods
Cell Type table	090-093	Defines the characteristics of different battery chemistries at the single cell level
Execute table	080-087	Each table contains a series of task codes that define the sequence of events to be performed when a function is initiated with the CHARGE switch or REMOTE.EXE
Miscellaneous data	099	Contains items that are universal to all battery types or that have no relation to battery processing

1.2.4.4 Battery Type ID and (Dis-)Charging Parameters

The BCM can store information for up to 32 battery types and battery parameters. We are currently only using 11 of the 32 battery type tables since there are 11 ID resistors defined (Table 1.2–11); on the other hand, we only use 6 of the 32 parameter tables since there is more than 1 resistor value for the Helmet and PGTs. For example, a circuit within the HL battery allowed the sensed resistance to change when a HL battery is installed; therefore, the value prior to connection was used to display a type of HL-B Empty, indicating that no battery is installed. Redundant ID resistors also help differentiate where the batteries are located in the BSA (see Section 1.2-6 Failure and Design History).

Table 1.2-11. Battery type tables

ID resistor (+/- error%)	Battery = type table	Battery type telemetry code	Data contained in Table	
			Battery name	Parameter table
4.22 KΩ 1%	Table 103	01	01EMU BSA	001
6.81 KΩ 1%	Table 110	02	02EMU Suit	006
4.87 KΩ 1%	Table 105	03	03HL-A	002
23.7 KΩ 1%	Table 129	04	04HL-B	002
19.1 KΩ 1%	Table 126	05	05REBA – 10	005
10.0 KΩ 1%	Table 116	06	06PGT	003
13.7 KΩ 1%	Table 121	07	07HL-B	002
10.7 KΩ 1%	Table 117	08	08REBA - 30	004
20.5 KΩ 1%	Table 127	09	09PGT	003
23.7 KΩ 1%	Table 129	10	10HL-B Empty	000
13.7 KΩ 1%	Table 121	11	11HL-B Empty	000

Once the BCM power up self-test is complete, the BCM polls each channel to determine the battery type via the resistor value. Resistor values are hard-coded in the Christie firmware to a specific battery type table. In the battery type table the user maps that battery type to a parameter table (as shown above in Table 1.2–11). The parameter table is where the user defines the required (dis-)charging profile used including input current, cut-off voltage, maximum charge time, and other parameters as described in Table 1.2–12.

Table 1.2-12. Description of battery parameter data

Battery parameter	Description
Charge amps	Defines the charge current during ReFLEX™ or Constant Current (CC) charging or the current limit during Constant Potential (CP) charging
Discharge amps	Sets the discharge current for a discharge or maintenance (a.k.a. “Analyze”) function
Alt charge amps	Defines the charge current that would be used during an Alt charge task. The BCMs perform an Alt charge on each battery prior to performing the charge type selected in this table’s Charge Code. The Alt charge task is activated for standard charges in Execute Table 80
Amp hour	Defines the rated amp-hour capacity of the battery. Not used unless Min Amp Hour is not defined
Min amp hour	The minimum acceptable amp-hour capacity of the battery is compared with the calculated Amp Hour (AH) after a maintenance (Analyze) function and will causes an “Amp-Hour Test Error” if the battery capacity is lower. A setting of 0.00 avoids the message from every being received
Number of cells	Defines the number of physical cells within the pack connected to the channel. This is critical to proper, safe operation and must be entered as two digits (e.g. ‘08’)
Charge code	Also critical to proper, safe operation. The charge and termination method letter selects the process used for charging a battery and for detecting when charge is complete. The Cell Type Table no. defines the particular chemistry of the battery cells. (See Section 1.2-5 Charge Types and Termination Criteria for charge mode details)
Charge time	Defines the maximum allowed charge time in HHMM; provides an added cut-off protection against overcharging
Alt charge time	Defines the charge duration (HHMM) of an Alt charge (a constant current charge with cut-off only occurring at this specified duration; cut-off is not based at all on battery voltage profile, i.e. battery chemistry)

Table 1.2-13 identifies the actual charging parameters defined in the BCM's Parameter Tables for each battery type. This information is broken down for each BCM dash-number.

Table 1.2-13. Battery parameter tables

-301	Data contained in table								
-303									
-305									
Table/ battery name	Chrg Amps	Dis- chrg Amps	Alt Chrg Amps	Amp- hrs	Min Amp- hrs	No. of cells	Chrg code	Chrg Time (HH: MM)	Alt Chrg Time
000 10HL-B Empty 11HL-B Empty									
001 01EMU BSA	1.55	1.50	1.55	46.0	26.6	11	D90N	2200 3000* 3000	0003
002 03HL-A 04HL-B 07HL-B	1.00	1.00	1.00	3.40	2.50	15	B91N	0400 0430# 0430	0003
003 06PGT 09PGT	0.55	1.00	0.55	1.90	1.00	30	B91N	0415	0003
004 08REBA-30	1.00	0.50 0.50 1.50	1.00	3.60	2.50	30	B91N	0445#	0003
005 05REBA-10	1.00	0.50 0.50 1.50	1.00	3.60	2.50	10	B91N	0445#	0003
006 02EMU SUIT	1.55	1.50	1.55	46.0	26.6	11	D93N	2200	0003

* Modified on-orbit by Exp-5 crew per OCA 05-1381A.

Modified on-orbit by Inc 18 crew per Chit 6647

While the Parameter Tables contain much of the information needed by the BCM to safely (dis-)charge a battery, all battery voltage information is provided at the single cell level via the Cell Type Table number contained in the CC. The voltages of a particular battery type are then simply calculated by multiplying the cell voltage by the number of cells in that particular battery type. For example, when charging an EMU battery in the

BSA, the BCM stops charging when the CC voltage per cell (1.98V) times the number of cells (11) is sensed during the charger's OCV check (21.78V).

Table 1.2-14. Cell types used with parameter tables

-301	Data contained in table			Voltage data description
-303	Table 90 silver-zinc (In BSA)	Table 91 NiCd, NiMH	Table 93 silver-zinc (In Suit)	
Cell type data in table	Table 90 silver-zinc (In BSA)	Table 91 NiCd, NiMH	Table 93 silver-zinc (In Suit)	Voltage data description
Rail voltage/cell	2.50	2.50	2.50	Determines the maximum voltage ever expected during a charge; used to determine if the battery exhibits high impedance or too many cells. If the battery voltage exceeds 95% of this a "Wrong Batt or Hi-imp" error is issued
Discharged voltage/cell	1.45	1.00	1.45	Determines the voltage at which a discharge task is terminated
Nominal voltage/cell	1.50	1.20	1.50	The nominal OCV for a fully charged cell (not used for controlling the charger)
Constant Current (CC) voltage/cell	1.96	1.50	1.98	Determines the voltage per cell used to terminate a normal (vs. Alt) constant current Charge. (i.e. charge code D - EMU ICBs)
	1.98*			
Constant Potential (CP) voltage/cell	1.96	1.55	1.98	Determines the voltage per cell during a constant voltage charge (no EVA batteries currently use this method of charging)

* Modified on-orbit by Exp-5 crew per OCA 05-1339.

1.2.5 Charge Types and Termination Criteria

Along with the cell type, the charge code in the Parameter Table also contains letters designating the following:

1 st position	A – L	Each letter defines the standard charge type and charge termination method to be used for the battery
Last position	N (normal) R (reverse)	This polarity suffixes defines whether the battery’s thermal switch is normally closed (N) or normally open (R)

- The EMU ICBs are charged using a Constant Current (CC) with termination at a set Voltage Cutoff (table code D).
- All other EVA batteries are charged using a ReFLEX™ charge with termination using the Maximum Curve criteria (table code B).

Each of these two methods of charging and charge termination are described in detail below, as is Alt Charging. Note that the Christie chargers are also capable of CP charging and of terminating by several other methods (Standard Curve, by time, at a set time after a voltage is reached, and when a thermal switch trips.) For details on these other methods, refer to Christie’s Operator’s Manual CASP/2000.

CC charging: Uses the current entered in the CHARGE AMPS parameter. The charge delivered to the battery is a constant stream of electrical current. This is suggested for silver-zinc batteries. The charge voltage is allowed to vary to keep the charge current constant. The resulting voltage profile is therefore a function of the chemical reactions occurring in the battery during the charge.

Voltage cutoff: Senses when the battery voltage reaches the value calculated from the CC V/CELL entry in the CELL TYPE table, then divides the current by the REDUCED CURR entry in Table 099. When the voltage again reaches the sense point, charging is terminated.

ReFLEX™ charging: Is the recommended method of charging sealed nickel cadmium batteries. It is a Christie Electronic process that charges at the rate set by the CHARGE AMPS parameter, and uses a brief discharge (or “burp”) pulse once a second. This allows faster charge times and reduces memory in nickel cadmium batteries. The charge voltage is allowed to vary to keep the charge current constant. The resulting voltage profile is therefore a function of the chemical reactions occurring in the battery during the charge.

Maximum Curve cutoff: Monitors the rate of change of the battery voltage to determine cell condition, but waits until the battery voltage actually starts decreasing during charge. This method delivers more energy (then Standard Curve cutoff) to the battery, but also increases heating of the cells. This process is recommended for low

impedance nickel cadmium batteries. More capacity is available from any one charge using this method, but the total number of recharges of a battery is reduced.

Alt charging: The Alt charge mode is a timed charge termination versus the normal charge termination defined in the battery’s parameter table. The Alt charge charges until the time specified in ALT CHARGE TIME is expired. The BCM Charge process has been programmed, via Table 080, to always start with an Alt charge. This was done in an attempt to remove any battery electrode passivation prior to the charger beginning to monitor the voltage profile. Passivation temporarily increases the batteries resistance (impedance) to charging and discharging, thus affecting the normal voltage profile and possibly stopping a charge by triggering false termination, Low-slope Error or Wrong Batt or Hi-Imp indications.

The type of task being performed, or the communications mode that the BCM is in, is displayed via the serial data Task field coming through the MDM; it is NOT shown on the front panel display. Table 1.2–15 lists the possible indications that can be received.

Table 1.2-15. BCM task field display codes

Code	Task
0	No history
1	Constant current charge
2	ReFLEX™_charge
3	PCS mode
4	Download mode
5	ALT charge
The Following Apply to -305 Only	
6	Discharge
7	Charge-Discharge
12	Charge-Discharge-Charge

1.2.5.1 Task Sequences and Execute Tables

When the MODE switch is taken to CHARGE, or when the “disch” menu item is executed from the REMOTE.EXE program, the Christie firmware actually starts a sequence of events that are defined by a sequence of Task Codes in the Execute Tables (no. 080 to 085). A sequence of up to 16 tasks could be executed with a single switch throw or command execution. Codes also exist to allow the sequence to be repeated multiple times or indefinitely until the STOP switch is pressed. Table 1.2–16 lists the task codes for the Execute Tables normally used for on-orbit operations (Table no. 080 and 081). The BCM’s other Execute Tables were populated generically by Christie Corp.; these tables might be changed and/or used in the future to allow more automated maintenance cycling of the EVA batteries. For more information, see Christie’s Operations Manual and EVA Battery-to-BCA/BSA ICD.

Table 1.2-16. Execute table task sequences

Function/table	Task code sequence	Comments
Charge/table 080	43 11 00 00 00 00 00 00 00 00 00 00 00 00 00 00	Alt charge (43), standard charge (11), stop (00)
Discharge/table 081	32 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00	Discharge (32), stop (00)
Examples of other possible functions		
Charge - discharge	43 11 35 32 00 00 00 00 00 00 00 00 00 00 00 00	Alt charge (43), standard charge (11), timed wait (35), discharge (32), stop (00)
Rapid recovery cycles	43 11 35 32 15 15 15 15 11 35 62 00 00 00 00 00	Alt charge (43), standard charge (11), 1-hr timed wait (35), discharge (32), 4-hr timed wait (15)x4, standard charge (11), 1-hr timed wait (35), discharge with AH analysis (62), stop (00)

A timed wait is often desired between discharge and charge tasks to allow the battery to cool off before starting the next task. The desired time is specified in hours and minutes by the Wait Time parameter of Table 99 Miscellaneous Data. This time is used for all battery types. Because of this, multiple WAIT codes could be used or Table 99's Wait Time could be set to the longest cooling time required by any of the batteries; with the current battery types, that would be the 4 hours required by the EMU ICBs. Since Table 99 currently has the Wait Time set to 1 hour, four Wait codes would have to be placed between a discharge and subsequent charge to meet this requirement. NOTE: While different WAIT task codes exist (14, 15, 34, 35, etc.), all waits are of this same duration. What changes is the message displayed during the wait (signified by the first digit) and whether the charger does nothing during the wait (second digit = 4) or moves to the subsequent channels while the wait time counts down (second digit = 5).

1.2.6 Failure and Design History

1.2.6.1 Failure Modes Documentation

The BCA has several failure modes that are considered Criticality 1 items due to the potential to cause battery explosion. See the Failure Modes and Effects Analysis (FMEA)/Critical Items List (CIL) report from Lockheed Martin (Document no. P104955) for details on failure modes for the following:

- Main power switch
- Mode (CHARGE/STOP) switch
- Data (REMOTE/HISTORY) switch
- Remote port
- Display
- LED

1.2.6.2 In-Flight Anomalies and Off-Nominal Signatures

MER-IFI 842 Failure to Discharge EMU Battery

When attempting to perform on-orbit maintenance discharge of EMU battery, S/N 2020, in BSA slot EMU 4, the discharge could not be initiated. The crew reported a History display (as read on the ISS Windows-based laptop) message for Channel 4 of " OP * Ch4 00:00:00" with "Discharged Look at 1,3,4" flashing on the second line. The discharge was reattempted with Battery Charger no. 3 and Battery charger no. 4 both powered. This also failed resulting in the same message to the crew. The crew later confirmed that OCV of the battery was 20.4 volts, confirming that the battery was connected properly and the charger was sensing the voltage.

MER-IFI (not incorporated) Battery Charger Amp Readings During PSA Use with EMU Middeck Charger

BCs on MEGA display show from 0.00 to ~0.25 to 0.3 amps (Program Unique Identifiers (PUIs) ALXS01BT01013C, 0203C, 0303C, and 0403C) when initiating EMU battery charge using the PSA utility outlet and middeck EMU battery Charger. The chargers themselves were not powered. We saw another occurrence of this subsequently, when charging batteries in BC 3 and 4. The analog amp draw showed 0I3 amps with PSA power on and the RPCs open.

MER-IFI (not incorporated) BC 1 Shutdown After Charge Initiation

Approximately 5 minutes after CHARGE initiation, BC 1 charge voltage dropped from 40.5 to 0. BC 1 serial data indicated NO HISTORY for all channels. The crewmember was directed to cycle the MODE switch back to CHARGE and charging was reinitiated with no anomalies.

MER-IFI 701 Battery Charger 1 Low Slope Error/Garbled Display

When topping off EVA batteries in the BSA, BC 1 gave error messages for the PGT battery in CH 1 ("Low Slope error") and the HL battery in CH 4 ("Wrong Batt/High Imp" – garbled on display but captured in serial data downlink). The OCV for the PGT battery was 26.8 V dc, which indicates a bad battery (typically ~40 V). The OCV for the HL battery was 18.6 V dc, which indicates a partially charged battery. The charge was

reattempted in BC 2 with the same errors. The batteries were marked as “bad” and returned on a subsequent flight. Batteries that are in a deeply discharged state will not take a charge.

MER-IFI 740 (EXP 4) BC3 Serial Data Charge Indication Anomaly

When BC 3 advanced to Ch 3, shortly after initiating the charge, the serial data telemetry for channel 3 indicated zero amps on the Mega Data Display. The serial data volts increased consistent with a nominal charge. The analog amps (ALXS01BT0303C) for this channel were nominal.

MER-IFI 619 In-suit EMU Battery Charger (BCA) Early Termination

EXP 3 began charging EVA batteries in prep for UF-1. EMU batteries 2012 and 2013 were placed in the EMUs (3010 and 3016 respectively) for charging. These batteries were last used on 7A.1 on 8/16/2001 and were discharged (20.24 amp-hr and 21.57 amp-hrs) by the last EVA on 7A.1 and left on ISS in this state. During the subsequent charge on EXP 3, EMU 1 charge current was ~1.49, and EMU 2 charge current was ~1.48 amps. EMU 1 battery stopped charging at 1 hr 58 min with TASK COMPLETED OK. At this time, EMU 2 charge current changed to ~1.11 amps (due to UIA anomaly split). EMU 1 charged ~2.98 amp-hr and EMU 2 charged ~4.9 amp-hr.

1.2.6.3 Ground Testing Anomalies

Problem Report no. 2503 Battery Charger 2 Analog Current Anomaly

BC 2 analog current data did not correlate with RS-485 data. BC 2 analog voltage was nominal. There are no operational impacts since loss of BC 2 analog current data only affects redundancy; RS-485 serial data is primary source of data. Potential sources of the anomaly have been isolated to wiring harness W071, W082, Airlock MDM, or BC 2.

High Impedance Problem – EMU battery

The BCA design was based in part on the ICD for the Yardney (silver zinc) EMU battery. The problem was identified during charging of partially discharged batteries. The BCA failed to initiate charge due to high impedance, “HIGH IMP.” The Christie firmware records this as an erroneous condition and skips over the battery. Batteries that were discharged by ~ 2 amp-hr, or more, have charged successfully. The recommended workaround option was to perform EMU Checkout on battery power. Currently, we leave batteries discharged on ISS.

Wrong Charge Table Selected

During ground testing of the -305 BCM, the wrong table was selected. The error was repeated twice but could not subsequently be reproduced. In all instances, an empty table was selected. Analysis determined no hazard to crew from any incorrectly selected table.

Table 1.2-17. Malfunction summary

No.	Anomaly	Cause	Status	Workaround	Comments
1	BCM History screen shows blank display upon power-up	Noise (due to diode capacitance) between front end processor and Christie processor	Fixed in - 303 units	Cycle power	Replaced blocking diode with short circuit protection resistor in the backup battery (Li) circuit. Diode capacitance caused battery controller chip to malfunction during startup in original configuration
2	BCM shows garbled display upon startup	Same as 1	Fixed in - 303 units	Cycle power	Same as 1
3	BCM initiates immediate charge upon startup	Affects BC 3 and BC 4 only. Current leakage through TCO circuitry in the unpowered unit causes the front-end processor to startup with erroneous data in registers	Fixed in - 303 units	Procedures written to power up all four units within 7 seconds	Changed BCM circuit (NAND gate) to eliminate current leak through TCO path

Table 1.2-17. Malfunction summary (continued)

No.	Anomaly	Cause	Status	Workaround	Comments
4	Garbled "Task Completed OK" message when stop switch was used to stop charge	Unknown, possibly related to 5	Fixed in - 303 units if related to 5	Verify battery is fully charged based on duration and amperage. Status indication should still be good via telemetry	At elevated temps, corrupted pointer in Random Access Memory (RAM) causes program to begin reading message string from incorrect location in Erasable Programmable Read-Only Memory (EPROM)
5	Garbled "Stop switch Toggled" message when stop switch was used to stop charge	A RAM location of the front-end processor appeared to be erroneous at elevated temps, which caused a pointer to address an erroneous message location	Fixed in - 303 unit. Micro-controller replaced	Status indication via telemetry will be correct	At elevated temps, corrupted pointer in RAM causes program to begin reading message string from incorrect location in EPROM
6	Pages skipped when attempting to toggle through history data	Data transfer problem between Christie and display	Fixed in backup units	Do not cycle DATA switch while the hourglass is displayed. Cycle DATA switch to retrieve skipped data	Channel counter in firmware is incorrectly set for hourglass update routines

Table 1.2-17. Malfunction summary (continued)

No.	Anomaly	Cause	Status	Workaround	Comments
7	“Low slope error” for PGT batteries	BCM does not see the desired increase in voltage over a specified time or saw a decrease in voltage	Addition of a 3 min alternate charge postpones the slope test until 6 minutes of charge time have elapsed	Condition should be rare. If encountered, crew will re-initiate the charge.	Characteristic behavior for NiMH batteries that have been deeply discharged and/or have sat for extended period of time, can exhibit a negative voltage slope during initial charge
8	High charge current on BCM display	System noise on the BCM current-sense amplifier	Fixed in backup units	Modification made to UIA enables insight into EMU in-suit battery charge	Capacitor added between the current-sense op amp output and ground
9	BCM will not top off EMU batteries because of “High Imp”	Constant current charge profile is not compatible with EMU battery at beginning of charge	No fix available (would require upgrade of firmware)	Ensure batteries are sufficiently discharged, via EMU Checkout (C/O) or other means, to accept a toff charge	EMU procedure written for the option of performing EMU C/O on battery. SSATA testing was performed to verify that battery is sufficiently discharged to preclude “High Imp”

Table 1.2-17. Malfunction summary (continued)

No.	Anomaly	Cause	Status	Workaround	Comments
10	BCM cannot discharge EMU batteries in BSA	Current leakage through TCO circuitry in the unpowered unit	Fixed in backup units	Power BCs 3 and 4 on to enable discharge	<p>Changed BCM circuit (NAND gate) to eliminate current leak through TCO path. The powered BCM detects current in unpowered unit and opens a charge channel that Christie firmware detects as an open fuse, resulting in "Open Circuit" message being issued.</p> <p>This was thought to be the problem initially on EXP 5 attempt to perform a discharge; however, in troubleshooting, both BC 3 and 4 were powered up with no joy on the discharge</p>

Table 1.2-17. Malfunction summary (continued)

No.	Anomaly	Cause	Status	Workaround	Comments
11	Early charge cutoff for batteries in the EMU	High system impedance causes extended RC decay profile	Battery charge parameters have been updated to account for impedance	None required	Impedance in A/L electrical lines biases the measured battery voltage high. BCMS were recalibrated/adjusted to account for impedance in A/L lines
12	BCM HISTORY screen display "Look At" message after power up	Same as 1	If same as 1, then fixed in backup units	Power off UIA prior to powering up BCA	Replacing blocking diode with short-circuit protection resistor in backup battery (Li) circuit. EMU battery line capacities suspected to cause battery controller chip to malfunction during startup in original config
13	Short circuit error	Unexplained. Possibly related to test setup in SSATA. Occurred during the test on S/N 1002 and 1006	Unable to recreate, so closed as unexplained	Reinitiate charge on affected battery	In one case, the battery charged about 5 min, in other charged 1 hr, then terminated with "Short circuit error." Could not duplicate malfunction

Table 1.2-17. Malfunction summary (concluded)

No.	Anomaly	Cause	Status	Workaround	Comments
14	Anomalous immediate return to MAIN DISPLAY when attempting to view history	History display time-out counter not always set correctly.	Fixed in backup units	Cycle through history as needed to obtain data	History display timeout counter was not always reset for the history mode
15	Anomalous voltage reading on EMU batteries (77.0 V dc)	Data transfer problem between Christie and display. Takes up to 2 minutes to get new value, so bogus value may be displayed for up to 2 minutes	Closed. Firmware updated to minimize occurrences. Fixed in backup units	Wait for data to update	Firmware re-written to parse (displayed) data from Christie more accurately. Determined impact was minimal. Current is updated more often than voltage
16	Garbled history data	Data transfer problem between Christie and display. Same cause as 15	Fixed in backup units	Cycle through history as needed to obtain data	Firmware re-written to parse (displayed) data from Christie more accurately. Determined impact was minimal. Current is updated more often than voltage

1.2.6.4 Design History

The BCA was designed and manufactured by Lockheed Martin Space Operations. The first flight of the BCA was ISS Flight 7A. It was launched in place in the ISS Airlock module and included four -301 versions of the BCM. Two of the -303 versions were prepositioned by ISS Flight 6A in response to the ground testing anomalies; it was determined to be cheaper to R&R the units on-orbit after their delivery on ISS 7A. The -305 version *was installed by STS-124. A -306 version is in development at the time of this publication and is expected to fly in late 2009 or 2010.*

Materials and Constraints

The design of the BCA conforms to materials requirements of JHB 8080.5, Std. M/P-1. All materials used in the BCA meet the requirements of NHB 8060.1C, JSC-09604, and MIL-STD 975.

1.2.7 Original Equipment Manufacturer Data

1.2.7.1 Operating Limits

	Limit conditions	Operating limits (min/max)	sPUI	Constraints/comments
1	Temperature limits	45°F (7.2 °C)/110°F	N/A	<ul style="list-style-type: none"> ▪ Qual limits ▪ Assumes coldplate in Avionics Rack is functioning ▪ Reference SCCN 2373
2	Pressure limits	10 psia to 15.2 psia	N/A	
3	Input voltage	120 +/- 6 V dc to each BCM	N/A	<ul style="list-style-type: none"> ▪ Each BCM supplied by separate RPC ▪ Operating beyond these limits incurs risk of hardware damage or decreased performance
4	Input power	0.4 amps nominal per BCM	N/A	<ul style="list-style-type: none"> • Power consumption measured during testing was less than 200 watts for four modules
5	Input over-current protection	3.7 amps to 4.2 amps	N/A	<ul style="list-style-type: none"> ▪ Over-current protection provided by RPCM for each BCM ▪ Reference SSP 30263:002
6	Output voltage (BSA supply)	12.0 +/- 0.5 V dc	N/A	<ul style="list-style-type: none"> ▪ BSA receives power from each, or all of, the BCMs in the BCA ▪ Does not include recharge power to the batteries
7	Output current (BSA supply)	<0.25 amp max	N/A	<ul style="list-style-type: none"> ▪ BSA receives power from each, or all of, the BCMs in the BCA. In the BSA, this powers electronics for fan control, TCO, driver circuit, and charge status LED ▪ Does not include recharge power to the batteries
8	Output over-current protection (BSA supply)		N/A	<ul style="list-style-type: none"> ▪ BSA receives power from each, or all of, the BCMs in the BCA

	Limit conditions	Operating limits (min/max)	sPUI	Constraints/comments
8	Output over-current protection (BSA supply)		N/A	<ul style="list-style-type: none"> ▪ BSA receives power from each, or all of, the BCMs in the BCA ▪ Does not include recharge power to the batteries
9	Output voltage (EMU battery recharge)	22.0 +/- 0.1 V dc at charge completion	N/A	<ul style="list-style-type: none"> ▪ Function provided by BCA via PSA interfaces ▪ See Battery ICD JSC-38983
10	Output current (EMU battery recharge)	1.55 +/- 0.05 amps	N/A	<ul style="list-style-type: none"> ▪ Function provided by BCA via PSA interfaces ▪ See Battery ICD JSC-38983
11	Output voltage (PGT battery recharge)	44 to 44.5 V dc at charge completion	N/A	<ul style="list-style-type: none"> ▪ See Battery ICD JSC-38983
12	Output current (PGT battery recharge)	0.5 amps ± 0.05	N/A	<ul style="list-style-type: none"> ▪ See Battery ICD JSC-38983
13	Output voltage (EHIP battery recharge)	23 to 23.5 V dc at charge completion	N/A	<ul style="list-style-type: none"> ▪ See Battery ICD JSC-38983
14	Output current (EHIP battery recharge)	1.0 Amps ± 0.05	N/A	<ul style="list-style-type: none"> ▪ See Battery ICD JSC-38983
15	Output voltage (BSA external charge port)	48 V dc for 30-cell REBA 16 V dc for 10-cell REBA	N/A	<ul style="list-style-type: none"> ▪ As programmed for REBA recharge ▪ See Battery ICD JSC-38983 for other possible battery types
16	Output current (BSA external charge port)	1.0 amps ± 0.05	N/A	<ul style="list-style-type: none"> ▪ As programmed for REBA recharge ▪ See Battery ICD JSC-38983 for other possible battery types
17	Discharge current (EMU battery discharge)	1.50 Amps ± 0.05 3.00 Amps ± 0.05	N/A	<ul style="list-style-type: none"> ▪ Only –301 and –303 models ▪ –305 models
18	Discharge current (PGT battery discharge)	0.50 Amps ± 0.05 1.00 Amps ± 0.05	N/A	<ul style="list-style-type: none"> ▪ Only –301 and –303 models ▪ -305 models
19	Discharge current (EHIP battery discharge)	1.00 Amps ± 0.05	N/A	<ul style="list-style-type: none"> ▪ –301, –303 and –305 models
20	Discharge current (REBA battery discharge)	0.50 Amps ± 0.05 1.50 Amps ± 0.05	N/A	<ul style="list-style-type: none"> ▪ Only –301 and –303 models ▪ –305 models

1.2.7.2 Non-Operating Limits

	Limit conditions	Non-operating limits (min/max)	sPUI	Constraints/comments
17	Survival temperature limits	30° F (-1.1°C)/150° F (65.6° C)	N/A	<ul style="list-style-type: none"> ▪ Qual limits ▪ Reference SCCN 2373
18	Survival pressure limits	Space vacuum to 15.2 psia	N/A	

Ref. Engineering Memo: EVA-EV-1272

1.2.7.3 Reference Material

Specifications and other Documents

- A. BCA End Item Specification – JSC-33279
- B. BCA-to-Airlock ICD – JSC-33234
- C. SPCE PTRS – JSC-33277
- D. BCA Top Assy Drawing – SEG39128212
- E. BCM Top Assy Drawing – SEG39128256
- F. Batteries-to-SPCE ICD – JSC-38983

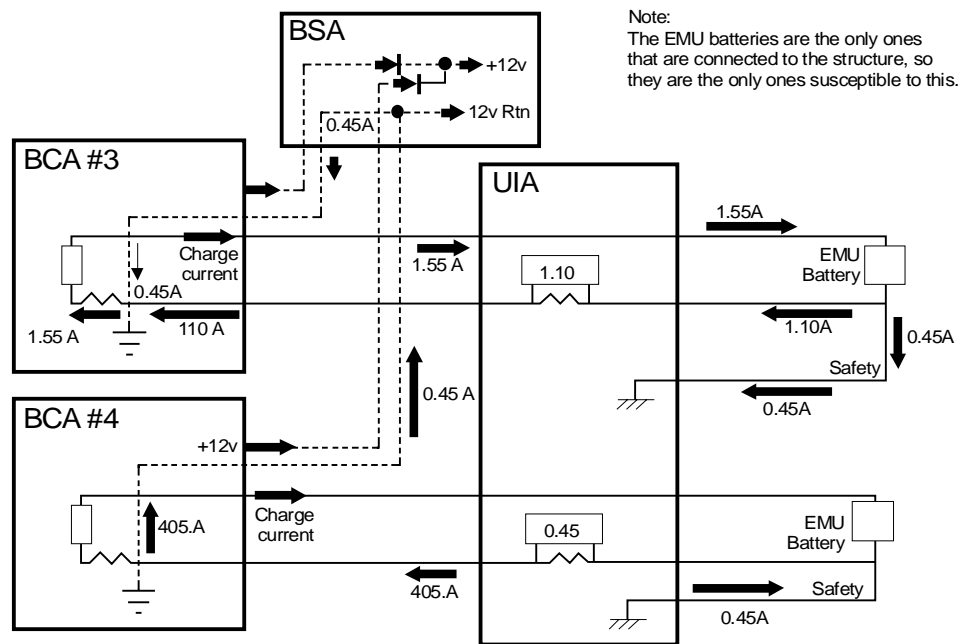


Figure 1.2-14. EMU battery in-suit charging sneak circuit

1.2.8 References

COTS Vendor Documents – Chistie Electronic Corp.

- A. CASP Flowcharts, Fax from Christie dated October 28, 1999

Description: *Flowcharts and descriptions show the tests, measurements, and decisions CASP makes when charging and discharging batteries as well as when CASP reports error (completion) codes.*

- B. OPERATOR'S MANUAL CASP/2000 (L, H, and D), TD-608 Rev. E, Software Version 5.0

Description: *Contains details on the capabilities and modes of operation of the CASP, definitions and descriptions of the tables and parameters that control the CASP's operation, as well as descriptions of the various messages and errors.*

- C. CASP 1000/1200/2000 INTERFACE PROGRAM OPERATION MANUAL, TD-639X2, Software Revision A

Description: *Contains details on the use of the TABLES.EXE and REMOTE.EXE interface programs; much of the same information contained in the Operator's Manual.*

- D. TECHNICAL MANUAL CASP/2000 (L and H)', TD-617 Rev. A

Description: *The purpose of this technical manual is to help technicians repair and maintain the CASP/2000. It assumes the user is familiar with the operation of the CASP. This document has detail down to the internal electrical component level.*

<http://christiecorp.com>

ISS Program-Related References

- A. Design, Analysis and Test References
- B. Lockheed Martin/M. Sommers, Lead Engineer – BCA, BSA, PSA
- C. Failure Modes & Effects Analysis & Critical Items List (FMEA/CIL) Report – LMSO-P104956, March 1999
- D. Safety Assessment Report (SAR) – LMSO-P104980, March 1999
- E. JSC-33234B Battery Charger Assembly to Airlock ICD, February 1999
- F. JSC-38983 EXTRAVEHICULAR ACTIVITY (EVA) BATTERIES TO BATTERY CHARGER ASSEMBLY (BCA) BATTERY STOWAGE ASSEMBLY (BSA) INTERFACE CONTROL DOCUMENT (ICD)
- G. Drawing No. SKG39134917 Battery Charger Assembly Firmware Program Documentation, Rev. A (available electronically from EDCC)

1.3 BATTERY STOWAGE ASSEMBLY (BSA)

1.3.1 ORU Specification Table

Table 1.3-1. Battery stowage assembly reference data

Description	Specification	Comments
Part Number:	SEG39128213-301	Designed as an ORU (fasteners captive); SODF ORU Changeout procedure does NOT exist.
Existing Flight Units (Quantity):	2	Includes qualification unit (sn100x) that is currently located at JSC in the building 7 SSATA chamber; sn1002 is on-orbit
Dimensions: BSA	35.24 in. W x 14.6 in. H x 9.5 in. D	Dimensions do not include protrusions from panel surface plane (i.e., handholds, tether rings, switches, etc.)
Weight (dry): BSA	48 lb	
Connector Interfaces:	Part no. TBS	Electrical connectors (qty - 4) to BCA

1.3.2 General Description

The purpose of the Battery Stowage Assembly (BSA) is to provide a stowage facility for batteries, while they are being charged via the Battery Charger Assembly (BCA). The BSA was intended to provide long-term stowage as well. However, past experience shows that batteries left connected in the BSA experience a “parasitic” discharge that cause battery OCVs to be lower than 1 V after a few months of stowage. Therefore, operationally it is suggested that batteries not be left connected in the BSA for longer than a few weeks. The BSA provides the mechanical and electrical interfaces for recharging EVA-related batteries. The BSA has no internal power supplies; the BCA supplies power to the BSA for all functions. The BSA provides a visual status to the crew during charging via the CHARGING IN PROGRESS LED. The BSA is equipped with two fans (A and B). Only one fan is used at a time; it dissipates potential gas buildup during charge. The BSA is equipped with two microswitches to identify whether the door is open or closed. Only one switch is used at a time. Which microswitch and fan is active is determined by jumper (A or B) position (refer to *Figure 1.3-2*).

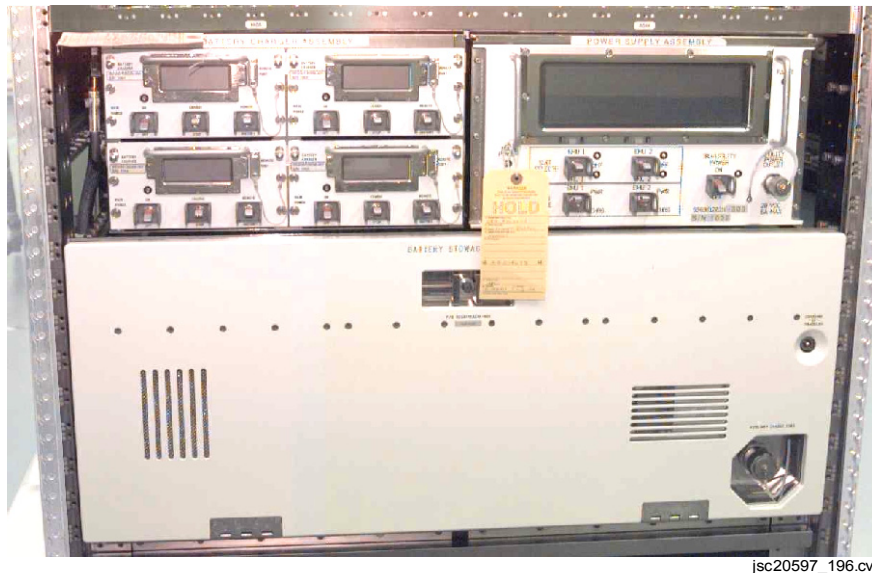
1.3.3 Subsystem Detail

1.3.3.1 Location and Structure

Location

The BSA is mounted in the Equipment Lock Avionics Rack (see Figure 1.3-1) and is located below the Power Supply Assembly and the Battery Charger Assembly.

As with most other items in the Joint Airlock, the BSA is an On-Orbit Replaceable Unit (ORU). Due to the large size of the spare and the limited on-orbit stowage space available, the spare unit will remain on the ground until it is needed.



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Figure 1.3-1. Avionics rack lower section (BCAs, PSA, and BSA)

Structure

The BSA door provides a means for covering and protecting the batteries that are under charge and to contain debris that may be generated in the event of an explosive battery. Each stowage slot contains structural features that interface with the battery's locking mechanisms. The locking mechanisms operate in the same manner as they do with the hardware with which the battery is used. *Figure 1.3-2* shows the battery stowage assembly.

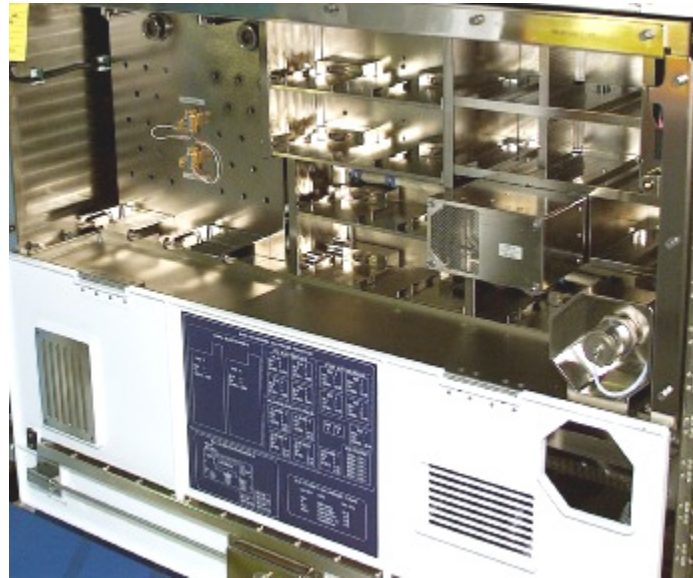


Figure 1.3-2. Battery stowage assembly (close-up of BSA slots)

1.3.3.2 Interfaces

Power Interfaces

The BCA supplies power to the BSA for battery recharge and operating the fan circuitry. Only one Battery Charger (BC) must be powered for the BSA fan to operate. Battery Charger (BC) subassemblies, BC1, BC2, BC3, and BC4 each receives 120 volts from RPCM AL1A4A_B RPC 3, 4, 5, and 6, respectively. Each BC is capable of charging six independent batteries (or channels) in series with the channels hardwired to specific locations in the BSA that cannot be changed on-orbit. This wiring defines the sequence in which the batteries will be charged. Table 1.3–2 shows the sequence for each BC.

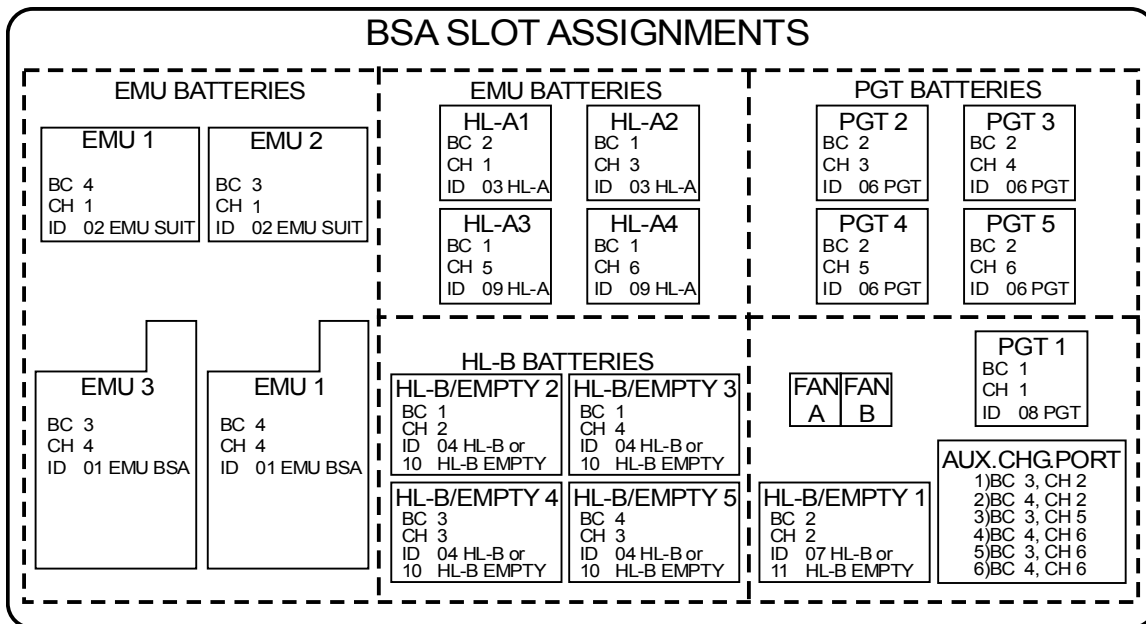
Table 1.3-2. Battery charger channel sequence

	BC 1	BC 2	BC 3	BC 4
Channel 1	PGT 1	HL-A 1	EMU 2 (in-suit)	EMU 1 (in-suit)
Channel 2	HL-B/EMPTY 2	HL-B/EMPTY 1	ACP 1 (REBA)	ACP 2 (REBA)
Channel 3	HL-A 2	PGT 2	HL-B/EMPTY 4	HL-B/EMPTY 5
Channel 4	HL-B/EMPTY 3	PGT 3	EMU 3	EMU 4
Channel 5	HL-A 3	PGT 4	ACP 3 (REBA)	ACP 4 (REBA)
Channel 6	HL-A 4	PGT 5	ACP 5 (REBA)	ACP 6 (REBA)

The 16 batteries that can be stowed in the BSA include two EMU batteries, nine Helmet Light (HL) batteries (HL-A, HL-B/EMPTY), and five Pistol Grip Tool (PGT) batteries. As designed, eight channels are dedicated to charge batteries external to the BSA (grayed cells in Table 1.3-2.) For more information on charging in-suit EMU batteries and the Auxiliary Charge Port (ACP) usage, see the BCA section (Section 1.2). The ACP is currently used only for REBA battery connection to the BCA. The ACP can also be used to charge a variety of batteries by updating a BCA parameter table such that the

charger associates the ID resistor in a newly-provided ACP charge cable with the appropriate charge parameters.

The label located on the inside of the BSA door provides crewmembers with a reference to identify battery location, charging sequence, and the associated battery charger (shown in Figure 1.3-3). Each wiring interface for the BSA is unique to each battery type as shown in Figure 1.3-4 to Figure 1.3-7.



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Figure 1.3-3. Battery storage assembly label (drawing SDG33113132)

The BCA uses an associated ID resistor to determine the type of battery to be charged and the charge profile to be used. Each of the 16 battery slots in the BSA has a resistor hardwired to the circuit board. The unique case is the HL-B/EMPTY battery slots, which were originally going to be used for charging REBA batteries as well. With an adapter installed (note: adapter was never built), the resistor in the BSA will then be connected in parallel with a resistor in the adapter. This configuration allows two profiles to be used with the HL-B/EMPTY slots. This same adapter technique could be used on any of the BSA slots, but no situation has required this to be implemented.

Resistors for the ACP are integral to the battery adapter cable supplied by the battery manufacturer. Currently, the REBA BSA Cable (SEG33112214) is the only cable of this type. The BSA electrical pin assignments for the REBA BSA cable connection to the ACP (J6) are shown in Figure 1.3-8.

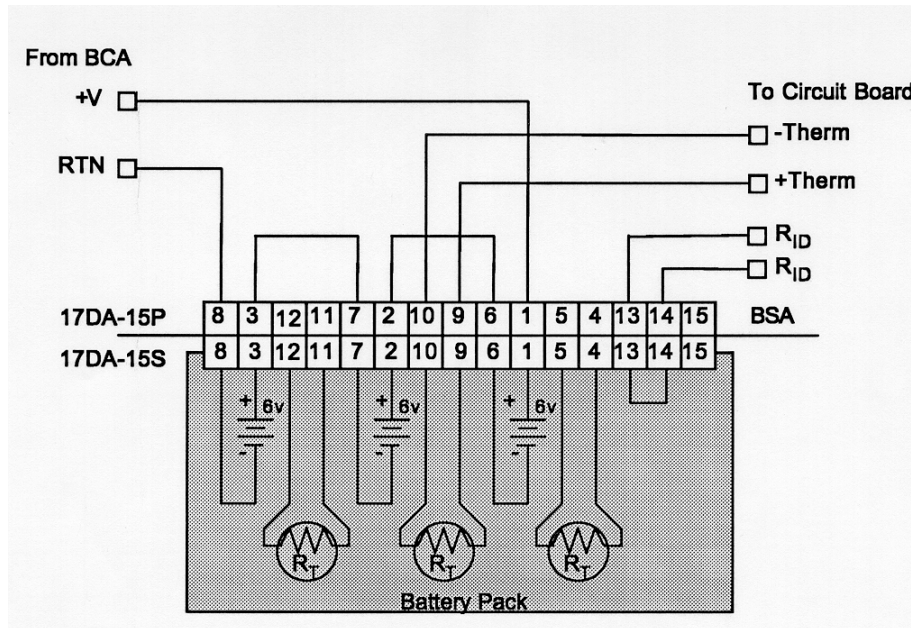


Figure 1.3-4. BSA to HL wiring interface

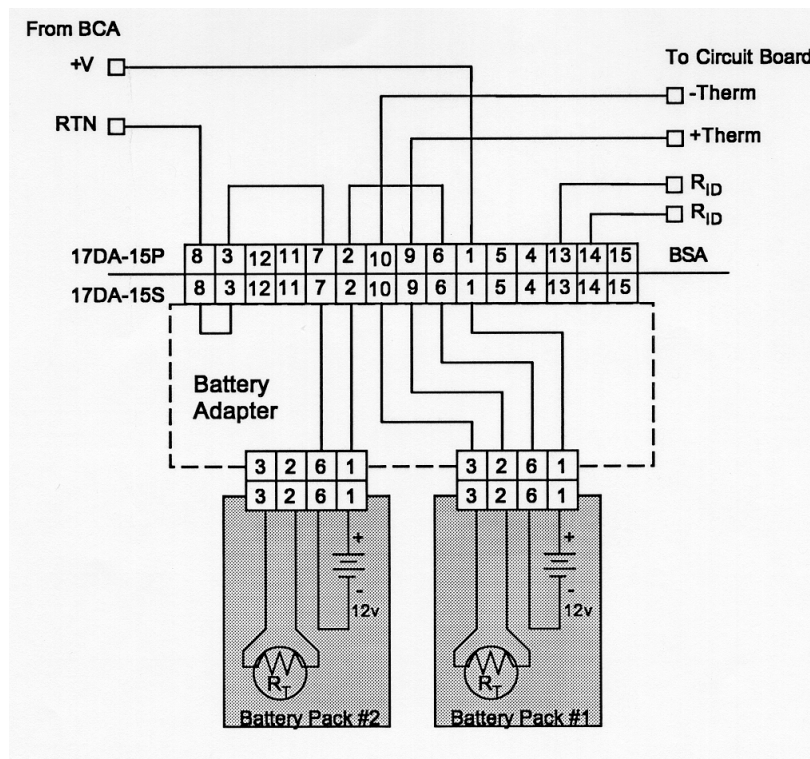


Figure 1.3-5. BSA to REBA adapter wiring interface (concept; not built)

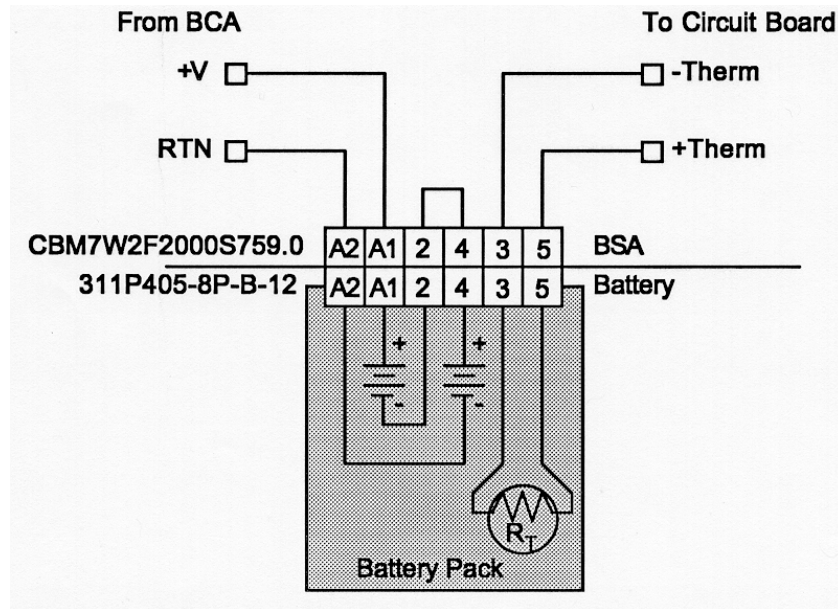


Figure 1.3-6. BSA to PGT (NiMH) wiring interface

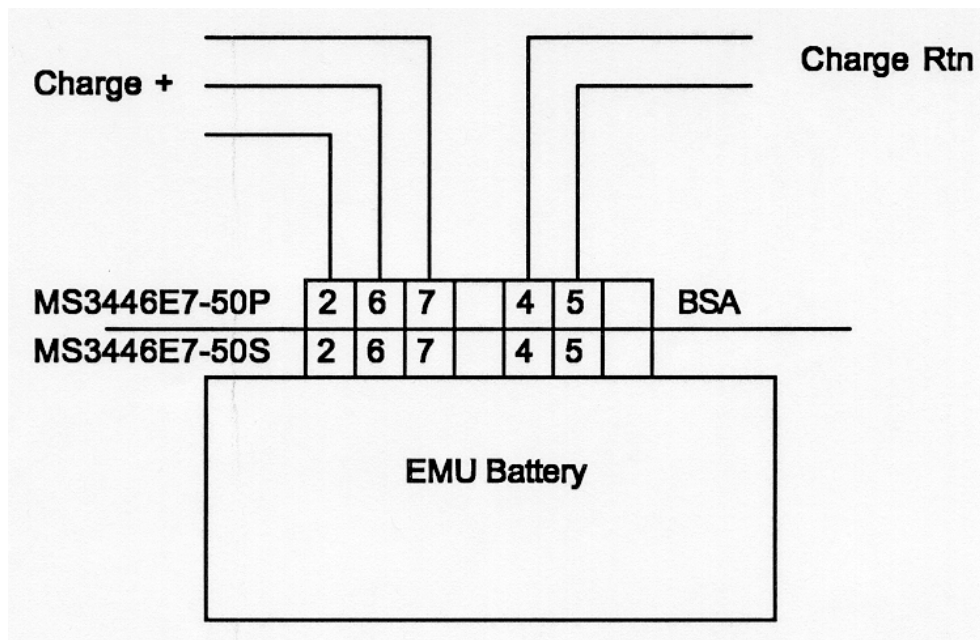


Figure 1.3-7. BSA to EMU battery wiring interface

BSA aux. charge port (pins)				REBA BSA cable (socket)	
BCM no. : channel	Pwr pins (+V, +Vrtn)	Thermister pin (+)	ID resistor pin (+)	No. of cells	Resistor ID value
BC3 : Ch2 (EXT 1)	C, A	B	V	REBA-30	15.6 Kohms
BC3 : Ch5 (EXT 3)	j, g	h	f	REBA-10	12.1 Kohms
BC3 : Ch6 (EXT 5)	R, N	P	d	REBA-10	12.1 Kohms
BC4 : Ch2 (EXT 2)	W, E	X	D	REBA-30	15.6 Kohms
BC4 : Ch5 (EXT 4)	S, U	T	e	REBA-10	12.1 Kohms
BC4 : Ch6 (EXT 6)	c, L	M	b	REBA-10	12.1 Kohms
Other/ Common	(+12 V dc, rtn) H,F	(-Therm) Z			

Pins are designated by letters



Figure 1.3-8. Auxiliary charge port (uncapped)

Data Interfaces

There is no telemetry associated with the BSA. All charge data is collected at the BCA; reference the BCA section (Section 1.2) for telemetry that can be monitored from the battery chargers.

Thermal Interfaces

The BSA uses the rack structure to conduct heat away from the unit.

User Interface Photos

For Fan and Jumper photos, see 1.650 BSA FAN SWAP procedure in the EVA SYSTEMS CHECKLIST)

1.3.4 Operational Detail

1.3.4.1 Door and Battery Latches

To install a battery in the BSA for charging, the door must first be opened. (See Figure 1.3-9) The crew has found that opening the door fully is not required; as such, the EMU Don/Doff Assembly (EDDA) need not be moved beyond the 60-degree limitation of the EDDA rotation strut. Squeezing the door latch handles together directly actuates linear rods at each end of the door, unlatching the door. (See Figure 1.3-10.)

If the door is opened during a charge, the closed-circuit door microswitch activates all Thermal Cutoffs (TCOs) and all charging is be paused with the exception of in-suit battery recharge.

The BSA door must be closed to begin charging to ensure that crewmembers are protected from the batteries in the event of a battery failure.

Proper battery installation requires that the battery mount lock engages the BSA. While not common, tolerance issues have caused some batteries not to lock into specific locations within the BSA; try swapping battery locations if this occurs.

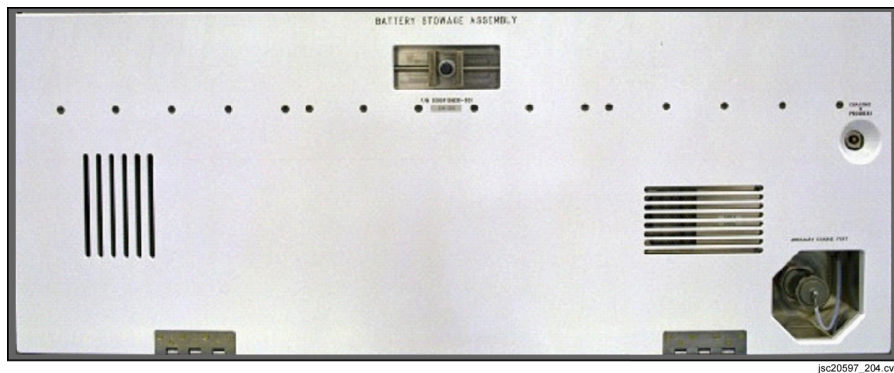


Figure 1.3-9. BSA door

BATTERY STOWAGE ASSEMBLY



Figure 1.3-10. BSA door latch

1.3.4.2 Display

After power is supplied to the BSA, the CHARGING IN PROGRESS LED illuminates as the batteries in the BSA or EMU are being charged. The BSA LED extinguishes after all the batteries are charged, including those attached to the Auxiliary Charge Port (Figure 1.3-11) and the in-suit EMU batteries. This charge LED is driven by circuitry in the BCA.

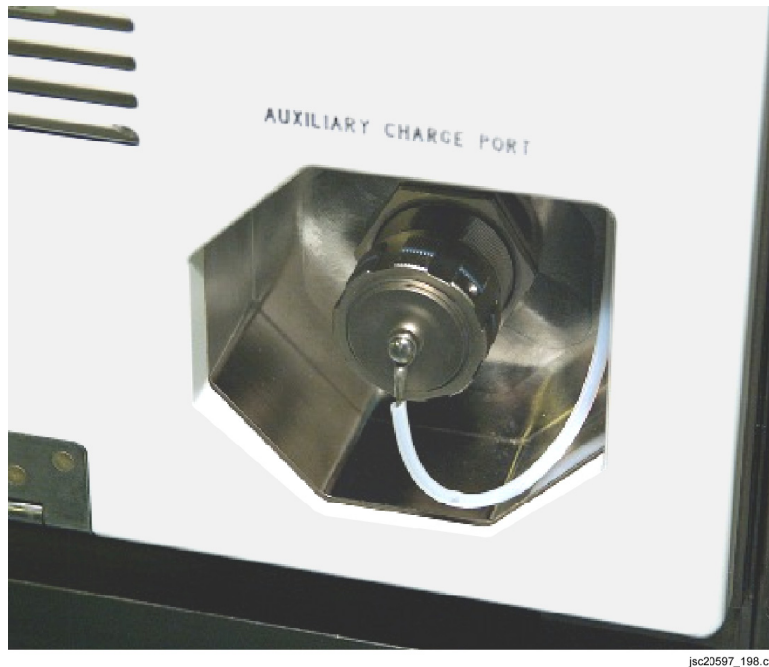


Figure 1.3-11. Auxiliary charge port (capped)

1.3.4.3 Failure Modes and Signatures

For detail, see FMEA/CIL report from Lockheed Martin Space Operations.

Published signatures and workarounds include the following:

BSA Fan and Door Microswitch

The R&R Procedure can be found in SODF:

- ISS EVA SYS: AIRLOCK CONTINGENCY: 1.650 BSA FAN SWAP: switches a jumper located between the two BSA EMU battery slots and reconfigures the fan vent duct.

Jammed/Bound Fan: No known data signature; can only be detected by lack of fan sound.

Failed Open Fan Control Circuit or Door Microswitch Circuit: With charger(s) activated and door closed, all 16 BSA slots will indicate "Over-Temp Error."

Only one fan/microswitch combination is operational at any one time, based on the jumper positioning. The BCA pauses charging if one of the two fans is not operating due to an open fan control circuit or the microswitch circuit.

1.3.5 Original Equipment Manufacturer Data

1.3.5.1 OPERATING LIMITS

	Limit conditions	Operating limits (min/max)	sPUI	Constraints/comments
1	Temperature limits	10° F (-12.2° C)/ 110° F (43.3° C)	N/A	Qual limits
2	Pressure limits	10 psia to 15.2 psia	N/A	
3	Input voltage	12.0 +/- 1.0 V dc	N/A	Supplied by each of the four BCMS in the BCA. Operating beyond these limits incurs risk of hardware damage or decreased performance
4	Input power	< 0.25 amps nominal	N/A	BSA electronics only. Does not include power to batteries under charge
5	Input over-current protection	N/A	N/A	Provided by the BCA
6	Output voltage (EMU battery recharge)	22.0 +/- 0.1 V dc at charge completion	N/A	Function and power provided by BCA. See Battery ICD JSC-38983
7	Output current (EMU battery recharge)	1.55 +/- 0.05 amps	N/A	Function and power provided by BCA. See Battery ICD JSC-38983
8	Output voltage (PGT battery recharge)	44 to 44.5 V dc at charge completion	N/A	Function and power provided by BCA. See Battery ICD JSC-38983
9	Output current (PGT battery recharge)	0.5 Amps ± 0.050	N/A	Function and power provided by BCA. See Battery ICD JSC-38983
10	Output voltage (EHIP battery recharge)	23 to 23.5 V dc at charge completion	N/A	Function and power provided by BCA. See Battery ICD JSC-38983
11	Output current (EHIP battery recharge)	1.0 Amps ± 0.050	N/A	Function and power provided by BCA. See Battery ICD JSC-38983
12	Output voltage (BSA external charge port)	48 V dc for 30-cell REBA 16 V dc for 10-cell REBA	N/A	As programmed for REBA recharge. Function and power provided by BCA. See Battery ICD JSC-38983
13	Output current (BSA external charge port)	1.0 amps ± 0.050	N/A	As programmed for REBA recharge. Function and power provided by BCA. See Battery ICD JSC-38983

1.3.5.2 NON-OPERATING LIMITS

	Limit conditions	Non-operating limits (min/max)	sPUI	Constraints/comments
14	Survival temperature limits	10° F (-12.2° C)/ 150° F (65.6° C)	N/A	Qual limits
15	Survival pressure limits	Space vacuum to 15.2 psia	N/A	
16	Fan short		N/A	BSA includes a circuit for fan over-current/over-voltage protection. In the event of failure, power to fan is terminated and the "TCO" line on all channels is set
17	Discharge current (EMU battery discharge)	1.50 Amps ± 0.05 3.00 Amps ± 0.05	N/A	Only -301 and -303 models -305 models
18	Discharge current (PGT battery discharge)	0.50 Amps ± 0.05 1.00 Amps ± 0.05	N/A	Only -301 and -303 models -305 models
19	Discharge current (EHIP battery Discharge)	1.00 Amps ± 0.05	N/A	-301, -303 and -305 models
20	Discharge current (REBA battery discharge)	0.50 Amps ± 0.05 1.50 Amps ± 0.05	N/A	Only -301 and -303 models -305 models

Ref. Engineering Memo: EVA-EV-1272

As proven by testing

- Acceptance and Certification Testing

Exceptions or Waivers

- EMECB TIA # 0161 (SCCN 2345)
- SCCN 2374 for qual vibration levels
- NCR-BSA-001 for EMI outages

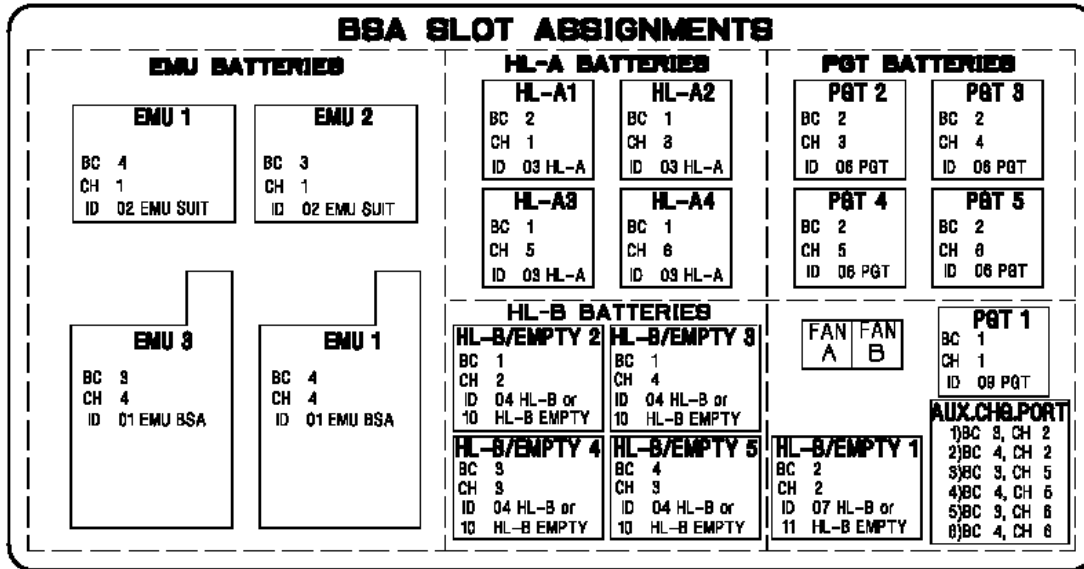


Figure 1.3-12. BSA battery label chart (Identical to one located on BSA door)

<u>WAS:</u>	EMU 1	<u>IS:</u>	EMU 4
	BC 4		BC 4
	CH 4		CH 4
	ID 01 EMU BSA		ID 01 EMU BSA

Figure 1.3-13. EMU decal correction

1.3.6 ISS AIRLOCK “SNEAK GROUND CIRCUIT”

This section documents the known condition in the ISS airlock of a “sneak” ground path in the Service and Performance Checkout Equipment (SPCE) hardware for operation with the EMU. This sneak circuit is responsible for several issues and signatures that may be seen during EVA operations in the airlock. The root of the grounding issue has been traced to the BSA. See Figure 1.3-12 and Figure 1.3-13 for the BSA battery label chart and the EMU decal correction.

1.3.6.1 History

STS-104 (IFI 500)

During the STS-104 (7A) post-EVA3 (1st EVA from ISS airlock) procedures, the In-Suit EMU battery recharge terminated early after approximately 8.5 hours (GMT 202:20:18:00) for SCU-1 and terminated early after approximately 6 hours (GMT 202:18:32:00) for SCU-2. Both In-Suit EMU battery recharges for SCU-1 and SCU-2 should have terminated after approximately 9.6 hours.

Expedition 3 (IFI 619)

EXP 3 crew began charging EVA batteries for UF-1 support using the airlock chargers EMU ICBs 2012 and 2014 were placed in the EMUs (3010 and 3016 respectively) for charging. EMU batteries 2012 and 2014 were last used on STS-105 (7A.1 - did not use

ISS airlock) on 8/16/01. They were discharged (SN2012 = 20.24amp-hr and 2014 = 21.57 amp-hr) during the last EVA on STS-105 and left on ISS in that state. The charging began at GMT 333/23:46. EMU1 charge current was 1.49 amps, EMU2 charge current was 1.48amps (as read by the UIA displays). At GMT 334/01:48 EMU1 battery (S/N 2012) stopped charging (about 2 hours of charge time). The crew read the history display and it showed 1 hr 58 min 12 sec of charge time and TASK COMPLETE - OK. At this time the EMU2 current changed to 1.11 amps (due to UIA Anomaly split). EMU2 charge stopped at GMT 334/03:33. Based on these times EMU1 charged 2.98 amp-hr; EMU2 charged 4.9 amp-hr. The expected charge time for both ICBs was approximately 14 hrs. FIAR #JSCEC0910F was generated to specifically track this issue.

1.3.6.2 BSA Single Point Ground (SPG) “Sneak Circuit”

The investigation (FIAR JSCEC0920F) that followed these initial anomalies in 2001, determined that there was insufficient isolation in the grounding scheme between the UIA, BSA, and BCA (and thru PSA). The SCU shielding and EMU DCM grounding is tied to a single point ground (SPG) as well as the UIA panel structure. This creates a path for the current fraction to flow (see figure 1). This has existed in the airlock since launch in July 2001. A review of the drawings found a “sneak current” path that permits a fraction of the EMU1 return current to flow via the EMU2 return path (or vis versa). This initial investigation did not focus on the sneak circuit path for the early termination of the in-suit battery charge since it was determined that no hardware fix would be available and that an operational workaround (not performing in suit battery recharges) was implemented.

Following issues with battery recharges in the BSA itself later, the SSATA was used to validate the existence of the sneak circuit and assess potential on-orbit solutions. After completing the initial SSATA testing for the existence of the sneak circuit, two cables (J4 & J5) used to connect the BC 3 and BC 4 to the BSA to accommodate the in-suit battery charge (thru PSA) were disconnected from the rear of the BSA (P/N SED33110816). With these two cable disconnected, the sneak circuit was eliminated.

1.3.6.3 Summary of On-Orbit Signatures

UIA panel voltage of ~1.0 for both EMUs when not powered

Case 1 (PSA IRU/Utility Outlet PWR switch affect)

Expedition 5 (8/30/2002)

Following the EMU battery discharging (in EMU), a strange voltage signature with the SCU hooked up to the suits was observed.

SIGNATURE: A voltage of 0.98 on UIA EMU1 and 1.03 on UIA EMU2

The configuration was as follows:

PSA Main PWR switch - ON

PSA Suit Sel switches (two) - OFF

PSA Mode switches - PWR (this isn't verified as part of the procedure - at the time - but we hadn't used the charge position since Exp 3)
IRU/UTILITY OUTLET PWR - ON (nothing plugged into outlet)
IRU PWR - ON (pump off)
UIA PWR switches (two) - OFF
SCUs connected to DCM (two suits)
EMU DCM PWR switch (two) - SCU

Basically the SCUs are connected to the suits but all switches are OFF, only the PSA (main power and outlet) and IRU are powered. (BCs are all off also)

When the IRU is powered off, the voltage remains the same.

When the PSA IRU/UTILITY OUTLET power switch is turned off (PSA main power still on), the voltage on the UIA panel goes to -0.00 (normal reading).

Case 2 (Nominal power down of EMUs):

STS-118 (IFI 2576)/STS-123 (AR 3203)

This particular signature in the data can be seen when the SCU is mated to the DCM, the PSA is powered up, the UIA EMU power is off, and the EMU DCM power switch is in the SCU position. The EMU power down sequence during post-EVA ops is where the voltage offset is typically seen. This is the same configuration as seen during Exp 5.

BCA Analog Amps with PSA Outlet Operations

Case 1 (BCA amps due to EMU middeck battery charger on PSA Outlet)

Expedition 4 (04/03/2002)

SIGNATURE: Amp reading of ~0.25 to 0.3 on all four battery chargers when the PSA is turned on with the EMU middeck battery charger operating from the PSA Utility Outlet port (BCs are all OFF).

The sum of the four current readings is ~equal to the current on the PSA Utility outlet to the middeck charger. The amp reading didn't start until the EMU battery charging was started.

UIA Split Amps

Case 1 (UIA split amps during In-suit EMU battery charging)

SIGNATURE: Amp reading of ~0.45 on EMU2 UIA panel reading and 1.1 amps on EMU1.

Expedition 3 (IFI 619)

This signature occurs due to the sneak circuit when the battery charging for one EMU is completed (in this case EMU2) and the other EMU continues with an in-suit

battery charge (in this case EMU1). The UIA panel was redesigned just before launch to allow ground monitoring of the EMU battery current charge on the UIA panel displays due to issues with the ability to see the data on the BCA serial data at the time. Reference Figure 2.

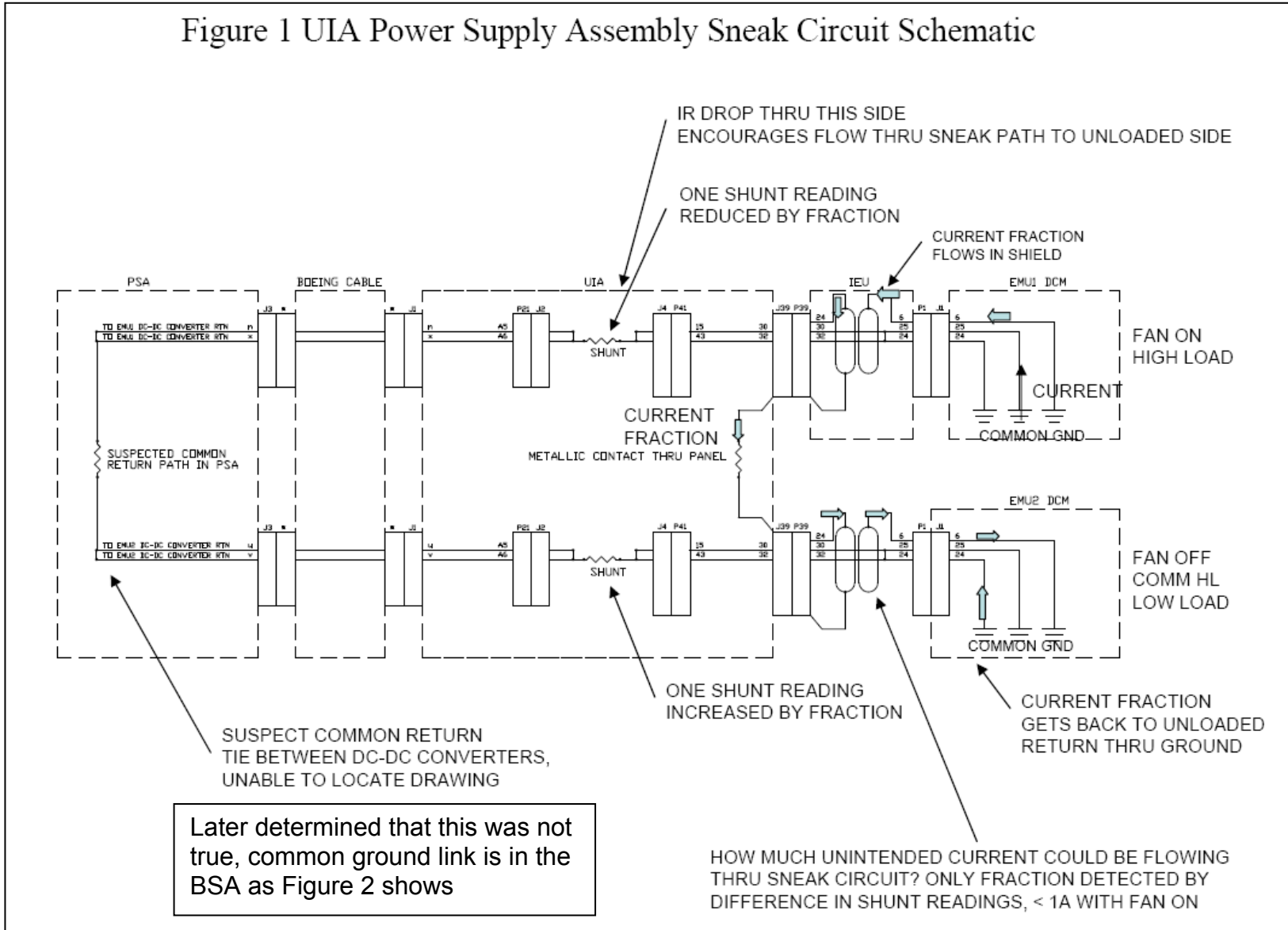
Case 2 (UIA split amps during EMU Donning, Fan On)

SIGNATURE: UIA amp reading for EMU 2 appeared to increase when Fan on for EMU1 during EMU donning.

STS-118 (IFI 2576, PRACA JEMU000F002)

During suit donning activity for STS-118 EVA 1, the UIA current for EMU2 was observed to increase when the EMU1 fan was switched on. No switch throws were performed on EMU2 and the corresponding PSA current telemetry for EMU2 showed no change in total current drawn by both EMUs in SCU power mode was found to agree with that drawn in battery mode, suggesting that some of EMU1's current was flowing through the UIA shunt for EMU2.

Figure 1 UIA Power Supply Assembly Sneak Circuit Schematic



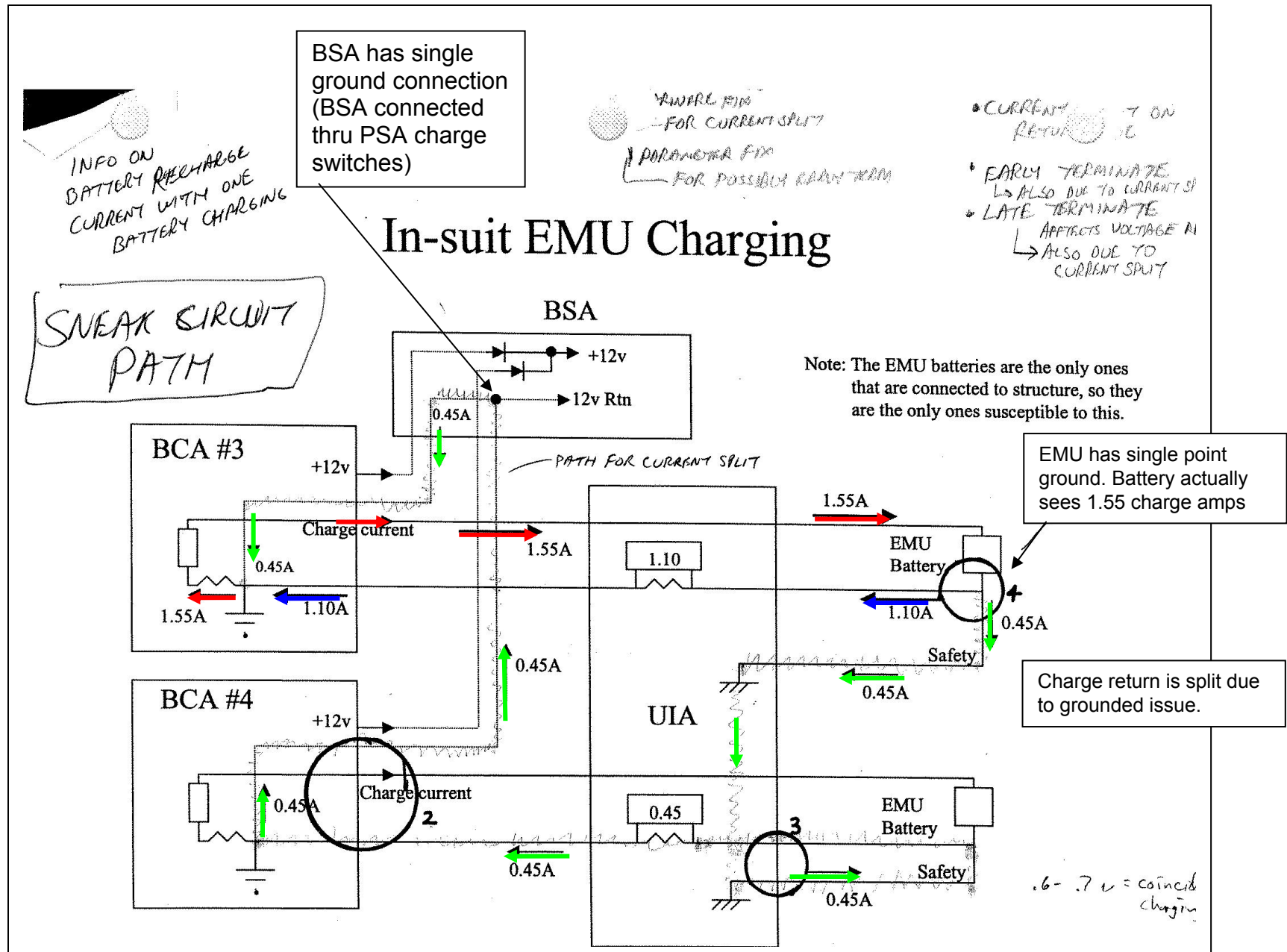
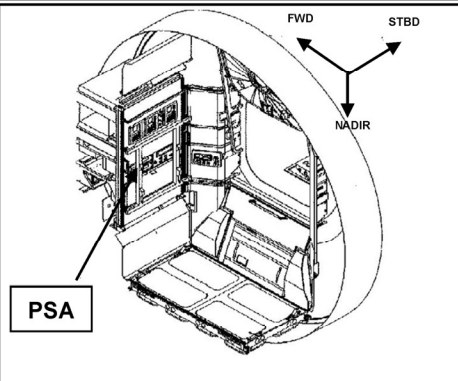
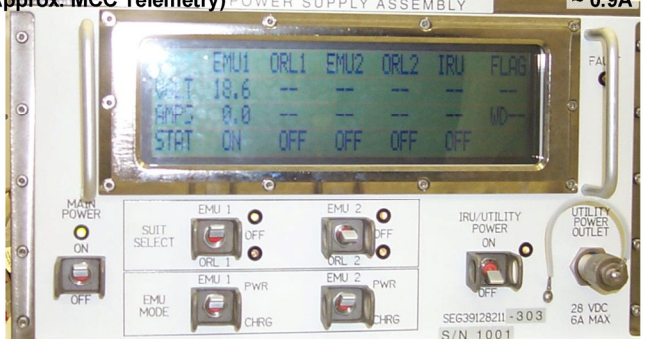
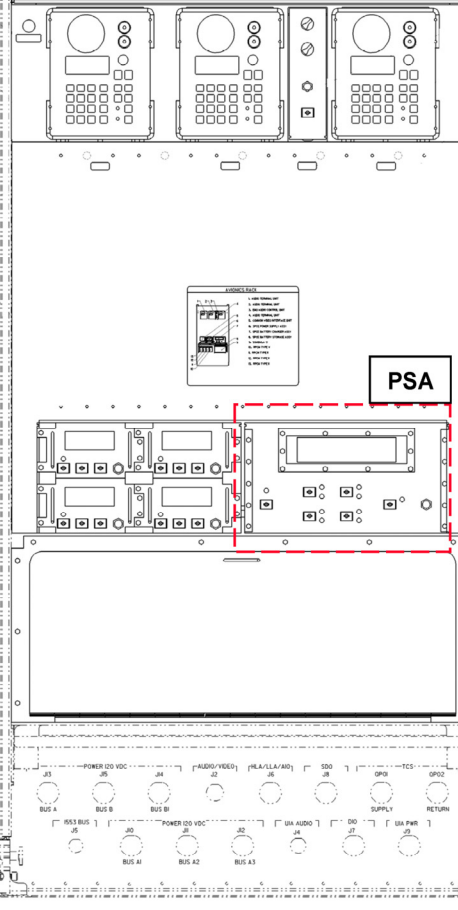
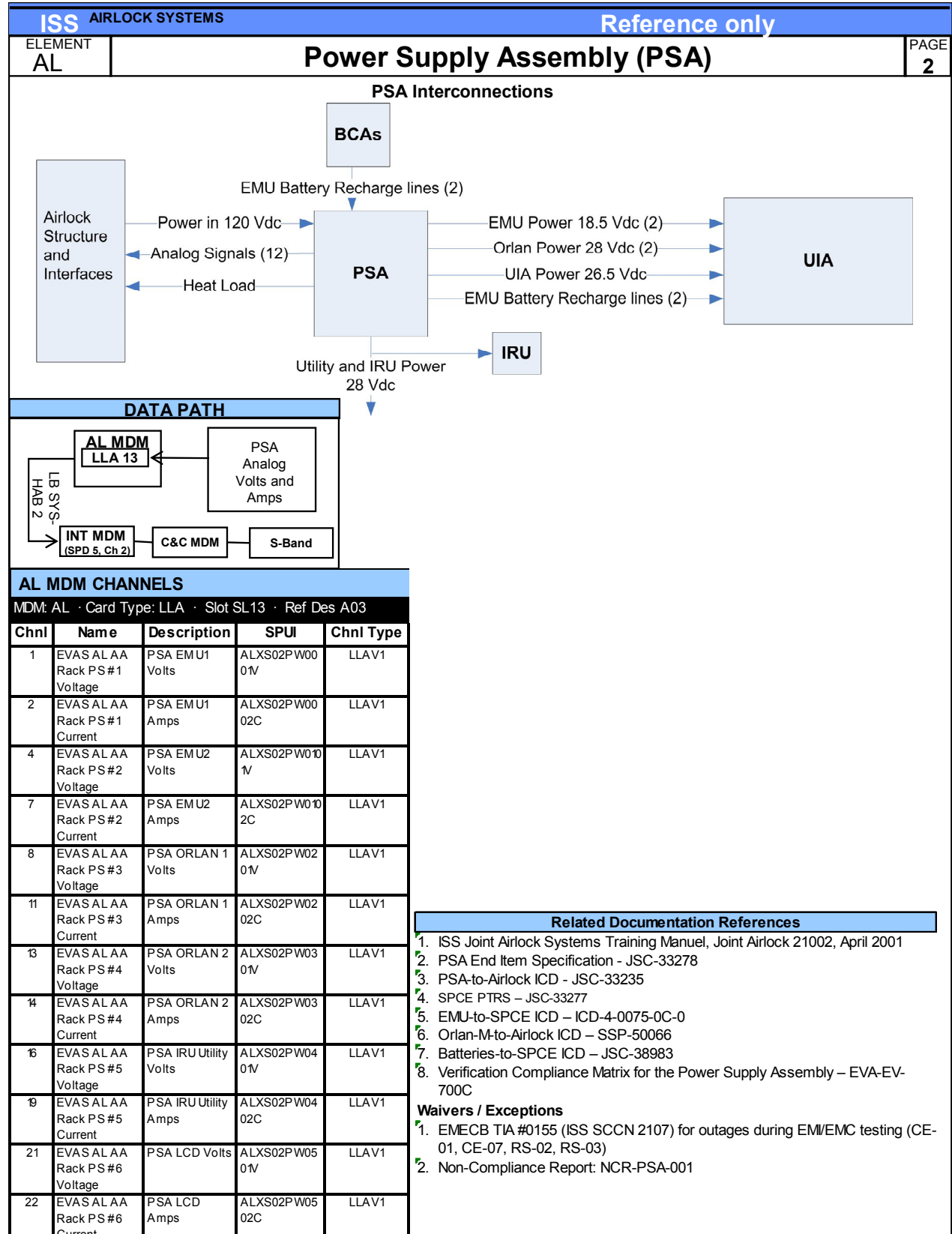


Figure 1.3-14. In suit charging current split on return per Lockheed Martin/Marc Sommers (2002)

1.3.7 REFERENCE MATERIAL

- Specifications and other Documents
- BSA End Item Specification – JSC-33280
- BSA-to-Airlock ICD – JSC-33236
- SPCE PTRS – JSC-33277
- BSA Top Assy Drawing – SEG39128213
- Batteries-to-SPCE ICD – JSC-38983
- EVA Batteries to BCA/BSA ICD Rev NC March 1998 (CCBD-0538R1) JSC-38983
- Lockheed Martin/M. Sommers, Lead Engineer – BCA, BSA, PSA
- Failure Modes & Effects Analysis & Critical Items List (FMEA/CIL) Report – LMSO-P104956, March 1999
- Safety Assessment Report (SAR) – LMSO-P104980, March 1999
- Hamilton Sunstrand EVAM-407 Rev A ISS SPCE Sneak Current Analysis and Acceptability for Use
- Hamilton Sunstrand EVAM-400 UIA Sneak Current Analysis and Recommendations
- IFI 500 In-Suit EMU Battery Recharge Early Termination 07-24-2001
- IFI 619 ISS EMU Battery Charge Anomaly 12-04-2001
- IFI 2576 Potential sneak circuit in the SPCE 08-12-2007
- FIAR JSCEC1391F
- PRACA JEMU000F002 SNEAK CIRCUIT PATH IN THE DCM

ISS AIRLOCK SYSTEMS		Reference only
ELEMENT AL	Power Supply Assembly (PSA)	PAGE 1
 <p style="text-align: center;">PSA</p>	<p>PSA sn1002: EMU1~18.4V EMU2~18.4V IRU~27.5V LCDs~27.3V (Approx. MCC Telemetry) POWER SUPPLY ASSEMBLY ~ 0.9A</p> 	
<p>AL1F1 - Avionics Rack PSA: SEG39128211 Installed: sn1002 (type-303) Spare: sn1003 (type-305)</p> <ul style="list-style-type: none"> • stowed behind the avionics rack • no ops differences in -303 vs. -305 	<div style="border: 1px solid black; padding: 5px;"> <p style="text-align: center; background-color: #0056b3; color: white; margin: 0;">POWER PATH (POST 13A)</p> <p>Solar Array: Channel 2A -or- Channel 3A</p> <p>DCSU: (Direct Current Switching Unit) 2A: RBI 6 -or- 3A: RBI 6</p> <p>SARJ: (Solar Array Rotary Joint) Port -or- Starboard</p> <p>DDCU: (DC-to-DC Converter Unit) LA2A -or- LA3B</p> <p>RPCM (Remote Power Control Module) LA-2A3B-D: RPC 3</p> <p>RPCM AL-2A3B-B: RPC 18</p> <p style="text-align: center;">PSA</p> </div>	
 <p style="text-align: center;">PSA</p>	<p style="text-align: center; background-color: #0056b3; color: white; margin: 0;">Ops Notes & History</p> <ol style="list-style-type: none"> 1. 28V Utility Power Outlet: DC-to-DC converter will trip open at minimum of 7 Amps total current draw. + ~ 0.3 amps = IRU w/ Pump + ~ 3.0 amps = Shuttle-type EMU (ICB) Charger (2 batts) + ~ 5.0 amps = Shuttle-type EMU (LIB) Charger (2 batts) + ~ 10 amps* = Shuttle-type REBA Charger (2 batts) + ~3.0 amps = Shuttle-type EHIP/PGT Charger (4 EHIP) + ~2.5 amps = Shuttle-type EHIP/PGT Charger (2 PGT) * NOTE exceeds the trip limit of the PSA when both batteries are charging. 2. EMU DC-to-DC Converter Trip during EMU power transitions: During Post-Depress when EMU Power switches both taken to BATT at the same time, the "crowbar-type" limiter may trip open one or both converters due to an over-voltage transient spike above 20.5V. Indicated by the voltage dropping low or to zero (IV crew also would see fault indication on the PSA display.) Reset by taking PSA Suit Select switch to OFF, then back to EMU; avoided by crew staggering DCM Power transitions, e.g. first one EMU is switched, then the other. May also occur if Suit Select switch is not OFF when Main Power is applied. 3. Power indications affected by UIA sneak grounding circuit when EMU Umbilical connected: PSA indications do not appear to be affected. However, when an umbilical is connected to at least one EMU, UIA indicates that some current and/or voltage is "split" onto the each umbilical's ground/return circuit. (1) Amp split seen during In-suit battery recharge (see IFI-0619), (2) EXP-5 Insuit Battery Discharge: ~1V per umbilical seen w/ PSA Main Power - ON, Suit Select - OFF; same indication w/ IRU / Utility Converter powered. 	



1.4 POWER SUPPLY ASSEMBLY (PSA)

1.4.1 Quick Look Reference Data

Table 1.4-1 shows the Power Supply Assembly (PSA) specifications.

Table 1.4-1. Power supply assembly reference data

Description	Specification	Comments
ORU Procedure Owner: OSO	4.2.802 - Airlock power supply assembly R&R	"6529.doc"
Dimensions: Power supply assembly	9.0"W x16.5"H x14.0"D	Dimensions do not include protrusions from panel surface plane (i.e. handholds, tether rings, switches, etc.)
Weight (dry): Power supply assembly	37.0 lb	
Supply voltages:	Volts	Nominal Amps
Channel		
EMU 1	18.5 V +/- 0.5 max. 22.0 V	<5 A but no more than 10A max.
EMU 2	18.5 V +/- 0.5 max. 22.0 V	<5 A but no more than 10A max.
Orlan 1	28.0 V +/-0.6 max. 34.0 V	~3 A but no more than 12A max.
Orlan 2	28.0 V +/-0.6 max. 34.0 V	~3 A but no more than 12A max.
IRU/Utility power outlet	28.0 V +/- 1.0/same	0.4A/6 A max.
UIA and PSA displays	26.5 V	~ 0.24 A

1.4.2 General Description

The purpose of the PSA is: to provide the Extravehicular Mobility Unit (EMU) or the Orlan-M suits with vehicle power, to power the In-Flight Refill Unit (IRU) and/or the Utility Power Outlet, to power hardline communications circuits within the Umbilical Interface Assembly (UIA) and to power the displays for the UIA and the PSA. The PSA also acts as a passive interface between the Battery Charger Assembly (BCA) modules and the EMUs (via the UIA and SCUs) for in-suit recharging of the EMU battery.

The separate Direct Current (DC)-to-DC converters within the PSA can support the operation of two EMUs, two Orlan-M space suits, or one of each. One DC-to-DC converter supplies power to the IRU for filling the EMU feedwater tanks and to the Utility Power Outlet to power ancillary equipment, such as the shuttle-type EVA battery chargers.

1.4.3 Subsystem Details

1.4.3.1 Location and Structure

Location

The PSA is mounted in the Avionics Rack in the Equipment Lock, just to the right of the four Battery Charger Modules (BCMs) and above the Battery Stowage Assembly (BSA). As with most other items in the Joint Airlock, the PSA is an ORU. The stowage location of the spare unit is behind the Avionic Rack.

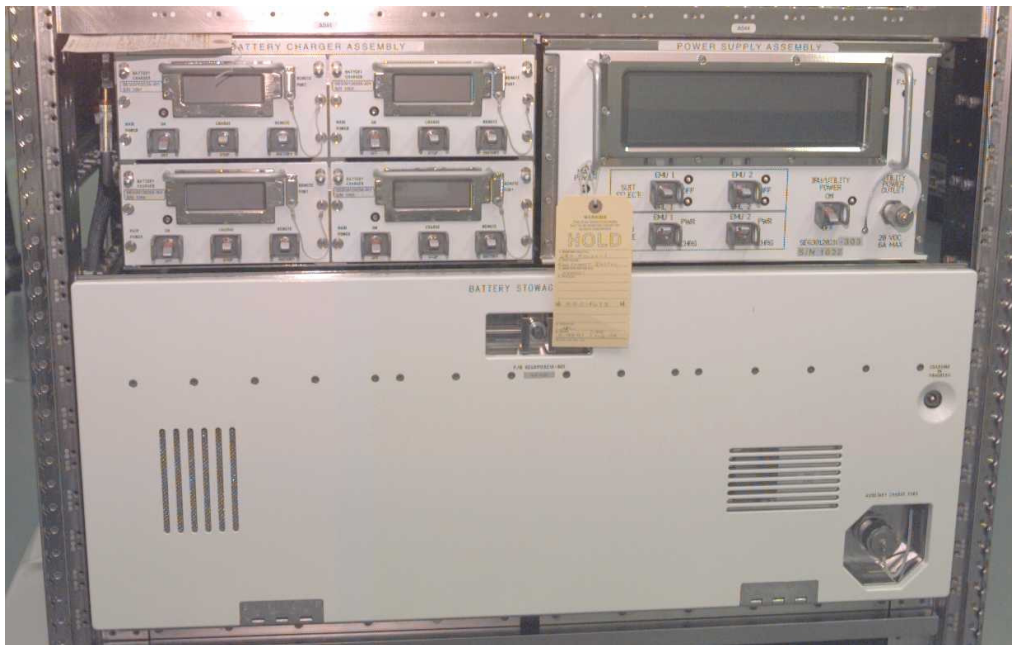
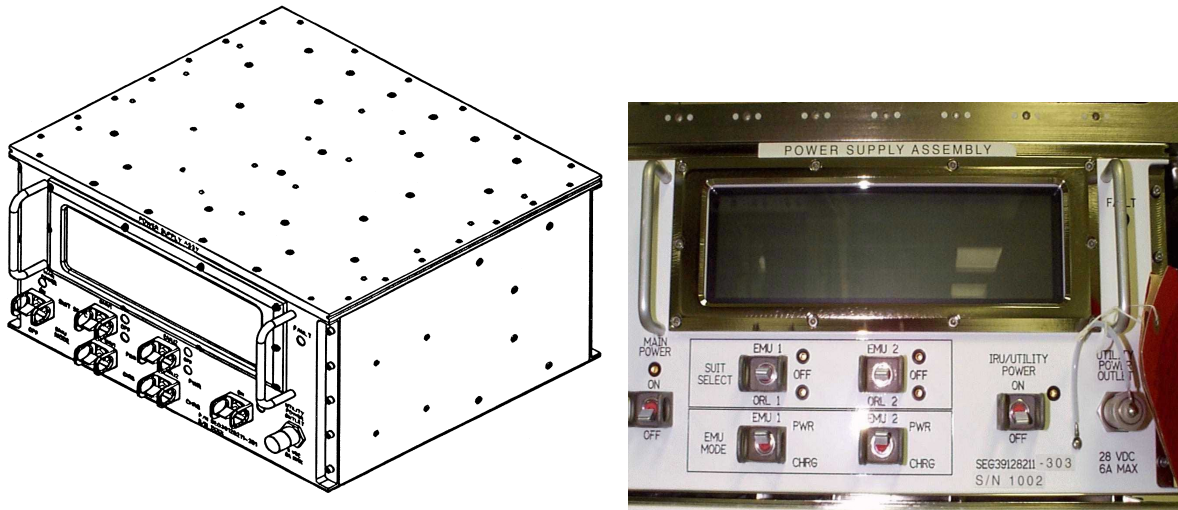


Figure 1.4-1. Avionics rack-lower section (BCAs, PSA, BSA)

Structure

Figure 1.4-2 shows the appearance and structure of the PSA.



Dimensions: 9.0 in. high by 16.5 in. wide by ~ 14 in. deep
Weight: ~ 37 lb

Figure 1.4-2. Power supply assembly

1.4.3.2 Interfaces

Power Interface

Power is supplied to the PSA by the Joint Airlock Remote Power Control Module (RPCM). The PSA is designed to operate on 120 V dc power with 500 watts nominal and 1200 watts peak. The operational current draw from the RPCM is nominally 5 amps during suit power-up and should never exceed 10 amps. Over-current protection is provided by both an internal circuit and by the RPCM itself.

The PSA supplies power to EMU(s), Orlan-M(s), UIA, IRU, and any 28 V devices connected to the Utility Power Outlet. Additionally, power is provided to the EMU by the BCA through a passive battery recharge interface in the PSA and the UIA for in-suit battery recharge. The in-suit battery recharge is not currently used due to the sneak circuit referred to in Section 1.2 BCA.

Each piece of hardware that requires power from the PSA is connected to the PSA via individual power channels. The PSA receives the supply input from the RPCM and regulates it to the appropriate level for each channel using dedicated DC-to-DC converters (refer to Section 1.4.3.3 for values of supply volts and amps for each channel).

Data Interface

Output analog signals are provided to the Airlock Multiplexer/Demultiplexer (MDM) for transmission to Mission Control Center (MCC) for ground monitoring of the PSA performance. Only the voltage and current from each DC-to-DC converter are provided to the MDM; the status/fault information is only provided on the PSA front panel display.

Thermal Interface

The PSA interfaces with the Avionics Rack Moderate Temperature Loop (MTL) cold plate for cooling. This cold plate removes heat from the PSA at a rate of no less than 310 BTU/hr per specification.

User

The front panel of the PSA provides the user interface to power the different channels and receives status information (see Figure 1.4-3). The panel contains six switches, a Liquid Crystal Display (LCD), a utility power outlet port and an amber fault LED in the upper right corner.

Section 1.4.4, Operational Details, contains the details of the switches and display.

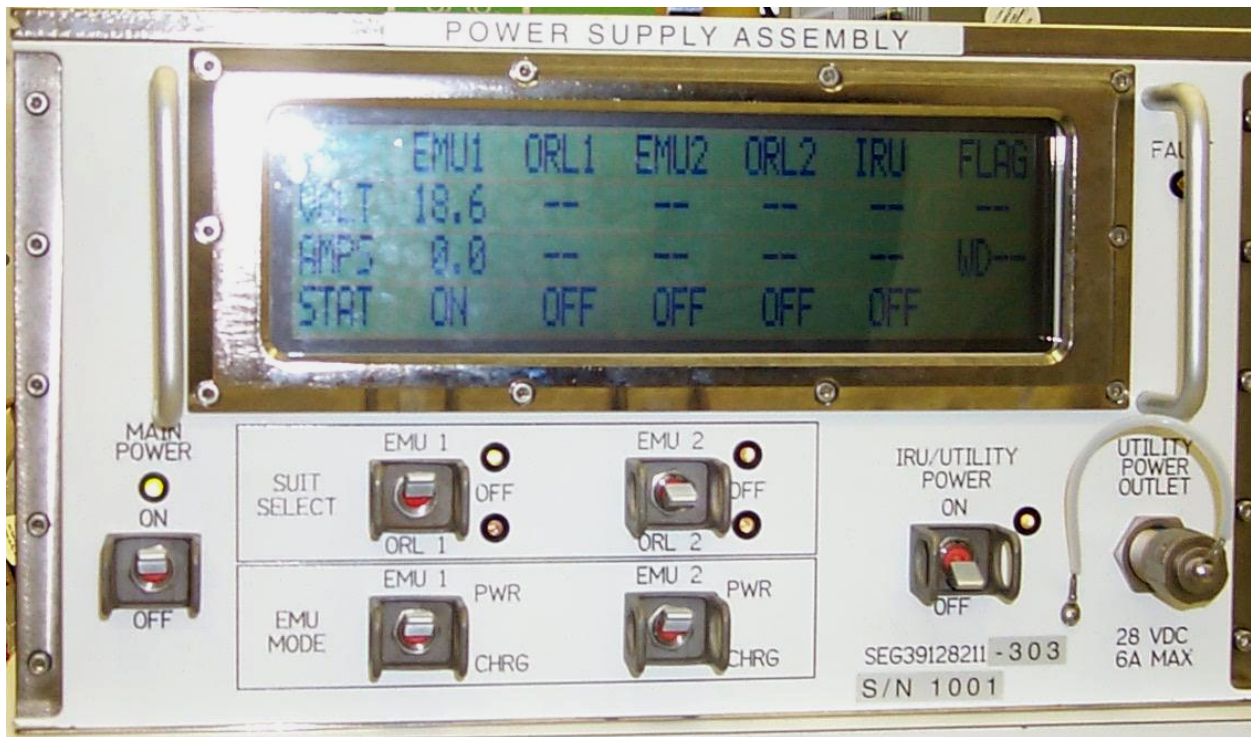


Figure 1.4-3. PSA display and controls

1.4.3.3 Performance

Table 1.4-2 specifies the volts and amps supplied by the PSA for each channel.

Table 1.4-2. PSA supplied volts and amps

Channel	Nominal volts	Max volts	Nominal amps
EMU 1	18.5 V +/- 0.5	22.0 V	<5 A but no more than 10A max.
EMU 2	18.5 V +/- 0.5	22.0 V	<5 A but no more than 10A max.
Orlan 1	28.0 V +/-0.6	34.0 V	~3 A but no more than 12A max.
Orlan 2	28.0 V +/-0.6	34.0 V	~3 A but no more than 12A max.
IRU/Utility power outlet	28.0 V +/- 1.0/ same		0.4 A/6A max.
UIA and PSA displays	26.5 V		~ 0.24 A

Note: Not all of the values in the table agree with the March 1999 Safety Assessment Report

The PSA is designed to operate within performance specifications during exposure to temperature ranges of +55° F to +109° F and following exposure temperatures from +40 ° F to +150° F. The PSA is required to operate at an airlock relative humidity of 25 percent to 70 percent and after, but not during, E/L exposure to vacuum.

1.4.3.4 Software

TBD

1.4.4 Operational Details

1.4.4.1 Switches

The MAIN POWER switch allows power to flow from the 120 V dc supply of the RPCM to the DC-to-DC converters for each of the channels. The LED above the switch indicates that power is available to the DC-to-DC converters when lit, as opposed to indicating switch position. When the switch is taken to the OFF position, the LED should extinguish unless a broken switch does not open the circuit causing the RPCM power to still be available. All LEDs function this way with the exception of the FAULT LED which only illuminates if an error is detected on one of the channels or a temperature fault is present. Placing the MAIN POWER switch in the ON position activates the PSA and the UIA displays and activates the UIA hardline communications circuitry by activating a 26.5 V converter.

The SUIT SELECT switch enables power to the EMU or to the Orlan DC-to-DC converters. This is a three-position switch with OFF as the center position. Two switches are available to allow powering of the EMUs or Orlans individually with labels indicating the EV-1 or EV-2 side. The green LEDs for these switches indicate that power is going through the converter and is being routed to the UIA.

Unlike the shuttle Airlock Power Supply (ALPS), the PSA does not have a required switch throw order to provide power to either type of suit. In addition, the PSA does not provide protection for either a hot mate or demate of the suit umbilical. The rationale for eliminating this safety feature is that several switch throws across different pieces of equipment must be made prior to having power available to either of the suits.

The EMU MODE switches have two positions labeled PWR and CHRG. The PWR position enables power from the EMU DC-to-DC converter to pass through the UIA providing power to the suit when the SCU is connected and power is taken to SCU on the EMU DCM. The CHRG position allows the BCA to recharge the EMU battery while it is in the suit. There is one switch for each EMU channel permitting independent power operations (e.g., one suit can be powered while the other suit is charging). The PWR switch position is only effective when the SUIT SELECT switch is in the EMU 1(2) position. The CHRG position is simply a feed-through from the BCA to the UIA and is, therefore, not dependent on any other PSA switch positions, even the MAIN POWER switch.

The IRU/UTILITY switch powers the both the IRU and the Utility Power Outlet. The utility outlet is located adjacent to the switch. This two-position ON/OFF switch provides power to both the IRU and the utility outlet simultaneously. The total load on this converter must remain below 6 amps (as stated on the panel); the converter will be shutdown if the load current exceeds 7amps. The Utility Power Outlet green LED indicates that power is being provided by the DC-to-DC converter and is available downstream of the switch. The following are known amperages used by hardware that may be used on this converter:

- IRU w/pump running: ~0.3 A
- Shuttle EMU ICB charger (two batteries): ~3 A
- Shuttle EMU Left Inboard (LIB) charger (two batteries): ~ TBS
- Shuttle EHIP/PGT charger (four HL, two PGT, or combo): ~4 A
- Shuttle REBA charger (two batteries): outlet's 7 amp limit; charge one battery only.

Note that trying to charge two REBA batteries at the same time on the utility outlet will likely cause the converter to trip, shutting down power for that circuit (both the charger and IRU if being used). Again, this can be reset by cycling the switch for the converter. This is indicated by "FALT" being displayed in the STAT row of the display.

1.4.4.2 Display

The LCD mounted on the control panel provides for direct monitoring of the output voltage and the amperage being supplied by the PSA to the different channels. In addition, the display provides a way to view the status of the channels and the status of the PSA itself. Upon power up of the PSA via the MAIN POWER switch, the display will go completely dark as the display performs a 5 second pixel check (illumination of all pixels).

The STAT row (Figure 1.4-4) indicates the present status of the channel: ON, OFF, or FALT. The FALT message indicates that a short circuit or over voltage condition has occurred and the hardware has safed itself. The EMU channels also have an additional

status code, CHRG, which indicates that the PSA is providing a pass through for the BCA. When CHRG is present, the VOLTS and AMPS rows contain two asterisks (**).

The last column of the display labeled “FLAG” is a general status of the PSA and contains dashes until an anomaly is detected. In the event that a problem is encountered, one of two messages appears: TEMP or WDXX. The TEMP message indicates a problem with heat build up in the PSA. The TEMP fault is indicated at 110° F but will not cause a shutdown of the PSA. WDXX is a watchdog counter that will provide the number of times the microcontroller has reset indicating a problem with the PSA software. A static value > 0 means the micro-controller has reset but did so successfully and the PSA displayed data is now correct. This may be a precursor to a micro-controller failure and an anomaly report should be written.

All of the analog numerical information on the display is downlinked for monitoring by ground personnel. The volts and amps for the UIA display channel are also downlinked but are not visible on the PSA display. The amber FAULT LED in the upper right of Figure 1.4-3 illuminates if any problem is detected by the PSA, whether it is in the STAT row or the FLAG column.

Display after PSA power-up

	EMU1	ORL1	EMU2	ORL2	IRU	FLAG
VOLT	--	--	--	--	--	--
AMPS	--	--	--	--	--	WD--
STAT	OFF	OFF	OFF	OFF	OFF	

EMU1 powered up, EMU2 performing battery recharge, both ORLANs off, and a DC-to-DC converter fault on the IRU channel

	EMU1	ORL1	EMU2	ORL2	IRU	FLAG
VOLT	18.5	--	**	--	0.0	--
AMPS	3.8	--	**	--	0.0	WD--
STAT	ON	OFF	CHRG	OFF	FALT	

Figure 1.4-4. PSA displays

1.4.4.3 Failure Modes and Signatures

Converter Trip: Tripped converters are indicated by low or no voltage output although the corresponding power switch is in the ON position and a FALT message is in the STAT row of the crew’s display. This can be caused by either an over-current or over-voltage condition which causes the crowbar-type protection system to activate. A crowbar circuit is an electrical circuit used to prevent an over-voltage condition of a power supply unit from damaging the circuits attached to the power supply. It operates by putting a short circuit across the voltage source. This protection system has activated on-board during post-depress on the EMU converters.

To avoid a DC-to-DC converter trip during EMU power transfers from PSA to battery power, the crewmembers should stagger their switch throws such that both DC-to-DC converters are not experiencing a significant load change at the same time. To reset a

locked converter, the effected hardware's power switch should be taken to off (e.g. EMU PWR switch to BATT), and the corresponding converters switch taken to OFF, then back ON (e.g. PSA suit select to OFF, then ON.)

Failure modes and effects analysis items for the PSA include:

- DC-to-DC converter modules for EMU, Orlan M, IRU/Utility, UIA display
- Main power switch
- Suit select switch
- EMU power/charge switch
- IRU/utility power switch
- Signal conditioner board
- Transistor board
- Capacitor block
- EMI filter
- Logic board
- Display
- LEDs
- Utility connector

See FMEA/CIL report from Lockheed Martin Space Operations for details.

1.4.4.4 Maintenance

ORU changeout procedures for the PSA are found in SODF: IFM - 4.2.802 - Airlock Power Supply Assembly R&R.

1.4.5 Original Equipment Manufacturer Data

1.4.5.1 Operating Limits

	Limit conditions	Operating limits (min/max)	sPUI	Constraints/comments
1	Temperature Limits	10° F (-12.2° C)/ 150° F (65.6° C) with functioning coldplate 10° F (-12.2° C)/ 110° F (43.3° C) without functioning coldplate	N/A	<ul style="list-style-type: none"> ▪ Qual limits ▪ TEMP FAULT occurs at 110° F ▪ When TEMP FAULT is tripped, TEMP is displayed in the FLAG column on the LCD display and the FAULT LED turns ON. ▪ The TEMP FAULT causes no shutdowns
2	Pressure limits	Space vacuum to 15.2 psia	N/A	
3	Input voltage	120 ± 6 V dc	N/A	<ul style="list-style-type: none"> ▪ Acceptance test requirement. ▪ Supplied by RPC ▪ Operating beyond these limits incurs risk of hardware damage or decreased performance. ▪ Input voltage was tested from 114 V dc to 126 V dc
4	Input power	500 watts nominal 1,200 watts peak 10 milliamps max with Main power switch OFF	N/A	<ul style="list-style-type: none"> ▪ Power consumption depends on actual loads configuration (e.g. 2 EMUs, 2 Orans, utility power load, FPU on/off, EMU operating mode, etc.) ▪ Reference JSC 33235 ▪ Nominal power consumption measured during testing was 473 watts, with peak power measuring 1180 watts
5	Input over-current protection	13.2 amps to 14.2 amps	N/A	<ul style="list-style-type: none"> ▪ Provided by Airlock RPC. Reference SSP 30263:002 ▪ The PSA internally self-limits input current to approximately 9.4 amps at 120 V dc
6	Input over-voltage/ under-voltage protection	Reference SSP 30263:002	N/A	<ul style="list-style-type: none"> ▪ Function provided by Airlock RPC
7	Output voltage (EMU supply)	18.5 ± 0.5 V dc	N/A	<ul style="list-style-type: none"> ▪ Supplied to UIA ▪ During testing output voltage was measured to be between 18.36 and 18.68 V dc

	Limit conditions	Operating limits (min/max)	sPUI	Constraints/comments
8	Output current (EMU supply)	7.5 amps min EMU BTA mode	N/A	<ul style="list-style-type: none"> ▪ Supplied to UIA ▪ Actual current depends upon EMU operating mode. See EMU ICD ICD-4-0075-0C-0 ▪ The steady current supplied during testing was measured to be between 7.88 and 7.98 amps ▪ The Amp values were taken from GSE calibrated Digital Multimeters (DMMs) ▪ To reset over-voltage and over-current protection: First, Suit Select switch to OFF. Then, if still not cleared, select Main power to OFF/ON
9	Output over-voltage protection (EMU supply)	22.0 V dc max	N/A	<ul style="list-style-type: none"> • During testing, the measured voltages at PSA shutdown for each EMU channel were 21.38 and 21.5 V dc
10	Output over-current protection (EMU Supply)	10 ± 0.5 amps	N/A	<ul style="list-style-type: none"> • During testing, the measured current at which the PSA shutdown each EMU channel was 10.2 and 10.32 amps
11	Output voltage (Orlan-M supply)	28.0 ± 0.6 V dc	N/A	<ul style="list-style-type: none"> ▪ Supplied to UIA ▪ During testing, output voltages were measured to be between 27.91 and 28.04 V dc
12	Output current (Orlan-M supply)	3.0 amps nominal 12.0 amps peak for up to 5 seconds	N/A	<ul style="list-style-type: none"> ▪ Supplied to UIA ▪ Actual current depends upon Orlan-M operating mode. See Orlan-M ICD SSP 50066 ▪ Nominal output current supplied during testing was measured to be between 3.03 and 3.13 amps. Output current for 5 seconds was measured at 12.39 and 12.45 amps
13	Output over-voltage protection (Orlan-M supply)	34.0 V dc max	N/A	<ul style="list-style-type: none"> • During testing, the measured voltage at PSA shutdown for each Orlan-M channel was 32.8 V dc
14	Output over-current protection (Orlan-M supply)	>15 amps, shut down in 1 second or less/ 5 to 15 amps, shut down in 6 ± 1 second	N/A	<ul style="list-style-type: none"> • During testing, the time required for the PSA to shutdown power to the Orlan-M supply when a 6 amp load was applied was 6.2 seconds for each Orlan-M channel and .008 seconds when the current load was increased from 3.0 to 15.5 amps
15	Output voltage (UIA Supply)	26.5 ± 2.0 V dc	N/A	<ul style="list-style-type: none"> ▪ During testing, output voltage was measured to be 25.28 V dc
16	Output current (UIA supply)	< 0.5 amps	N/A	<ul style="list-style-type: none"> • The steady current supplied during testing was measured to be .527 amps
17	Output over-current protection (UIA supply)	1.0 amps max	N/A	<ul style="list-style-type: none"> • During testing, the measured current at which the PSA shut down the UIA channel was .84 amps
18	Output voltage (IRU/FPU supply)	28.0 ± 1.0 V dc		<ul style="list-style-type: none"> ▪ During testing, output voltage was measured to be 27.62 V dc
19	Output current	< 0.4 amps with FPU		<ul style="list-style-type: none"> ▪ The steady current supplied during testing was

	Limit conditions	Operating limits (min/max)	sPUI	Constraints/comments
	(IR/FPU supply)	pump on		measured to be 1.1 amps
20	Output over-voltage protection (IRU/FPU supply)	32 V dc max	N/A	<ul style="list-style-type: none"> During testing, the measured voltage at PSA shutdown for the IRU/FPU Supply channel was 30.4 V dc
21	Over-current Protection (IRU/FPU supply)	7.8 amps max	N/A	<ul style="list-style-type: none"> During testing, the measured current at which the PSA shutdown the IRU/FPU Supply channel was 6.9 amps
22	Output Voltage (Utility Outlet)	28.0 ± 1.0 V dc	N/A	<ul style="list-style-type: none"> During testing, output voltage was measured to be 27.66 V dc
23	Output current (utility outlet)	6.0 amps min	N/A	<ul style="list-style-type: none"> Rated current The steady current supplied during testing was measured to be 6.1 amps
24	Over-voltage Protection (Utility Outlet)	32 V dc max	N/A	<ul style="list-style-type: none"> During testing, the measured voltage at PSA shutdown for the utility outlet supply was 30.4 V dc
25	Over-current protection (utility outlet)	7.8 amps max	N/A	<ul style="list-style-type: none"> During testing, the measured current at which the PSA shutdown the utility outlet was 6.9 amps
26	Output voltage (EMU battery recharge)	22.0 ± 0.1 V dc at charge completion	N/A	<ul style="list-style-type: none"> Function provided to UIA by BCA via PSA interfaces. See Battery ICD JSC-38983 Mode switch must be in recharge position Reference BCA
27	Output current (EMU battery recharge)	1.55 ± 0.05 amps	N/A	<ul style="list-style-type: none"> Function provided to UIA by BCA via PSA interfaces See Battery ICD JSC-38983 Mode switch must be in recharge position Reference BCA
29	Watchdog Fault	Counter that indicates that the microprocessor is being reset (e.g. due to a radiation hit)	N/A	<ul style="list-style-type: none"> The impact of rapid incrementing of the counter is that the information displayed is not being updated and may not be accurate Resolution/Workaround – If the counter is continually incrementing, the PSA may need to be replaced. However, an immediate R&R is not necessarily required as the unit is likely to still provide power normally and MDM telemetry can be used to monitor proper functionality.

Ref. Engineering Memo: EVA-EV-1272

1.4.5.2 Non-Operating Limits

	Limit Conditions	Non-operating Limits (min/max)	sPUI	Constraints
29	Survival temperature limits	10° F (-12.2° C)/ 125° F (51.7° C)	N/A	▪
30	Survival pressure limits	Space vacuum to 15.2 psia	N/A	▪

Ref. Engineering Memo: EVA-EV-1272

1.4.5.3 Notes

- A. PSA S/N 1002 in the Airlock Avionics Rack is a –303 configuration. S/N 1003 (on-orbit spare) is a –305 configuration. There are no form, fit, or functional differences between the two configurations.
- B. Possible faulty analog current sensor during PSA operations. Problem could be with airlock wiring, MDM, or with PSA. Current can be monitored/measured via PSA Display by the Crew.

1.4.5.4 Reference Material

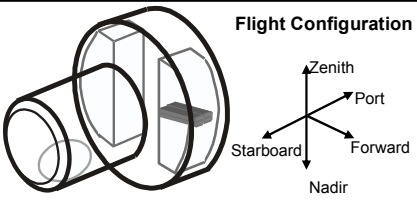
- **Specifications and Other Documents**
 - PSA End Item Specification - JSC-33278
 - PSA-to-Airlock ICD - JSC-33235
 - SPCE PTRS – JSC-33277
 - PSA Top Assy Drawing – SEG39128211
 - EMU-to-SPCE ICD – ICD-4-0075-0C-0
 - Orlan-M-to-Airlock ICD – SSP-50066
 - Batteries-to-SPCE ICD – JSC-38983
 - Verification Compliance Matrix for the Power Supply Assembly – EVA-EV-700C
 - Lockheed Martin/M. Sommers, Lead Engineer – BCA, BSA, PSA
 - Failure Modes & Effects Analysis & Critical Items List (FMEA/CIL) Report – LMSO-P104956, March 1999
 - Safety Assessment Report (SAR) – LMSO-P104980, March 1999

- **As Proven by Testing**
 - Acceptance and Cert. Testing

Exceptions or Waivers

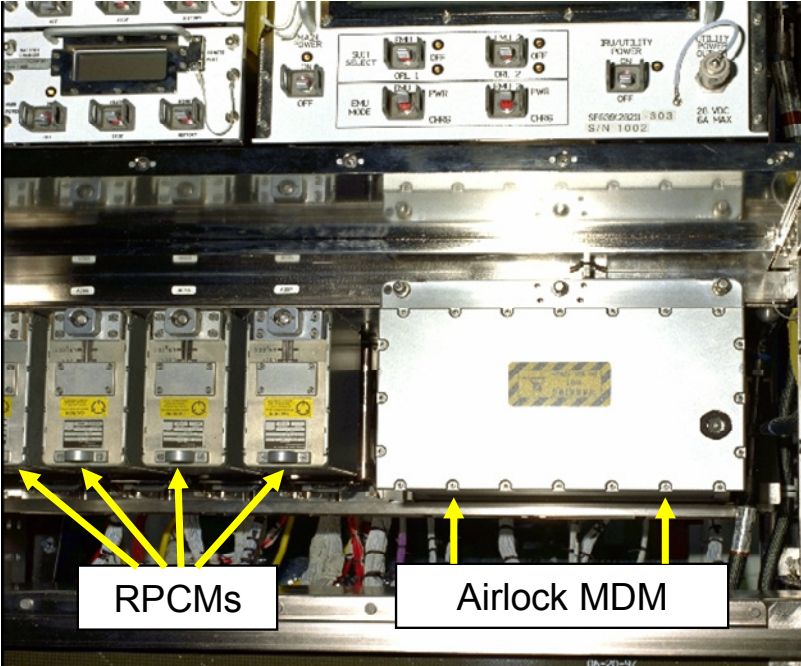
- EMECB TIA # 0155 (ISS SCCN 2107) for outages during EMI/EMC testing (CE-01, CE-07, RS-02, RS-03)
- NCR-PSA-001

ISS	AIRLOCK SYSTEMS	Reference only	
ELEMENT AL	Airlock MDM & Telemetry Formats	PAGE 1	



Flight Configuration

Zenith
Port
Starboard
Forward
Nadir



RPCMs **Airlock MDM**

AL1F1 - Avionics Rack
AL MDM: SEG

Spares: None on-board, can R&R cards

POWER PATH

Solar Array: Channel 2B

DCSU: (Direct Current Switching Unit) → 2B: RBI 1 & 6

DDCU: (DC-to-DC Converter Unit) → LA3B

RPCM (Remote Power Control Module) → LA-2A3B-D: RPC 3

RPCM → AL-2A3B-A: RPC 2 → **AL MDM**

POWER PATH (POST 13A)

Solar Array: Channel 2A -or- Channel 3A

DCSU: (Direct Current Switching Unit) → 2A: RBI 6 -or- 3A: RBI 6

SARJ: (Solar Array Rotary Joint) → Port -or- Starboard

MBSU: (Main Bus Switching Unit) → 2: RBI 1 & 4 -or- 3: RBI 1 & 9 & 11

DDCU: (DC-to-DC Converter Unit) → LA2A -or- LA3B

RPCM (Remote Power Control Module) → LA-2A3B-D: RPC 3

RPCM → AL-2A3B-A: RPC 2 → **AL MDM**

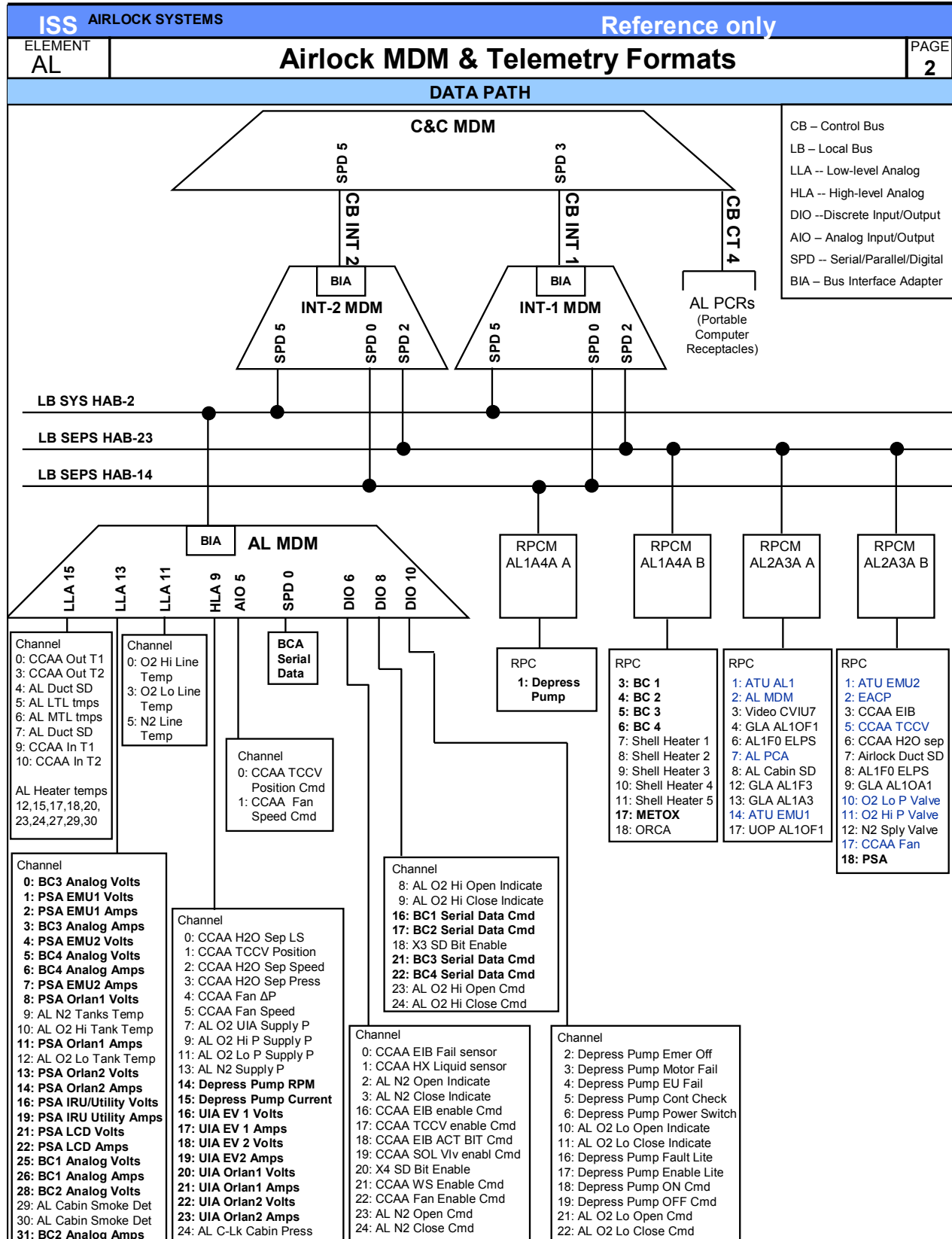
Telemetry Formats

ISS Software versions	Formats	Packet	Content
CCS R4.6 Current Config (No packet swapping)	4CSC	HK1	All EVA Airlock Telemetry
CCS R6 Updates after ~13A	JSC KSC	HK1 HK1	All EVA Airlock & Orlan Telemetry
 (Packet swapping)	LSC	HK1	All, except BCA Serial Data Status*
CCS R6 Updates after TBD	PSC QSC	HK1 HK1	All EVA Airlock & Orlan Telemetry
 (Packet swapping)	RSC	HK1	All EVA Airlock & Orlan Telemetry

*Will get BCA serial Volts, Amps, and Time, but not Channel, Type, Task, or Status. Will not get BCA Serial Data Status data.

EMU Telemetry

- EMU data comes down HK1 automatically when EMU and UHF radios are on and locked.
- EMU data preempts every odd numbered frame of HK1
- All nominal HK1 data rates are slowed down by 50%
- Russian Contingency Packet also preempts HK1, but every even numbered frame.
- If RCP and EMU data are running concurrently, all nominal HK1 data frames are preempted.



ISS AIRLOCK SYSTEMS		Reference only
ELEMENT AL	Airlock MDM & Telemetry Formats	PAGE 3
Impacts of AL MDM Failure		
<ol style="list-style-type: none">1. There will be no PSA, BCA, UIA, DPA data sent to the INT MDM, and therefore none of that data sent to the ground. The data seen on the ground will be static, but not appear blue like during an LOS. The AL MDM frame count will be static, which is an indication that the observed data from the AL MDM is no longer good.2. The Depress pump would no longer be able to turn on. The ALSYS1 gets the input from the UIA DPA power switch and then commands on the pump. Without the AL MDM, the pump will not work.3. A false indication with the Enable light on is possible. The AL MDM is needed to relay the INT MDM command to turn on and off the Enable light.4. The loss of the AL MDM does not affect the position of the O2 and N2 valves. They will stay in their last positions until commanded otherwise. Without the AL MDM, they cannot be commanded otherwise.5. Loss of Comm between the AL MDM and the INT MDM will result in the O2 and N2 valves closing if the AL MDM still retains the ability to command the valves.6. Loss of commanding to CCAA		

1.5 AIRLOCK (A/L) MULTIPLEXER/DEMULTIPLEXER (MDM)

1.5.1 Quick-Look Reference Data

Table 1.5-1 details the specifications for the Airlock (A/L) Multiplexer/Demultiplexer (MDM) On-orbit Replaceable Unit (ORU).

Table 1.5-1. AL MDM ORU specifications

Description	Specification	Comments
Connector Interfaces:		The "J1-X" interfaces are the connectors in the back of the MDM.
J1-A		Slots are the connector locations to the MDM.
Slot 12	--	
Slot 14	--	
J1-C		The middle column shows which devices are attached to the connector.
Slot 2	--	
Slot 4	--	
1553 User Bus B Slot 1	--	See Figure 1.5-4 (Back of MDM) for slot locations, user bus, and contact size slots.
J1-E		
Slot 3	--	
Slot 5	Airlock CCAA	See Table 3.8-2 for detailed listing of the sensors and effectors for each card slot
1553 User Bus A Slot 1	--	
J1-G		
Slot 11	O ₂ (hi, lo P) line T, N ₂ line T	
Slot 13	O ₂ Tank T, PSA, BCA, O ₂ tank T, N ₂ tank T, Smoke	
Slot 15	Smoke, CCAA, LTL, MTL, Heaters	
J1-B		
Slot 6	Lo P N ₂ Vlv, Smoke, CCAA	
Slot 8	Hi P O ₂ Vlv, Smoke, BCA	
Slot 10	Depress Pump, Lo P O ₂ Vlv	
J1-D		
Slot 0	BCA Serial Data	
Slot 1	--	
IOCU 1553 Local Bus A	--	
1553 User Bus B Slot 0	--	
J1-F		
Slot 7	--	
Slot 9	Depress Pump, O ₂ P, N ₂ P, CCAA, UIA, C-Ik P	
IOCU 1553 Local Bus B	--	
1553 User Bus A Slot 0	--	
J1-H		
Power Supply	AL-2A3B-A – RPC 2	Power source for AL MDM

Table 1.5-1. AL MDM ORU specifications (concluded)

Description	Specification	Comments
Dimensions: MDM Chassis	14.4"W by 9.15"H by 13.25" T	
Weight (dry, Pounds): LLA HLA DIO AIO SDO SPD IOCU Power Chassis Total	1.45 lb x 3 = 4.35 lb 1.48 lb x 2 = 2.96 lb 1.44 lb x 5 = 7.20 lb 1.45 lb x 2 = 2.90lb 1.54 lb x 2 = 3.08 lb 1.23 lb x 1 = 1.23 lb 1.60 lb x 1 = 1.60 lb 3.50 lb x 1 = 3.50 lb 28.64 lb x 1 = 28.64 lb 55.46 lb	The cards are LLA Low-level Analog HLA High-level Analog DIO Discrete Input/Output AIO Analog Input/Output SDO Solenoid Driver Output SPD Serial/Parallel/Digital IOCU Input/Output Controller Unit (CPU) Not all cards are used. See Figure 1.5-3

1.5.2 General Description

The A/L MDM performs data acquisition and enables the crew and the ground to monitor and control the health of the airlock hardware. Some of the hardware components lack a manual interface and can be controlled from either the ground or on station with a Portable Computer System (PCS). Most of the EVA-related hardware in the airlock are only monitored and cannot be commanded from the ground or from a PCS.

The A/L MDM is part of a larger networked system of MDMs. The network architecture is divided into three tiers: Tier I, Tier II, and Tier III. Tier I is the control tier that provides overall control and monitoring of the Terminal Bus Controller (USOS) systems. All data and telemetry must flow from Tier III and Tier II through data buses to the Command and Control (C&C) MDM in Tier I before it is sent to the PCS or to the ground. All commands flow through the C&C MDM in Tier I to Tier II, then Tier III. The PCS interfaces with the C&C MDM through a Utility Outlet Panel (UOP) Portable Computer Receptacle (PCR) for commanding and telemetry (see *Figure 1.5-1*). PCRs are currently located in the A/L, Lab, Service Module, and Functional Cargo Block (FGB). (The A/L PCR is located above and to the left of the avionics rack). MCC interfaces with the C&C MDM through the ISS communications systems for commanding and telemetry.

1.5.2.1 Tier I

Tier I consists of three identical C&C MDMs, making it two-fault tolerant. Typically, there is one C&C MDM operating, one powered on for back-up and one powered off. Labels on buses connected to the C&C MDMs are labeled as "CB," indicating that they are on the Control Bus. All three C&C MDMs are located in the Lab.

1.5.2.2 Tier II

Tier II executes system-specific application software that performs functions such as monitoring CO₂ levels or Guidance, Navigation, and Control (GNC) calculations. Tier II receives commands from Tier I and executes them or passes them on to Tier III. The Internal (INT) MDM (INT-1 is prime; INT-2 is backup) is the Remote Terminal (RT) to the C&C MDM and is connected by control bus CB INT-1. If the backup INT MDM is used, it is connected to the C&C MDM via CB INT-2. The INT MDM is then the bus controller to the local bus LB SYS-HAB-2. All Tier II data buses are labeled "LB," indicating that they are on the Local Bus. The A/L MDM is connected to LB SYS-HAB-2 and is, therefore, a remote terminal to the INT MDM. There are two identical INT MDMs; resulting in one-fault tolerance. The redundant INT MDM is powered off, which is the standard configuration. The exception to this rule are the system-critical GNC MDMs, which are both powered on since MDMs take 2 to 3 minutes to boot up. Both INT MDMs are located in the Lab.

1.5.2.3 Tier III

The A/L MDM is in Tier III or the User Tier. The User Tier processes thousands of sensors and effectors on the ISS. The A/L MDM collects data from the sensors and effectors in the Airlock. It sends all the gathered data from the Airlock hardware to Tier II (INT MDM) via a local bus (LB SYS-HAB-2). Tier II then routes the data to Tier I (C&C MDM), which in turn sends the data to the PCs through the PCRs and to the ISS communications system to be downlinked to MCC. The two A/L PCRs, which are accessible from the Utility Outlet Panel (UOP) in the Airlock, interface with the Control Bus (CB) CT 4. The A/L MDM receives power from AL-2A3B-A, RPC 2.

The A/L MDM is located in the Equipment Lock Avionics Rack behind the Battery Stowage Assembly (BSA). The A/L MDM is mounted on a coldplate for heat dissipation (Moderate Temperature Loop) and provides no visual feedback (LCD screen, LEDs, etc.). This MDM is an ORU because all of its components, including the chassis and Input/Output Controller Unit (IOCU) or motherboard, and the power supply cards, can be removed using an extraction tool. Tier III MDMs are zero fault tolerant since they do not have built-in redundancy.

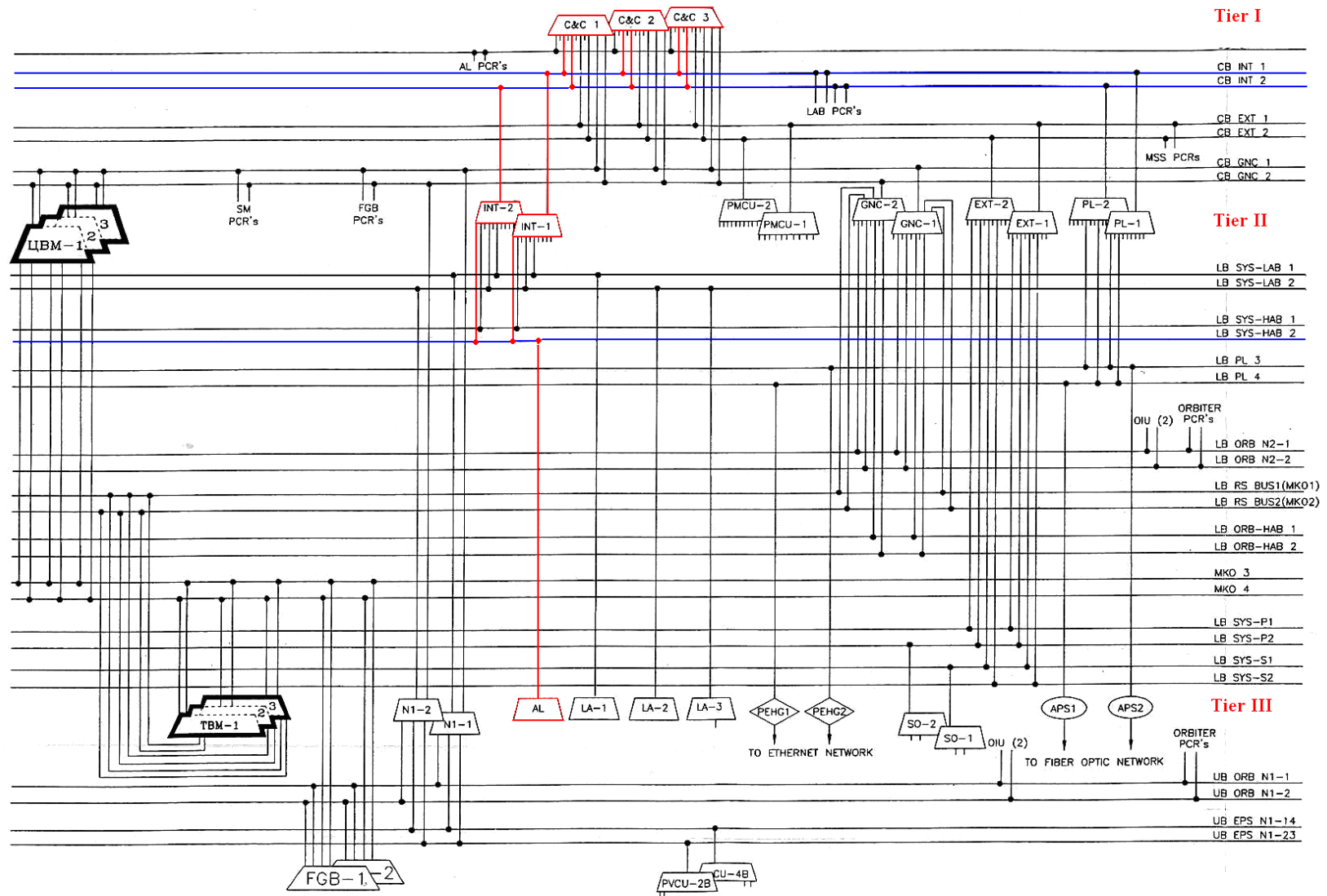


Figure 1.5-1. CDH 1553 tiered architecture (functional)

1.5.3 Subsystem Details

1.5.3.1 Location, Structure, and Temperature

Location

The A/L MDM is mounted on a coldplate (MTL) in the Equipment Lock (E/L) Avionics Rack (See *Figure 1.5-2*).

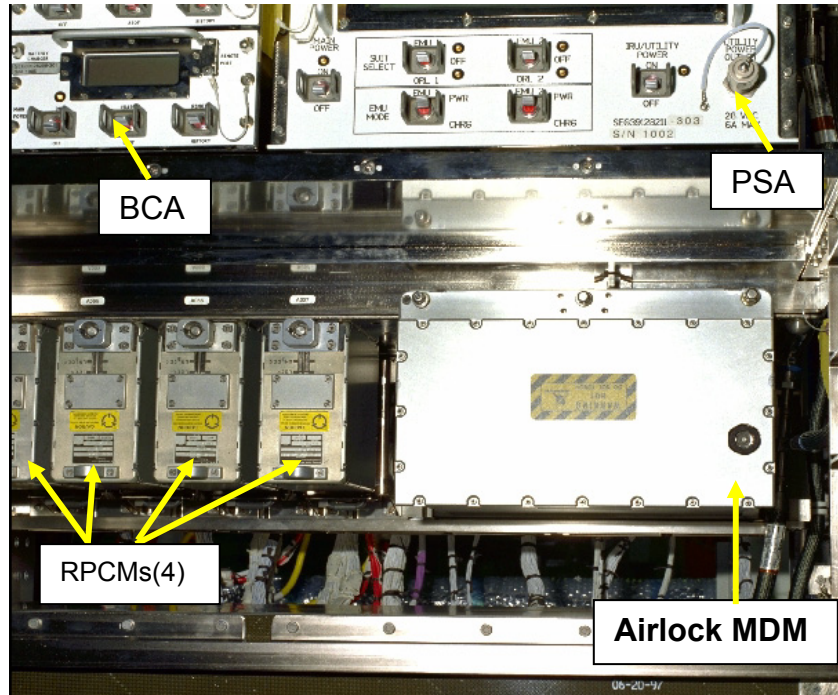


Figure 1.5-2. AL MDM location on avionics rack

Structure

The A/L MDM is an MDM-16 that can be populated with 16 cards in addition to the power supply and motherboard cards (See *Figure 1.5-3*). The MDM is 14.4 in. wide, 13.25 in. deep, and 9.15 in. high and weighs approximately 55.46 lb.

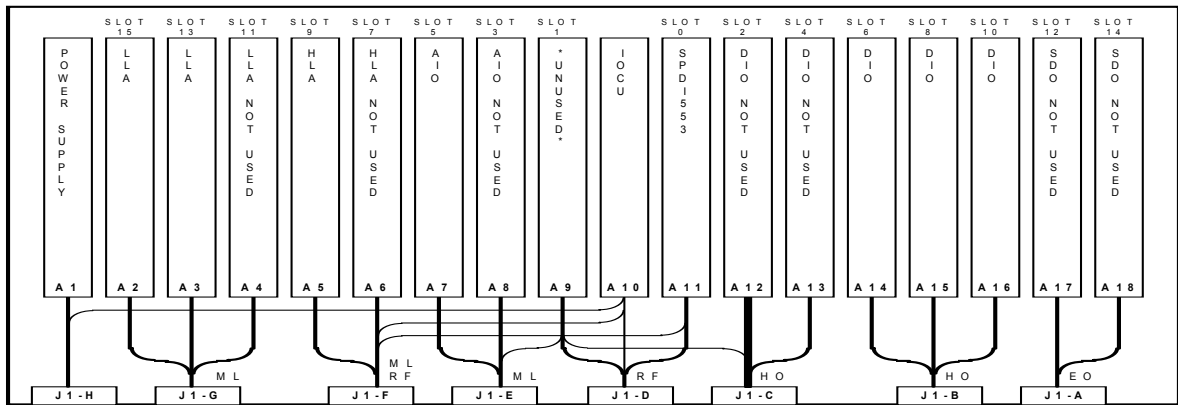


Figure 1.5-3. A/L MDM circuit card configuration

See Figure 1.5-4, Back of A/L MDM. The chassis is nonpressurized.

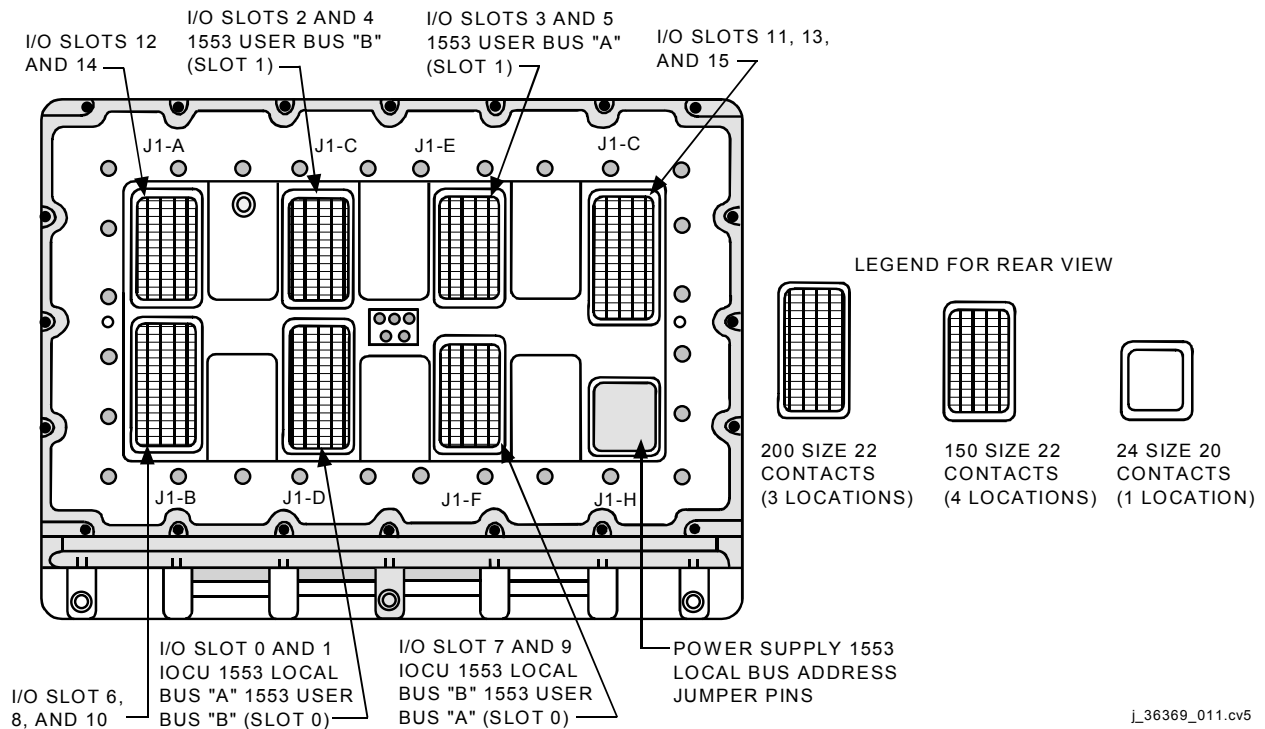


Figure 1.5-4. Back of A/L MDM

Temperature

For maintaining maximum accuracy of the analog cards, the ambient temperature should be maintained between 40° F and 110° F with baseplate temperature ranging from 70° F to 90° F. Non-operational MDMs can be exposed to temperatures from -45° F up to +160° F for a short while and still operate nominally when returned to normal operating temperatures.

1.5.4 A/L MDM Software

The software running on the A/L MDM is Airlock Systems 1 (ALSYS1). ALSYS1 CSCI (Computer Software Configuration Item) has three external interfaces: INTSYS CSCI, MDM Boot and Diagnostic Firmware (MDMBF) CSCI, and hardware.

The INTSYS CSCI is the flight software resident in the INT MDM (Internal Systems) and the interface is through the 1553B local bus LB-SYS-HAB-2. The A/L MDM ALSYS1 CSCI interfaces as the remote terminal to the INT MDM. Therefore, the INT MDM is the bus controller. The INT MDM initiates all communication with the A/L MDM ALSYS1 CSCI and sends commands and receives telemetry and command response from the A/L MDM.

The MDMBF CSCI is the boot and diagnostics firmware for the MDM that is responsible for booting up the A/L MDM. It initializes the ALSYS1 CSCI. The interface is through the MDM memory.

The hardware is defined as the equipment in the Joint Airlock and it interfaces with the sensors, effector lines, and RS-485 cable.

1.5.5 ALSYS1 Capabilities

The ALSYS1 capability (software functions) is grouped into four major subsystems: Environmental Control and Life Support System (ECLSS), Internal Thermal Control Systems (ITCS), Extravehicular Activity System (EVAS), and MDM Utilities Extension (MUE).

EVA is mainly concerned with the functionality of EVAS, MUE, and Atmosphere Control System Valve Control (ACSV), which is a sub-capability of ECLSS.

1.5.5.1 EVAS Capability

The EVAS capability consists of collecting and providing status data for the Depress Pump Assembly (DPA), Servicing, Power, and Checkout Equipment (SPCE), and the Crewlock pressure sensor (located under the UIA).

The depress pump receives power from RPC AL1A4A_A_01. Commands for the DPA RPC are executed through the INT MDM, which is the controller for this RPC. The INT MDM will also route a command to the A/L MDM to power on the depress pump enable light on the UIA. EVAS will then be able to command the DPA on and off, based on the depress pump power switch on the UIA. Once the switch is thrown, a 1 second command is sent to the DPA. Therefore, removing power from the DPA RPC will turn it off, but the DPA cannot be turned back on until the UIA switch command is reapplied. EVAS also processes status data from the DPA to determine what state to command the fault light to. The INT MDM will also send the command to power off the enable light when the DPA RPC is opened. All DPA status information is sent to the INT MDM via a 1553B bus.

The EVAS capability will acquire data cyclically from the PSA, BCA, UIA and provide it to the INT MDM via the 1553B bus.

The Crewlock pressure sensor is also acquired by EVAS and provided to the INT MDM via the 1553B interface.

1.5.5.2 MUE capability

The MUE assists in various applications including the capability to receive BCA serial data from RS-485 interface. The MUE commands the BCAs to activate serial data transmission. It then cyclically collects 63 bytes of BC serial data from each charger and generates BCA Serial Data Status, the status of the serial data transfer. This data is sent to the INT MDM via the 1553B bus at 0.1 Hz.

1.5.5.3 ACSVC capability

The ACSVC assists in various applications including controlling the supply of O₂ to the EMUs and masks during Exercise or Campout protocol.

If a loss of comm with the INT MDM is detected, the ACSVC will command closed the following valves:

- ACS High Pressure O₂ Supply Valve
- ACS Low Pressure O₂ Supply Valve
- ACS Low Pressure N₂ Supply Valve

If the A/L MDM itself were to fail or lose power, then the valves would stay in their last position, since there is no software to command them otherwise.

1.5.6 A/L MDM Sensors and Effectors

The hardware interfaces to the ALSYS1 CSCI is completed through the sensor and effector lines. Table 1.5-2 lists the associated data cards, the functions of the each channel in the cards with respect to airlock hardware, and the PUIs associated with them. Everything listed is either telemetry or commands. This information was referenced from the ODIN Console Handbook JSC-36332 Vol 1 Rev B, Section 5.7.8.

The bolded items in Table 1.5-2 are the items that affect EVA.

Below is a list of the bolded items and a description of their function.

- **A/L AA RACK BC #1,2,3,4 SERIAL DATA:** This is the serial data from the Battery Charger Assemblies. The ALSYS1 CSCI commands each individual BC(1,2,3,4) to activate their serial data transmission, using **AL AA BC #x Enable Cmd** (x=1,2,3,4). Then the MUE capability has the utility to use the RS-485 to collect the

BCA serial data. It cyclically acquires 63 bytes of **AL AA RACK BC #x Serial Data** from each battery charger. The MUE then provides this serial data to the INT MDM at a rate of 0.1Hz.

- **BCA 1,2,3,4 SERIAL DATA STATUS:** The MUE maintains serial data transfer status for each charger. It sends this status information to the INT MDM as **BCA x SERIAL DATA STATUS** (x=1,2,3,4) at a 0.1 Hz rate. The signals PUIs are ALDS15MD5301J, ALDS15MD5333J, ALDS15MD5365J, and ALDS15MD5397J respectively.
- **AL AA RACK BC #1 ENABLE CMD:** This is a discrete signal used by the MUE in ALSYS1 to activate the serial data transmission of Battery Charger 1.
- **AL AA RACK BC #2 ENABLE CMD:** This is a discrete signal used by the MUE in ALSYS1 to activate the serial data transmission of Battery Charger 2.
- **AL AA RACK BC #3 ENABLE CMD:** This is a discrete signal used by the MUE in ALSYS1 to activate the serial data transmission of Battery Charger 3.
- **AL AA RACK BC #4 ENABLE CMD:** This is a discrete signal used by the MUE in ALSYS1 to activate the serial data transmission of Battery Charger 4.
- **Airlock_O2_UIA_Sply_P OR ACS AL O2 #1 Line Pressure Sensor Data:** Pressure sensor for O2 entering the SCUs.
- **UIA_EV_1_VOLTS OR EVAS AL EMU1 Voltage Monitor:** UIA EMU Voltage sensor for EV-1.
- **UIA_EV_1_AMPS OR EVAS AL EMU1 Current Monitor:** UIA EMU Amp sensor for EV_1.
- **UIA_EV_2_VOLTS OR EVAS AL EMU2 Voltage Monitor:** UIA EMU Voltage sensor for EV-2.
- **UIA_EV_2_AMPS OR EVAS AL EMU2 Current Monitor:** UIA EMU Amp sensor for EV_2.
- **UIA_ORL1_VOLTS OR EVAS AL ORL1 Voltage Monitor:** UIA Orlan Voltage sensor for EV-1.
- **UIA_ORL1_AMPS OR EVAS AL ORL1 Current Monitor:** UIA Orlan Amp sensor for EV_1.
- **UIA_ORL2_VOLTS OR EVAS AL ORL2 Voltage Monitor:** UIA Orlan Voltage sensor for EV-2.

- **UIA_ORL2_AMPS OR EVAS AL ORL2 Current Monitor:** UIA Orlan Amp sensor for EV_2.
- **Airlock_Crewlock_Cab_Press OR EVAS AL CL Sensor Pressure:** Crewlock pressure sensor data from behind the UIA.
- **Airlock_Depress_Pump_RPM OR EVAS AL EL DPA EU RPM:** RPM sensor in the Depress Pump.
- **Airlock_Depress_Pump_Current OR EVAS AL EL DPA EU Current:** Current (Amps) sensor in the Depress Pump.
- **Airlock_Depress_Pump_Emer_Off OR EVAS AL EL DPA EU Emergency Off:** Discrete from the Depress Pump indicating if the DPA had an emergency shutdown or not.
- **Airlock_Depress_Pump_Mtr_Fail OR EVAS AL EL DPA EU Motor Failure:** Discrete from the Depress Pump indicating if the DPA had a motor failure or not.
- **Airlock_Depress_Pump_EU_Fail OR EVAS AL EL DPA EU Failure:** Discrete from the Depress Pump indicating if the DPA Electronics Unit failed or not.
- **Airlock_Depress_Pump_Cont_Chk OR EVAS AL EL DPA Continuity Check:** Discrete from the Depress Pump indicating if the DPA passes continuity check or not.
- **Airlock_Depress_Pump_Pwr_Switch OR EVAS AL DP Switch Status:** Depress Pump power switch setting on the UIA, indicating on or off position. The switch is set to either PUMP ON CMD or PUMP OFF CMD.
- **AL EL DPA EU ON COMMAND AND AL EL DPA EU OFF COMMAND:**
When the **EVAS AL DP Switch Status** is set to PUMP ON CMD, the EVAS capability will issue an **AL EL DPA EU ON COMMAND** set to ON and an **AL EL DPA EU OFF COMMAND** set to NOT OFF and hold both for 1 second. After the 1 second hold, EVAS will issue an **AL EL DPA EU ON COMMAND** set to NOT ON and an **AL EL DPA EU OFF COMMAND** to NOT OFF.

When the **EVAS DP Switch Status** is set to PUMP OFF CMD, the EVAS capability will issue an **AL EL DPA EU ON COMMAND** set to NOT ON and an **AL EL DPA EU OFF COMMAND** set to OFF and hold both for 1 second. After the 1 second hold, EVAS will issue an **AL EL DPA EU OFF COMMAND** set to NOT OFF and an **AL EL DPA EU ON COMMAND** to NOT ON.
- **AL CL DPA FAULT INDICATOR:** This command is issued from the AL MDM (ALSYS1 CSCI EVAS capability) to turn the Depress Pump Fault Light On or Off. The EVAS capability within the ALSYS1 determines if the command should be

given to turn the Fault Light On or Off from the DPA status data. If the **EVAS AL EL DPA EU Motor Failure** is set to MOTOR FAILED, or **EVAS AL EL DPA EU Failure** is set to ELECSW FAILED, or **EVAS AL EL DPA EU Emergency Off** is set to EMER DEACTIVATE, then the command is set to FAULT IND ON. Otherwise, the command is set to FAULT IND OFF.

- **EVAS DP STATUS:** This is a signal generated by the EVAS capability in the A/L MDM to indicate whether or not the DPA is FAILED or OPERATIONAL. It reflects the Fault Light. The signal is set by the same criteria as the **AL CL DPA FAULT INDICATOR** above. Since this signal is generated within the MDM software, it is not shown in Table 3.8-2, it is not a sensor or effector to the attached hardware. Its signal PUI is ALDS15MD0024J.
- **AL CL DPA POWER INDICATOR:** This command is issued from the A/L MDM (ALSYS1 CSCI EVAS capability) to the UIA to turn the Enable Light On or Off for the Depress Pump. This command originates with the INT MDM where the RPC for the depress pump is commanded from. The INT MDM commands the A/L MDM to turn the Enable Light On or Off. The A/L MDM then issues the command to the Enable Light on the UIA.
- **PSA_EMU1_VOLTS OR EVAS AL AA Rack PS #1 Voltage:** Voltage supplied to the EMU1 channel.
- **PSA_EMU1_AMPS OR EVAS AL AA Rack PS #1 Current:** Amps supplied to the EMU1 channel.
- **PSA_EMU2_VOLTS OR EVAS AL AA Rack PS #2 Voltage:** Voltage supplied to the EMU2 channel.
- **PSA_EMU2_AMPS OR EVAS AL AA Rack PS #2 Current:** Amps supplied to the EMU2 channel.
- **PSA_ORL1_VOLTS OR EVAS AL AA Rack PS #3 Voltage:** Voltage supplied to the Orlan 1 channel.
- **PSA_ORL1_AMPS OR EVAS AL AA Rack PS #3 Current:** Amps supplied to the Orlan 1 channel.
- **PSA_ORL2_VOLTS OR EVAS AL AA Rack PS #4 Voltage:** Voltage supplied to the Orlan 2 channel.
- **PSA_ORL2_AMPS OR EVAS AL AA Rack PS #4 Current:** Amps supplied to the Orlan 2 channel.
- **PSA_IRU_Utility_VOLTS OR EVAS AL AA Rack PS #5 Voltage:** Voltage supplied to the IRU or Utility Power Outlet channel.

- **PSA_IRU_Utility_AMPS OR EVAS AL AA Rack PS #5 Current:** Amps supplied to the IRU or Utility Power Outlet channel.
- **PSA_LCD_VOLTS OR EVAS AL AA Rack PS #6 Voltage:** Voltage supplied to power the UIA displays and the Hardline Comm circuitry in the UIA.
- **PSA_LCD_AMPS OR EVAS AL AA Rack PS #6 Current:** Amps supplied to power the UIA displays and the Hardline Comm circuitry in the UIA.
- **BCA1_Analog_VOLTS OR EVAS AL AA Rack BC #1 Voltage Monitor:** Voltage that BC#1 is using to charge batteries.
- **BCA1_Analog_AMPS OR EVAS AL AA Rack BC #1 Current Monitor:** Amps that BC#1 is using to charge batteries.
- **BCA2_Analog_VOLTS OR EVAS AL AA Rack BC #2 Voltage Monitor:** Voltage that BC#2 is using to charge batteries.
- **BCA2_Analog_AMPS OR EVAS AL AA Rack BC #2 Current Monitor:** Amps that BC#2 is using to charge batteries.
- **BCA3_Analog_VOLTS OR EVAS AL AA Rack BC #3 Voltage Monitor:** Voltage that BC#3 is using to charge batteries.
- **BCA3_Analog_AMPS OR EVAS AL AA Rack BC #3 Current Monitor:** Amps that BC#3 is using to charge batteries.
- **BCA4_Analog_VOLTS OR EVAS AL AA Rack BC #4 Voltage Monitor:** Voltage that BC#4 is using to charge batteries.
- **BCA4_Analog_AMPS OR EVAS AL AA Rack BC #4 Current Monitor:** Amps that BC#4 is using to charge batteries.
- **AL HI PRES O2 SUP VLV OPEN CMD and AL HI PRES O2 SUP VLV CLOSE CMD:** Commands the A/L MDM uses to open and close the High pressure O₂ Valve.
- **AL LO PRES O2 SUP VLV OPEN CMD and AL LO PRES O2 SUP VLV CLOSE CMD:** Commands the A/L MDM uses to open and close the Low pressure O₂ Valve.

Table 1.5-2. A/L MDM sensors and effectors

MDM	Slot	Card Type	Chnl no.	Sys-ID	Elem	Name	Description	SPUI	Chnl Type
						Slot 0			
A/L	0	SPD 1553			Airlock	N/A	AL AA RACK BC #1 SERIAL DATA	See Systems Brief on EVA	SPD
A/L	0	SPD 1553			Airlock	N/A	AL AA RACK BC #2 SERIAL DATA	Telemetry	SPD
A/L	0	SPD 1553			Airlock	N/A	AL AA RACK BC #3 SERIAL DATA		SPD
A/L	0	SPD 1553			Airlock	N/A	AL AA RACK BC #4 SERIAL DATA		SPD
						Slot 1			
A/L	1	N/A	N/A		Airlock	Unused			
						Slot 2			
A/L	2	DIO	0-31		Airlock	Spare			
						Slot 3			
A/L	3	AIO	0-31		Airlock	Spare			
						Slot 4			
A/L	4	DIO	0-31		Airlock	Spare			
						Slot 5			
A/L	5	AIO	0	ECLSS	Airlock	N/A	AL CCAA TCCV POSITION CMD	ALET14VL0002K	AIO1
A/L	5	AIO	1	ECLSS	Airlock	N/A	AL CCAA FAN SPEED CMD	ALET19FA0002K	AIO1
A/L	5	AIO	2-31		Airlock	Spare			
						Slot 6			
A/L	6	DIO	0	ECLSS	Airlock	Airlock_CCAA_EIB_Fail_Snsr	CCAA HW EIB Fault Sensor Reading A/L	ALET04IU0003J	DIO2
A/L	6	DIO	1	ECLSS	Airlock	Airlock_CCAA_HX_Liquid_Snsr	CCAA HW HX Liquid Sensor Reading A/L	ALET04IU0007J	DIO1
A/L	6	DIO	2	ECLSS	Airlock	Airlock_N2_Sply_Vlv_Ind_Op	ACS AL Low Pressure N2 Supply Valve Open Sensor Data	ALEA11VL0003J	DIO2
A/L	6	DIO	3	ECLSS	Airlock	Airlock_N2_Sply_Vlv_Ind_Cl	ACS AL Low Pressure N2 Supply Valve Closed Sensor Data	ALEA11VL0004J	DIO2
A/L	6	DIO	4-15		Airlock	Spare			
A/L	6	DIO	16	ECLSS	Airlock	N/A	AL CCAA EIB ENABLE CMD	ALET04IU0002K	DIO4
A/L	6	DIO	17	ECLSS	Airlock	N/A	AL CCAA TCCV ENABLE CMD	ALET14VL0001K	DIO4
A/L	6	DIO	18	ECLSS	Airlock	N/A	AL CCAA EIB ACTIVE BIT CMD	ALET04IU0001K	DIO3

Table 1.5-2. A/L MDM sensors and effectors (continued)

MDM	Slot	Card Type	Chnl no.	Sys-ID	Elem	Name	Description	SPUI	Chnl Type
A/L	6	DIO	19	ECLSS	Airlock	N/A	AL CCAA SOL VLV ENABLE CMD	ALET04IU0005K	DIO3
A/L	6	DIO	20	ECLSS	Airlock	N/A	AIRLOCK X4 SMOKE DET BIT ENABLE	ALEF20SK0001K	DIO3
A/L	6	DIO	21	ECLSS	Airlock	N/A	AL CCAA WS ENABLE CMD	ALET09WS0001K	DIO4
A/L	6	DIO	22	ECLSS	Airlock	N/A	AL CCAA FAN ENABLE CMD	ALET19FA0001K	DIO4
A/L	6	DIO	23	ECLSS	Airlock	N/A	AL LO PRES N2 SUP VLV OPEN CMD	ALEA11VL0001K	DIO4
A/L	6	DIO	24	ECLSS	Airlock	N/A	AL LO PRES N2 SUP VLV CLOSE CMD	ALEA11VL0002K	DIO4
A/L	6	DIO	25-31		Airlock	Spare			
						Slot 7			
A/L	7	HLA	0-31		Airlock	Spare			
						Slot 8			
A/L	8	DIO	0-7		Airlock	Spare			
A/L	8	DIO	8	ECLSS	Airlock	Airlock_O2_Hi_P_Sply_Vlv_Ind_Op	ACS AL High Pressure O2 Supply Valve Open Sensor Data	ALEA06VL0003J	DIO2
A/L	8	DIO	9	ECLSS	Airlock	Airlock_O2_Hi_P_Sply_Vlv_Ind_Cl	ACS AL High Pressure O2 Supply Valve Closed Sensor Data	ALEA06VL0004J	DIO2
A/L	8	DIO	10-15		Airlock	Spare			
A/L	8	DIO	16	EVA	Airlock	N/A	AL AA RACK BC #1 ENABLE CMD	ALXS01BT0101K	DIO4
A/L	8	DIO	17	EVA	Airlock	N/A	AL AA RACK BC #2 ENABLE CMD	ALXS01BT0201K	DIO4
A/L	8	DIO	18	ECLSS	Airlock	N/A	AIRLOCK X3 SMOKE DET BIT ENABLE	ALEF21SK0001K	DIO3
A/L	8	DIO	19-20		Airlock	Spare			
A/L	8	DIO	21	EVA	Airlock	N/A	AL AA RACK BC #3 ENABLE CMD	ALXS01BT0301K	DIO4
A/L	8	DIO	22	EVA	Airlock	N/A	AL AA RACK BC #4 ENABLE CMD	ALXS01BT0401K	DIO4
A/L	8	DIO	23	ECLSS	Airlock	N/A	AL HI PRES O2 SUP VLV OPEN CMD	ALEA06VL0001K	DIO4
A/L	8	DIO	24	ECLSS	Airlock	N/A	AL HI PRES O2 SUP VLV CLOSE CMD	ALEA06VL0002K	DIO4
A/L	8	DIO	25-31		Airlock	Spare			
						Slot 9			
A/L	9	HLA	0	ECLSS	Airlock	Airlock_CCAA_H2O_Sep_LS	CCAA HW WS Liquid Sensor Reading AL	ALET04IU0006Q	HLA3
A/L	9	HLA	1	ECLSS	Airlock	Airlock_CCAA_TCCV_Posn	CCAA HW TCCV Position Sensor Reading AL	ALET14VL0003H	HLA3
A/L	9	HLA	2	ECLSS	Airlock	Airlock_CCAA_H2O_Sep_Spd	CCAA HW WS Speed Sensor Reading AL	ALET09WS0002R	HLA3
A/L	9	HLA	3	ECLSS	Airlock	Airlock_CCAA_H2O_Sep_P	CCAA HW WS Pressure Reading AL	ALET09SR0001P	HLA2
A/L	9	HLA	4	ECLSS	Airlock	Airlock_CCAA_Fan_DP	CCAA HW Fan Delta Pressure Sensor Reading AL	ALET19SR0201P	HLA2
A/L	9	HLA	5	ECLSS	Airlock	Airlock_CCAA_Fan_Spd	CCAA HW Fan Speed Sensor Reading AL	ALET19FA0003R	HLA3

Table 1.5-2. A/L MDM sensors and effectors (continued)

MDM	Slot	Card Type	Chnl no.	Sys-ID	Elem	Name	Description	SPUI	Chnl Type
A/L	9	HLA	6	ECLSS	Airlock		O2 PRES SEN 1 PRESSURE SENSOR EXCITATION	ALEA31SR0002X	HLA4
A/L	9	HLA	7	ECLSS	Airlock	Airlock_O2_UIA_Sply_P	ACS AL O2 #1 Line Pressure Sensor Data	ALEA31SR0001P	HLA3
A/L	9	HLA	8	ECLSS	Airlock		O2 PRES SEN 2 PRESSURE SENSOR EXCITATION	ALEA32SR0002X	HLA4
A/L	9	HLA	9	ECLSS	Airlock	Airlock_O2_High_P_Sply_P	ACS AL O2 #2 Line Pressure Sensor Data	ALEA32SR0001P	HLA3
A/L	9	HLA	10	ECLSS	Airlock		O2 PRES SEN 3 PRESSURE SENSOR EXCITATION	ALEA33SR0002X	HLA4
A/L	9	HLA	11	ECLSS	Airlock	Airlock_O2_Low_P_Sply_P	ACS AL O2 #3 Line Pressure Sensor Data	ALEA33SR0001P	HLA3
A/L	9	HLA	12	ECLSS	Airlock		N2 PRES SEN 1 PRESSURE SENSOR EXCITATION	ALEA34SR0002X	HLA4
A/L	9	HLA	13	ECLSS	Airlock	Airlock_N2_Sply_P	ACS AL N2 #1 Line Pressure Sensor Data	ALEA34SR0001P	HLA3
A/L	9	HLA	14	EVA	Airlock	Airlock_Depress_Pump_RPM	EVAS AL EL DPA EU RPM	ALXD01IU0001V	HLA3
A/L	9	HLA	15	EVA	Airlock	Airlock_Depress_Pump_Current	EVAS AL EL DPA EU Current	ALXD01IU0002V	HLA3
A/L	9	HLA	16	EVA	Airlock	UIA_EV_1_VOLTS	EVAS AL EMU1 Voltage Monitor	ALXS03PW0001V	HLA3
A/L	9	HLA	17	EVA	Airlock	UIA_EV_1_AMPS	EVAS AL EMU1 Current Monitor	ALXS03PW0002C	HLA3
A/L	9	HLA	18	EVA	Airlock	UIA_EV_2_VOLTS	EVAS AL EMU2 Voltage Monitor	ALXS03PW0101V	HLA3
A/L	9	HLA	19	EVA	Airlock	UIA_EV_2_AMPS	EVAS AL EMU2 Current Monitor	ALXS03PW0102C	HLA3
A/L	9	HLA	20	EVA	Airlock	UIA_ORL1_VOLTS	EVAS AL ORL1 Voltage Monitor	ALXS03PW0201V	HLA3
A/L	9	HLA	21	EVA	Airlock	UIA_ORL1_AMPS	EVAS AL ORL1 Current Monitor	ALXS03PW0202C	HLA3
A/L	9	HLA	22	EVA	Airlock	UIA_ORL2_VOLTS	EVAS AL ORL2 Voltage Monitor	ALXS03PW0301V	HLA3
A/L	9	HLA	23	EVA	Airlock	UIA_ORL2_AMPS	EVAS AL ORL2 Current Monitor	ALXS03PW0302C	HLA3
A/L	9	HLA	24	EVA	Airlock	Airlock_Crewlock_Cab_Press	EVAS AL CL Sensor Pressure	ALXS03SR0001P	HLA2
A/L	9	HLA	25-31		Airlock	Spare			
						Slot 10			
A/L	10	DIO	0-1		Airlock	Spare			
A/L	10	DIO	2	EVA	Airlock	Airlock_Depress_Pump_Emer_Off	EVAS AL EL DPA EU Emergency Off	ALXD01IU0005J	DIO2
A/L	10	DIO	3	EVA	Airlock	Airlock_Depress_Pump_Mtr_Fail	EVAS AL EL DPA EU Motor Failure	ALXD01IU0003J	DIO2
A/L	10	DIO	4	EVA	Airlock	Airlock_Depress_Pump_EU_Fail	EVAS AL EL DPA EU Failure	ALXD01IU0004J	DIO2
A/L	10	DIO	5	EVA	Airlock	Airlock_Depress_Pump_Cont_Chk	EVAS AL EL DPA Continuity Check	ALXD01IU0006J	DIO2
A/L	10	DIO	6	EVA	Airlock	Airlock_Depress_Pump_Pwr_Switch	EVAS AL DP Switch Status	ALXD02CN0001H	DIO2
A/L	10	DIO	7-9		Airlock	Spare			
A/L	10	DIO	10	ECLSS	Airlock	Airlock_O2_Lo_P_Sply_Vlv_Ind_Op	ACS AL Low Pressure O2 Supply Valve Open Sensor Data	ALEA07VL0003J	DIO2
A/L	10	DIO	11	ECLSS	Airlock	Airlock_O2_Lo_P_Sply_Vlv_Ind_Cl	ACS AL Low Pressure O2 Supply Valve Closed Sensor Data	ALEA07VL0004J	DIO2

Table 1.5-2. A/L MDM sensors and effectors (continued)

MDM	Slot	Card Type	Chnl no.	Sys-ID	Elem	Name	Description	SPUI	Chnl Type
A/L	10	DIO	12-15		Airlock	Spare			
A/L	10	DIO	16	EVA	Airlock	N/A	AL CL DPA FAULT INDICATOR	ALXD02CN0002J	DIO4
A/L	10	DIO	17	EVA	Airlock	N/A	AL CL DPA POWER INDICATOR	ALXD02CN0003K	DIO4
A/L	10	DIO	18	EVA	Airlock	N/A	AL EL DPA EU ON COMMAND	ALXD01IU0007H	DIO3
A/L	10	DIO	19	EVA	Airlock	N/A	AL EL DPA EU OFF COMMAND	ALXD01IU0008H	DIO3
A/L	10	DIO	20		Airlock	Spare			
A/L	10	DIO	21	ECLSS	Airlock	N/A	AL LO PRES O2 SUP VLV OPEN CMD	ALEA07VL0001K	DIO4
A/L	10	DIO	22	ECLSS	Airlock	N/A	AL LO PRES O2 SUP VLV CLOSE CMD	ALEA07VL0002K	DIO4
A/L	10	DIO	23-31		Airlock	Spare			
						Slot 11			
A/L	11	LLA	0	ECLSS	Airlock	AIRLOCK_O2_HI_P_LINE_TEMP	ACS A078 AL O2 Temperature Sensor	ALEA78SR0001T	LLAC6
A/L	11	LLA	1-2		Airlock	Spare			
A/L	11	LLA	3	ECLSS	Airlock	AIRLOCK_O2_LO_P_LINE_TEMP	ACS A077 AL O2 Temperature Sensor	ALEA77SR0001T	LLAC6
A/L	11	LLA	4		Airlock	Spare			
A/L	11	LLA	5	ECLSS	Airlock	Airlock_N2_Line_Temp	ACS A075 A076 AL N2 Temperature Sensor	ALEA75SR0001T	LLAC6
A/L	11	LLA	6-31		Airlock	Spare			
						Slot 12			
A/L	12	SDO	0-15		Airlock	Spare			
						Slot 13			
A/L	13	LLA	0	EVA	Airlock	BCA3_Analog_VOLTS	EVAS AL AA Rack BC #3 Voltage Monitor	ALXS01BT0302V	LLAV1
A/L	13	LLA	1	EVA	Airlock	PSA_EMU1_VOLTS	EVAS AL AA Rack PS #1 Voltage	ALXS02PW0001V	LLAV1
A/L	13	LLA	2	EVA	Airlock	PSA_EMU1_AMPS	EVAS AL AA Rack PS #1 Current	ALXS02PW0002C	LLAV1
A/L	13	LLA	3	EVA	Airlock	BCA3_Analog_AMPS	EVAS AL AA Rack BC #3 Current Monitor	ALXS01BT0303C	LLAV1
A/L	13	LLA	4	EVA	Airlock	PSA_EMU2_VOLTS	EVAS AL AA Rack PS #2 Voltage	ALXS02PW0101V	LLAV1
A/L	13	LLA	5	EVA	Airlock	BCA4_Analog_VOLTS	EVAS AL AA Rack BC #4 Voltage Monitor	ALXS01BT0402V	LLAV1
A/L	13	LLA	6	EVA	Airlock	BCA4_Analog_AMPS	EVAS AL AA Rack BC #4 Current Monitor	ALXS01BT0403C	LLAV1
A/L	13	LLA	7	EVA	Airlock	PSA_EMU2_AMPS	EVAS AL AA Rack PS #2 Current	ALXS02PW0102C	LLAV1
A/L	13	LLA	8	EVA	Airlock	PSA_ORL1_VOLTS	EVAS AL AA Rack PS #3 Voltage	ALXS02PW0201V	LLAV1
A/L	13	LLA	9	ECLSS	Airlock	Airlock_N2_Tanks_Temp	PTCS A113 N2 Temperature Sensor	ALEA18SR0001T	LLAC6
A/L	13	LLA	10	ECLSS	Airlock	Airlock_O2_Tank_Hi_Temp	PTCS A111 O2 Temperature Sensor	ALEA16SR0001T	LLAC6
A/L	13	LLA	11	EVA	Airlock	PSA_ORL1_AMPS	EVAS AL AA Rack PS #3 Current	ALXS02PW0202C	LLAV1
A/L	13	LLA	12	ECLSS	Airlock	Airlock_O2_Tank_Lo_Temp	PTCS A112 O2 Temperature Sensor	ALEA17SR0001T	LLAC6

Table 1.5-2. A/L MDM sensors and effectors (continued)

MDM	Slot	Card Type	Chnl no.	Sys-ID	Elem	Name	Description	SPUI	Chnl Type
A/L	13	LLA	13	EVA	Airlock	PSA_ORL2_VOLTS	EVAS AL AA Rack PS #4 Voltage	ALXS02PW0301V	LLAV1
A/L	13	LLA	14	EVA	Airlock	PSA_ORL2_AMPS	EVAS AL AA Rack PS #4 Current	ALXS02PW0302C	LLAV1
A/L	13	LLA	15		Airlock	Spare			
A/L	13	LLA	16	EVA	Airlock	PSA_IRU_Utility_VOLTS	EVAS AL AA Rack PS #5 Voltage	ALXS02PW0401V	LLAV1
A/L	13	LLA	17-18		Airlock	Spare			
A/L	13	LLA	19	EVA	Airlock	PSA_IRU_Utility_AMPS	EVAS AL AA Rack PS #5 Current	ALXS02PW0402C	LLAV1
A/L	13	LLA	20		Airlock	Spare			
A/L	13	LLA	21	EVA	Airlock	PSA_LCD_VOLTS	EVAS AL AA Rack PS #6 Voltage	ALXS02PW0501V	LLAV1
A/L	13	LLA	22	EVA	Airlock	PSA_LCD_AMPS	EVAS AL AA Rack PS #6 Current	ALXS02PW0502C	LLAV1
A/L	13	LLA	23-24		Airlock	Spare			
A/L	13	LLA	25	EVA	Airlock	BCA1_Analog_VOLTS	EVAS AL AA Rack BC #1 Voltage Monitor	ALXS01BT0102V	LLAV1
A/L	13	LLA	26	EVA	Airlock	BCA1_Analog_AMPS	EVAS AL AA Rack BC #1 Current Monitor	ALXS01BT0103C	LLAV1
A/L	13	LLA	27		Airlock	Spare			
A/L	13	LLA	28	EVA	Airlock	BCA2_Analog_VOLTS	EVAS AL AA Rack BC #2 Voltage Monitor	ALXS01BT0202V	LLAV1
A/L	13	LLA	29	ECLSS	Airlock	Airlock_Cab_SD_Obsc	FDS AL1 ALX3 Smoke Detector Obscuration	ALEF21SK0003B	LLAV1
A/L	13	LLA	30	ECLSS	Airlock	Airlock_Cab_SD_Sctr	FDS AL1 ALX3 Smoke Detector Scatter	ALEF21SK0002B	LLAV1
A/L	13	LLA	31	EVA	Airlock	BCA2_Analog_AMPS	EVAS AL AA Rack BC #2 Current Monitor	ALXS01BT0203C	LLAV1
						Slot 14			
A/L	14	SDO	0-15		Airlock	Spare			
						Slot 15			
A/L	15	LLA	0	ECLSS	Airlock	Airlock_CCAA_Out_T1	CCAA Raw Outlet Temp 1 AL	ALET14SR0201T	LLAC6
A/L	15	LLA	1-2		Airlock	Spare			
A/L	15	LLA	3	ECLSS	Airlock	Airlock_CCAA_Out_T2	CCAA Raw Outlet Temp 2 AL	ALET14SR0301T	LLAC6
A/L	15	LLA	4	ECLSS	Airlock	Airlock_Duct_SD_Obsc	FDS AL1 MDM SD ALX4 Obscuration HW	ALEF20SK0003B	LLAV1
A/L	15	LLA	5	THOR	Airlock	AIRLOCK_RSTS_LTL_Temp	RSTS AL1 LTL Temperature Sensor	ALTT52SR0001T	LLAC6
A/L	15	LLA	6	THOR	Airlock	AIRLOCK_RSTS_MTL_Temp	RSTS AL1 MTL Temperature Sensor	ALTT51SR0001T	LLAC6
A/L	15	LLA	7	ECLSS	Airlock	Airlock_Duct_SD_Sctr	FDS AL1 MDM SD ALX4 Scatter HW	ALEF20SK0002B	LLAV1
A/L	15	LLA	8		Airlock	Spare			
A/L	15	LLA	9	ECLSS	Airlock	Airlock_CCAA_In_T1	CCAA Raw Inlet Temp 1 AL	ALET24SR0201T	LLAC6
A/L	15	LLA	10	ECLSS	Airlock	Airlock_CCAA_In_T2	CCAA Raw Inlet Temp 2 AL	ALET24SR0301T	LLAC6
A/L	15	LLA	11		Airlock	Spare			
A/L	15	LLA	12	THOR	Airlock	AIRLOCK_Htr1_Temp1	PTCS AL1 Shell Z1 RTD1	ALTP21SR0001T	LLAC6

Table 1.5-2. A/L MDM sensors and effectors (concluded)

MDM	Slot	Card Type	Chnl no.	Sys-ID	Elem	Name	Description	SPUI	Chnl Type
A/L	15	LLA	13-14		Airlock	Spare			
A/L	15	LLA	15	THOR	Airlock	AIRLOCK_Htr1_Temp2	PTCS AL1 Shell Z1 RTD2	ALTP22SR0001T	LLAC6
A/L	15	LLA	16		Airlock	Spare			
A/L	15	LLA	17	THOR	Airlock	AIRLOCK_Htr2_Temp1	PTCS AL1 Shell Z2 RTD1	ALTP23SR0001T	LLAC6
A/L	15	LLA	18	THOR	Airlock	AIRLOCK_Htr2_Temp2	PTCS AL1 Shell Z2 RTD2	ALTP24SR0001T	LLAC6
A/L	15	LLA	19		Airlock	Spare			
A/L	15	LLA	20	THOR	Airlock	AIRLOCK_Htr3_Temp1	PTCS AL1 Shell Z3 RTD1	ALTP25SR0001T	LLAC6
A/L	15	LLA	21-22		Airlock	Spare			
A/L	15	LLA	23	THOR	Airlock	AIRLOCK_Htr3_Temp2	PTCS AL1 Shell Z3 RTD2	ALTP26SR0001T	LLAC6
A/L	15	LLA	24	THOR	Airlock	AIRLOCK_Htr4_Temp1	PTCS AL1 Shell Z4 RTD1	ALTP27SR0001T	LLAC6
A/L	15	LLA	25-26		Airlock	Spare			
A/L	15	LLA	27	THOR	Airlock	AIRLOCK_Htr4_Temp2	PTCS AL1 Shell Z4 RTD2	ALTP28SR0001T	LLAC6
A/L	15	LLA	28		Airlock	Spare			
A/L	15	LLA	29	THOR	Airlock	AIRLOCK_Htr5_Temp1	PTCS AL1 Shell Z5 RTD1	ALTP29SR0001T	LLAC6
A/L	15	LLA	30	THOR	Airlock	AIRLOCK_Htr5_Temp2	PTCS AL1 Shell Z5 RTD2	ALTP30SR0001T	LLAC6
A/L	15	LLA	31		Airlock	Spare			

1.5.7 Impacts of failed Airlock MDM

The loss of the A/L MDM would impact EVA in several ways. One of which is the loss of the Depress Pump Assembly, since the command capability will be lost.

A false indication with the Enable light on is possible. The A/L MDM is needed to relay the INT MDM command to turn on and off the Enable light.

There will be no PSA, BCA, UIA, DPA data sent to the INT MDM, and therefore none of that data sent to the ground. The data seen on the ground will be static, but not appear blue like during an LOS. The A/L MDM frame count will be static, which is an indication that the observed data from the A/L MDM is no longer dynamic.

As mentioned in Section 1.5.5.3, the loss of the A/L MDM does not affect the position of the O₂ and N₂ valves. They will stay in their positions until commanded otherwise.

Loss of the A/L MDM would also affect the ability to perform METOX regenerations. The CCAA requires the A/L MDM powered on and dynamically controlling it. METOX regeneration requires the CCAA to be operational.

1.5.8 Flight Anomalies

Multiple telemetry bit errors on the Airlock MDM have been observed. In most cases, an MDM reset is not necessary, unless a lot of errors have occurred. Telemetry bits seem to be reset when powering up the PSA and during battery charging. So far the following bit errors have manifested:

- A/L MDM Card 10, Type DIO, Ch 18 **AL EL DPA EU ON COMMAND**
- A/L MDM Card 10, Type DIO, Ch 19 **AL EL DPA EU OFF COMMAND**
- A/L MDM Card 13, Type LLA, Ch 3 **EVAS AL AA Rack BC #3 Current Monitor** (toggled from alarm and back to normal)
- A/L MDM Card 13, Type LLA, Ch 6 **EVAS AL AA Rack BC #4 Current Monitor** (toggled from alarm and back to normal)
- A/L MDM Card 13, Type LLA Ch 2 **EVAS AL AA PS #1 Current** (toggled) (EMU1)
- A/L MDM Card 13, Type LLA Ch 7 **EVAS AL AA PS #2 Current** (toggled) (EMU2)

1.5.9 Related Documentation References

Airlock Systems 1 CSCI 683H31A SRS Rev G, S683-70743, S. D. Savage

ISS Command and Data Handling Training Manual, CDH TM 21109

ODIN Console Handbook JSC-36332 Vol 1 Rev B, Section 5.7.8

Space Station Program Space Station MDM Standard ICD, SSP 30261

ISS AIRLOCK SYSTEMS		Reference only	
ELEMENT AL	Depress Pump Assembly		PAGE 1

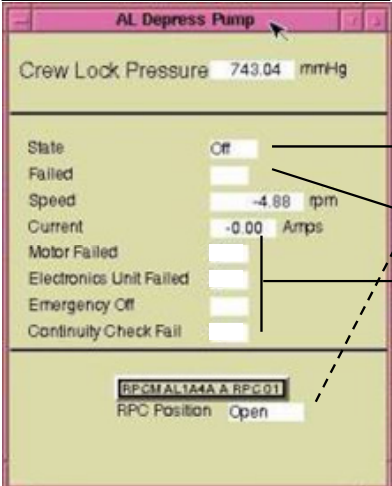

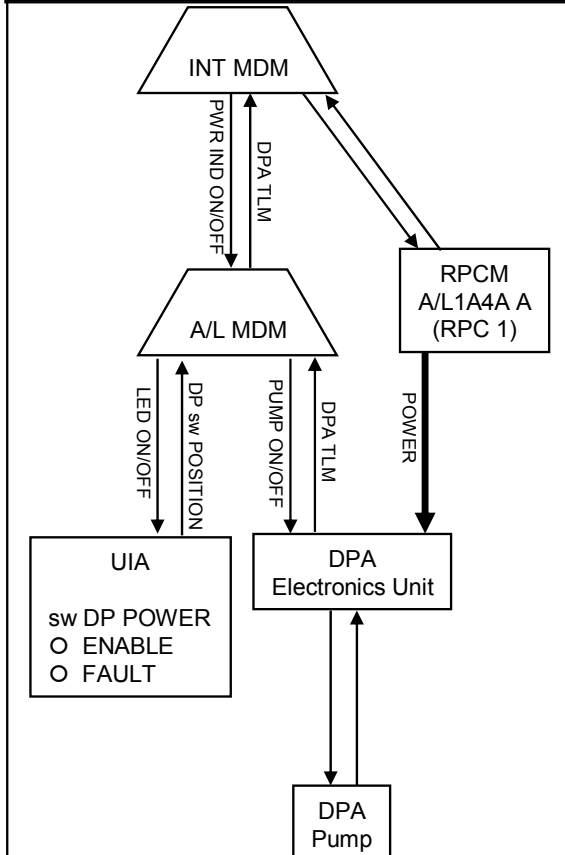
Depress Pump (blue)
AL10F1

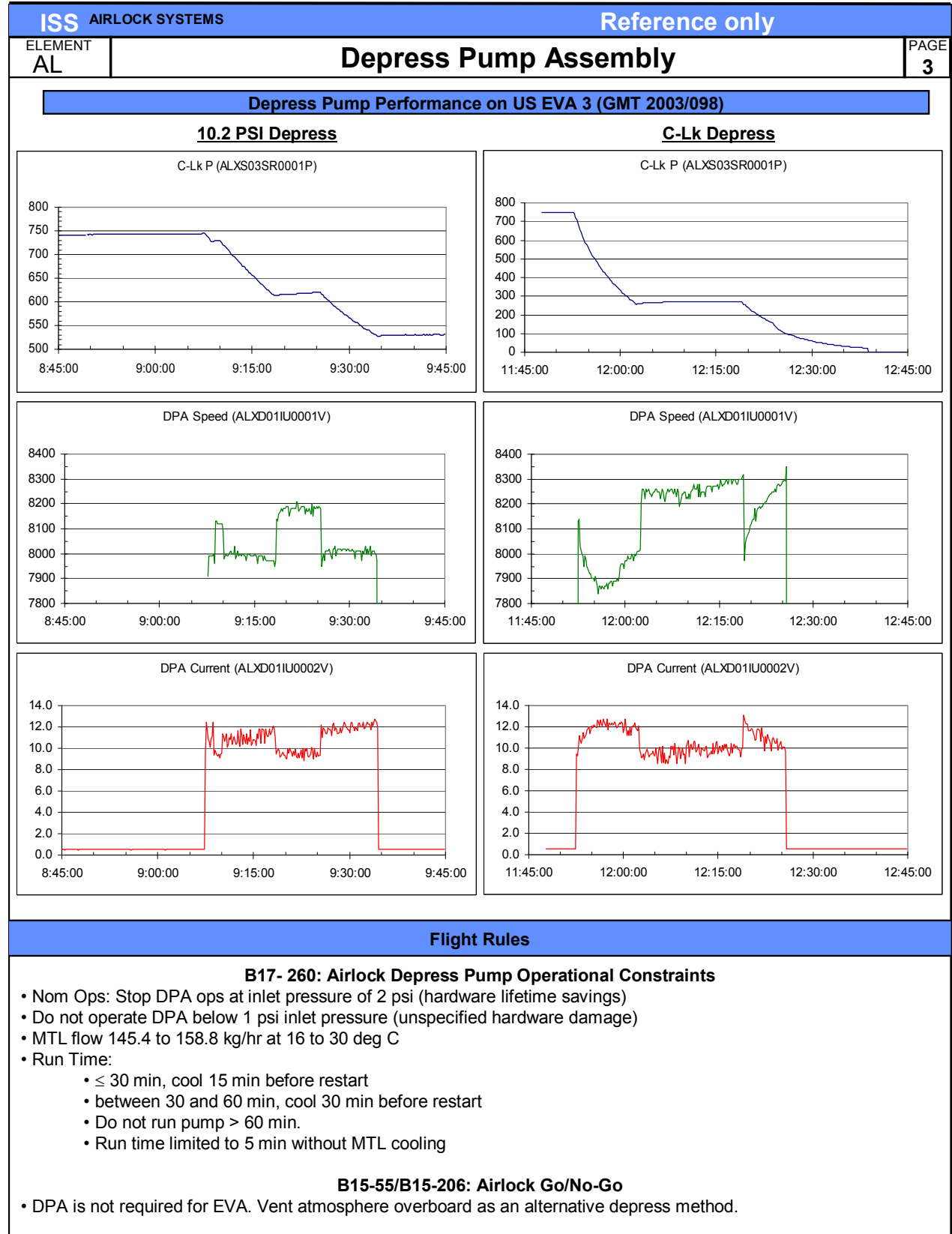
Depress Pump Electronics Unit (black)
AL1F2

Depress Air Hose (clear) to Node 1 Stbd Fwd IMV Duct
NOD1S2

DEPRESS PUMP
MAN ISOV (VL014)
AL1D3

SW DEPRESS PUMP PWR
DEPRESS PUMP FAULT LED
DEPRESS PUMP ENABLE LED
AL1D3

ISS AIRLOCK SYSTEMS		Reference only								
ELEMENT AL	Depress Pump Assembly		PAGE 2							
<div style="background-color: #4a86e8; color: white; padding: 2px; text-align: center; font-weight: bold;">On-Orbit PCS Display</div> 	<div style="background-color: #4a86e8; color: white; padding: 2px; text-align: center; font-weight: bold;">MCC-H MSK Display</div> 	<div style="background-color: #4a86e8; color: white; padding: 2px; text-align: center; font-weight: bold;">Nominal Values During Pump Operation</div> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td>Enable Light – ON</td></tr> <tr><td>Power Switch – ON</td></tr> <tr><td>Current: 9 – 13 A</td></tr> <tr><td>Speed: 7,700 – 8,200 RPM</td></tr> <tr><td>Fault Light – OFF</td></tr> <tr><td>Motor – Blank EU – Blank</td></tr> <tr><td>Emerg – Blank CC – Blank</td></tr> </table>		Enable Light – ON	Power Switch – ON	Current: 9 – 13 A	Speed: 7,700 – 8,200 RPM	Fault Light – OFF	Motor – Blank EU – Blank	Emerg – Blank CC – Blank
Enable Light – ON										
Power Switch – ON										
Current: 9 – 13 A										
Speed: 7,700 – 8,200 RPM										
Fault Light – OFF										
Motor – Blank EU – Blank										
Emerg – Blank CC – Blank										
<div style="background-color: #4a86e8; color: white; padding: 2px; text-align: center; font-weight: bold;">Fault Detection</div> <p>Motor Fail</p> <ul style="list-style-type: none"> • Failure to reach 6000 rpm in 10 seconds • Overtemp (115 °C) • Rotor out of phase with EU pulse signal <p>Electronics Unit Fail</p> <ul style="list-style-type: none"> • Power Interrupt • Overvolt (144.6 V) <p>Emergency Off</p> <ul style="list-style-type: none"> • Overcurrent (27.5 A) <p>Continuity Check</p> <ul style="list-style-type: none"> • Broken electrical path within DPA 	<div style="background-color: #4a86e8; color: white; padding: 2px; text-align: center; font-weight: bold;">DPA CMD/TLM/Power Overview</div> 									
<p>sw DEPRESS PUMP PWR Behavior</p> <ul style="list-style-type: none"> • When A/L MDM senses sw – ON, it issues a PUMP ON cmd to the DPA EU for 1 second in duration. • Conversely, when sw – OFF, a 1-second PUMP OFF cmd is sent to the DPA EU. • Applying power (RPC 01 – CL) with the sw – ON will NOT result in PUMP = ON. 										
<p>References:</p> <ul style="list-style-type: none"> • 00007A2a Depress Pump Assembly Micron-A Technical Description and Operation Manual • S683-70743 Airlock Systems I SRS 										



ISS AIRLOCK SYSTEMS		Reference only	
ELEMENT AL	Depress Pump Assembly		PAGE 4
OCADs			
Hazard Report: ECL-210-11-01.B	Hazard Description: Loss of Atmosphere Due to Depressurization Pump Leakage/Inadvertent Operation/Failure	Operational Control: Upon completion of depressurizing the Crewlock, using the depressurization pump assembly, the manual valve at the Depress pump inlet will be closed to prevent atmospheric leakage path to space.	

1.6 DEPRESS PUMP ASSEMBLY

PURPOSE

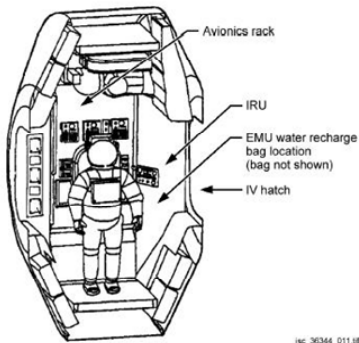
TBD

DESCRIPTION

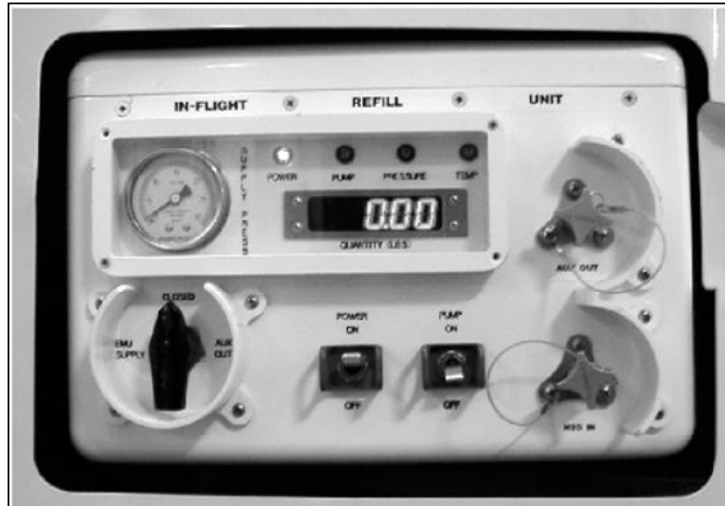
TBD

ISS AIRLOCK SYSTEMS Reference only

ELEMENT AL **In-Flight Refill Unit (IRU)** PAGE 1

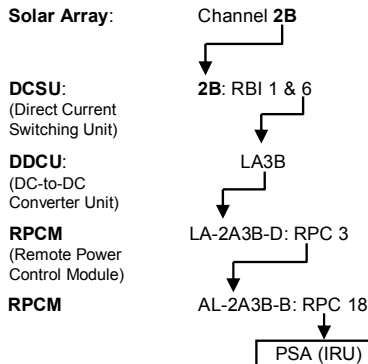


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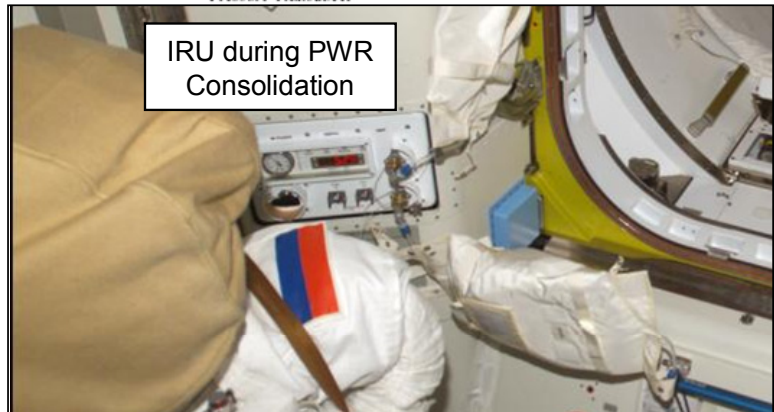
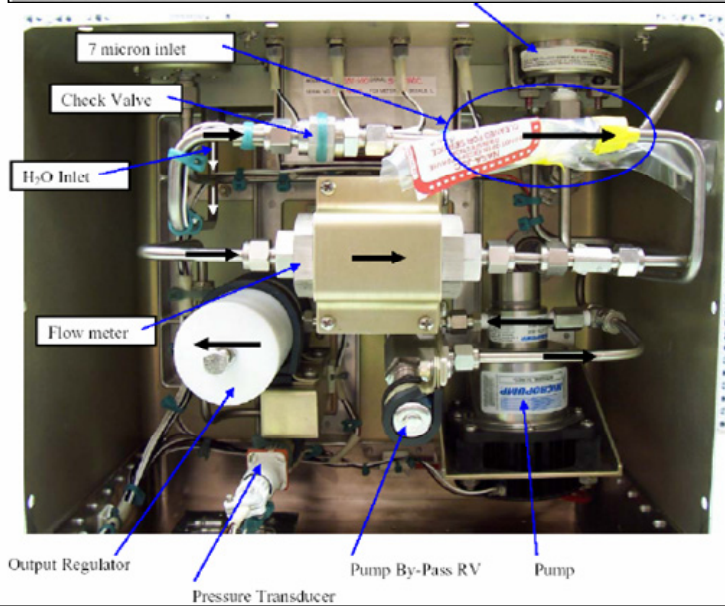
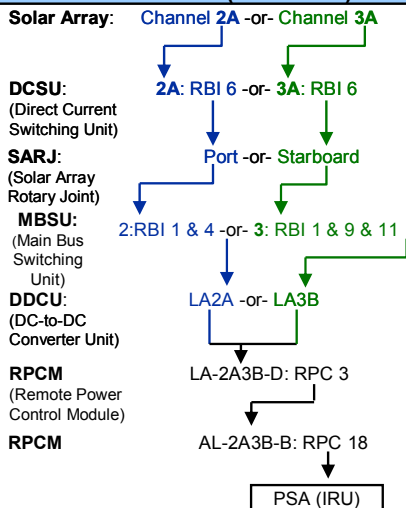


AL1F1 - Avionics Rack
IRU: SEG39128310-303
Engineering Name: Fluid Pumping Unit (FPU)
One spare on-board, stowed behind the avionics rack

POWER PATH



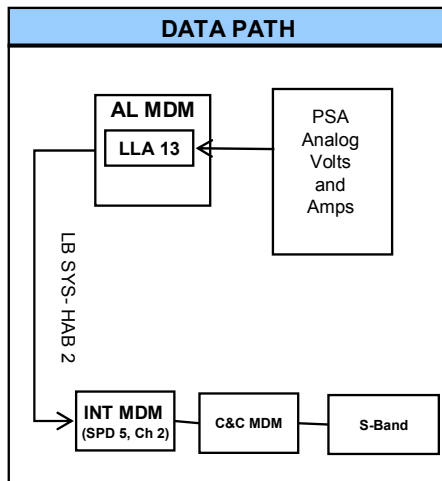
POWER PATH (POST 13A)



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ELEMENT AL	In-Flight Refill Unit (IRU)
	PAGE 2

OPERATING LIMITS		
Limit Conditions	Operating Limits (min/max)	Constraints
Temperature Limits	37°F (2.8°C) / 150°F (65.6 °C)	Qual limits (wet)
Over-temperature Protection	None	LED on front of unit will illuminate if pump-housing temperature reaches 150°F ± 5°F. Pump will continue to operate. Requires crew action to turn off pump.
Pressure Limits	10 psia to 15.2 psia	Operating beyond these limits is possible (so long as there is no danger of freezing the water) but should be evaluated on a case-by-case basis.
Over-pressure Protection (at EMU Supply and AUX Out)	30 psid mechanical 16.9 psig electrical	<ul style="list-style-type: none"> - Pump will bypass through Relief Valve 2 at 15 psid. - Pump will bypass internally through Relief Valve 1 at 30 psid. - Power will automatically be removed from pump if pressure exceeds approximately 16.9 psig. LED will illuminate on front of unit if this event occurs. - The backpressure regulator in the UIA, which will limit pressure to 16.5 ± 0.5 psig, provides additional protection. - External regulator at 15 psig

OPERATIONAL CONSTRAINTS AND NOTES
Do not run pump dry. DO NOT run pump longer than 8 minutes without water.
Low limit on flow meter – Counter will not detect water flow at flow rates less than 0.05 gpm (0.42 lbm/min)
Accuracy of pressure gauge on front of IRU is ± 2.0 psig



MAJOR COMPONENTS
Pump Assembly
Transducer/Regulator Assembly
Flow Meter Assembly
Pressure Gauge (0-30 PSIG)
Inlet Filter (7 Micron)
Check Valve
Pump By-Pass Relief Valve Proportional

AL MDM CHANNELS		
Card	Ch #	Data
LLA 13	16	PSA IRU/Utility Volts
	19	PSA IRU/Utility Amps

ISS AIRLOCK SYSTEMS		Reference only	
ELEMENT AL	In-Flight Refill Unit (IRU)		PAGE 3
Related Documentation References			
<ul style="list-style-type: none"> 1. SPCE Operating Limits and Constraint Sheets, EVA-EV-1272, 12/10/2004 2. ISSH Airlock In-Flight Refill Unit (IRU), Dwg No 12.8 3. In-Flight Refill Unit SAR Report; LMSO-P104967, April 1999 4. Project Technical Requirements Specification for the Payload Water Reservoir (PWR), CTSD-SS-2350, February 2001 5. In-Flight Refill Unit FMEA/CIL Report; P104966, May 1998 			
OCADS			
	Hazard Number	Hazard Description	Operational Control
1.	SPCE-IRU-001, Cause 4, Control b	Crew Induced Loads	In the event that a leak occurs from the IRU a crewmember is present during normal operating procedures and will turn off the pump.
2.	SPCE-IRU-009, Cause 1, Control b	Inadequate design of FPU	In the event that the pump temperature indicator (LED on front panel) is activated the crew is advised to turn off the power to the FPU to avoid touch temperature concerns and damaging the pump.
3.	SPCE-IRU-011, Cause 2, Control b	Overpressurization of IRU	In the event that a failure occurs within the ISS or Orbiter galley, the crew will be monitoring the charging of the Payload Water Reservoir (CWR) and disconnect the QD from the ISS or Orbiter outlet port to prevent overpressurization of the CWR. At a nominal inlet flow rate from the galley to the CWR of 60 lbm/hr the CWR will fill in approximately 28 minutes. The CWR will hold approximately 3 gallons of water (~25 lbm).

1.7 IN-FLIGHT REFILL UNIT (IRU)

1.7.1 General Description

The In-Flight Refill Unit (IRU) is used to pump water from a Payload Water Reservoir (PWR) into the EMU, to fill or “recharge” the feedwater tanks, via the Umbilical Interface Assembly (UIA) and the Service and Cooling Umbilical (SCU). The entire IRU is an On-Orbit Replaceable Unit (ORU). The IRU faceplate is shown in Figure 1.7-1.



Figure 1.7-1. IRU faceplate

1.7.2 Location and Structure

Location

The IRU is mounted to the Equipment Lock (E/L) wall between the Avionics Rack and the IV hatch. Refer to Figure 1.7-2 for the location of the IRU.

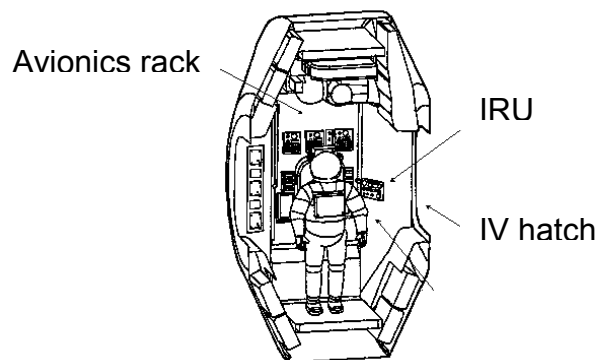


Figure 1.7-2. IRU Location

There are eight 3/16 in. hex captive screws that attach the IRU to the airlock structure. The water line interface between the IRU and the UIA is through a Gamah fitting. The electrical interface between the IRU and the PSA is through a 28-volt electrical connector from the PSA.

1.7.3 Quick Look Reference Data

Table 1.7-1 details the specifications for the IRU ORU.

Table 1.7-1. IRU ORU specifications

Description	Specification	Comments
Part Number	SEG39128310-303	
Dimensions	14.2in.W by 10.8in.H by 13.4in.T	
Weight (dry)	30.0 lb	
Pump	500 RPM Flow rate: 60lb/hr	Magnetically coupled gear pump
Pressure regulator	Regulation pressure: 15 psid	15 psid across the regulator
Relief valve	Cracking pressure: 15.5 psid Reseat pressure: 15 psid	15 psid across the valve
Power	28 V dc	Supplied by PSA
Connector interfaces	Fluid (water to UIA): Gamah fitting Power: Generic ISS electrical connector	Gamah connectors are not self-sealing
Kick bump loads	125 lb	Quasi-static load, concentrated area, any direction
Thermal limits	+40° F to +150° F +55° F to +109° F	Non-operational limits Operational limits
Location	In the E/L between the Avionics Rack and IV hatch	One spare on orbit, stowed behind closeout in Avionics Rack

1.7.4 Subsystem Details

1.7.4.1 Operation

The IRU contains a pump and a pressure regulator that are used to transfer water at a supply pressure of 15 psid relative to E/L atmospheric pressure. The crew's main interface is the IRU faceplate, which contains a power switch, a pump switch, a rotary output valve, a supply pressure gauge, LEDs, quantity display, an outlet port, and an inlet port. The only telemetry is the amps and volts supplied from the PSA to the IRU. The IRU is not to be run with a dry PWR connected. Reference Figure 1.7-3 for a simplified view of fluid flow paths and electrical supply.

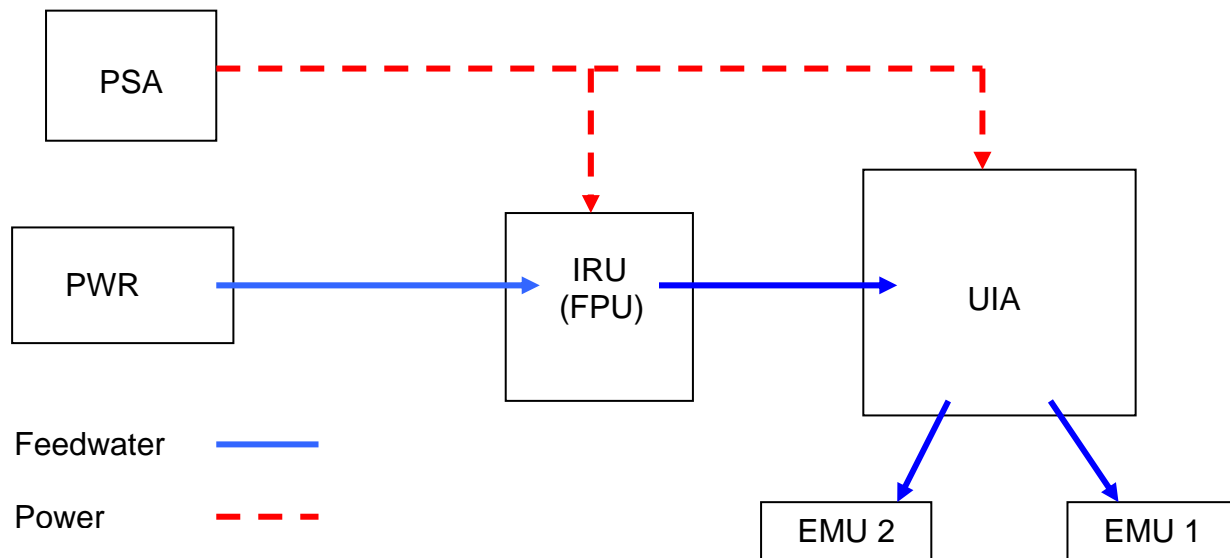


Figure 1.7-3. IRU fluid flow and electrical supply diagram

1.7.4.2 POWER and PUMP Switches

The POWER switch activates the IRU via power supplied from the PSA. The PUMP switch activates the IRU pump. Both switches have two positions, either ON or OFF.

H2O Outlet Valve (Rotary)

The H2O outlet valve is a three-position rotary switch. The EMU SUPPLY position opens the fluid path between the IRU pump outlet and the UIA. The CLOSED position simply closes all fluid paths. The AUX OUT position allows fluid to flow from the IRU pump outlet to the AUX OUT port. The rotary dial has hard stops at the EMU SUPPLY and AUX OUT positions. For the CLOSED position, the dial must line up with the labels; there is not a hard stop.

H2O IN and AUX OUT ports

The H2O IN and Aux OUT ports on the IRU faceplate attach to the quick disconnect at the end of the PWR hose (see Figure 1.7-5 and Figure 1.7-6). The AUX OUT port can be used to pump water between two PWRs. A tethered cap protects each port.

Light Emitting Diodes (LEDs)

There are four LEDs on the IRU: Power, Pump, Pressure, and Temperature. When the IRU is powered, the Power, Pressure, and Temperature LEDs illuminate for 2.5 seconds to verify LED operation. The pump LED only illuminates during nominal operations to indicate the pump is on.

Table 1.7-2. IRU LED operation

LED	Illuminated color	Condition for illumination
Power	Green	<ul style="list-style-type: none"> • Nominal operation; indicates IRU is powered
Pump	Green	<ul style="list-style-type: none"> • Nominal operation; power to pump enabled
Pressure	Yellow	<ul style="list-style-type: none"> • Overpressure: >15.5 psi downstream of IRU pressure regulator • Automatic shutdown of pump <ul style="list-style-type: none"> ○ Prevents overpressurization of EMU feedwater tanks • Remains illuminated until power is removed from IRU
Temperature	Yellow	<ul style="list-style-type: none"> • Overtemperature: Motor temperature > 60° C (140° F) • Condition does not shut the pump down <ul style="list-style-type: none"> ○ Requires manual shutdown • Remains illuminated until power is removed from IRU

Supply Pressure Gauge/IRU Display Quantity/EMU H2O WP

The Supply Pressure Gauge indicates the pressure of the water being pumped into the EMU in psid. The gauge has a range of 0 to 30 psi and an accuracy of ± 2 psig.

The IRU Quantity Display indicates the amount of water pumped from the PWR into the EMUs (displayed as XX.XX pounds). The Quantity Display receives the quantity input from a flow meter upstream of the supply pressure gauge.

Figure 1.7-4 shows IRU ground test data obtained in August 2000 for EMU water recharge. The data shows IRU Supply Pressure and EMU H2O/WP on the left Y axis and should not be referenced to the “lbs Actual” and “lbs IRU” data. The right Y axis shows the actual water quantity versus IRU displayed quantity (IRU flowmeter) during ground tests and should not be referenced to the “IRU Supply P” and “EMU H2O/WP” data.

In Figure 1.7-4, the “lbs Actual” and “lbs IRU” show that the flow meter display may be inaccurate when there is low flow. For example, the EMU feedwater bladders may still be expanding, but the flow of the water is too slow for the gauge to sense a change in the flow rate. This is indicated by the change in data points at ~12 minutes. The “lbs Actual” terminates with a value of ~18 lb while the “lbs IRU” terminates indicating ~17 lb.

In Figure 1.7-4, the “EMU 1 H2O/WP” and “EMU 2 H2O/WP” start off indicating ~0 psi depending on the residual pressure left in the feedwater bladders. The pressure will increase sharply over the first 5 minutes to ~2 psi where it levels off and increases only slightly for the next 5 minutes. Then, from 10 to 15 minutes, there is a sharp increase in pressure to ~13 psi, and then a gradual increase to ~14 psi over the final 10 minutes.

The IRU pump tries to maintain a pressure of ~15 psid. As shown in Figure 1.7-4, the “IRU Supply P” data shows initial supply pressure starting at ~11 psi for the first 10 minutes since the feedwater bags range from empty to half full and are providing little backpressure. From 10 to 15 minutes, there is a sharp increase to ~15 psi. This is due to higher backpressure from the feedwater bladders as they continue to be filled to capacity.

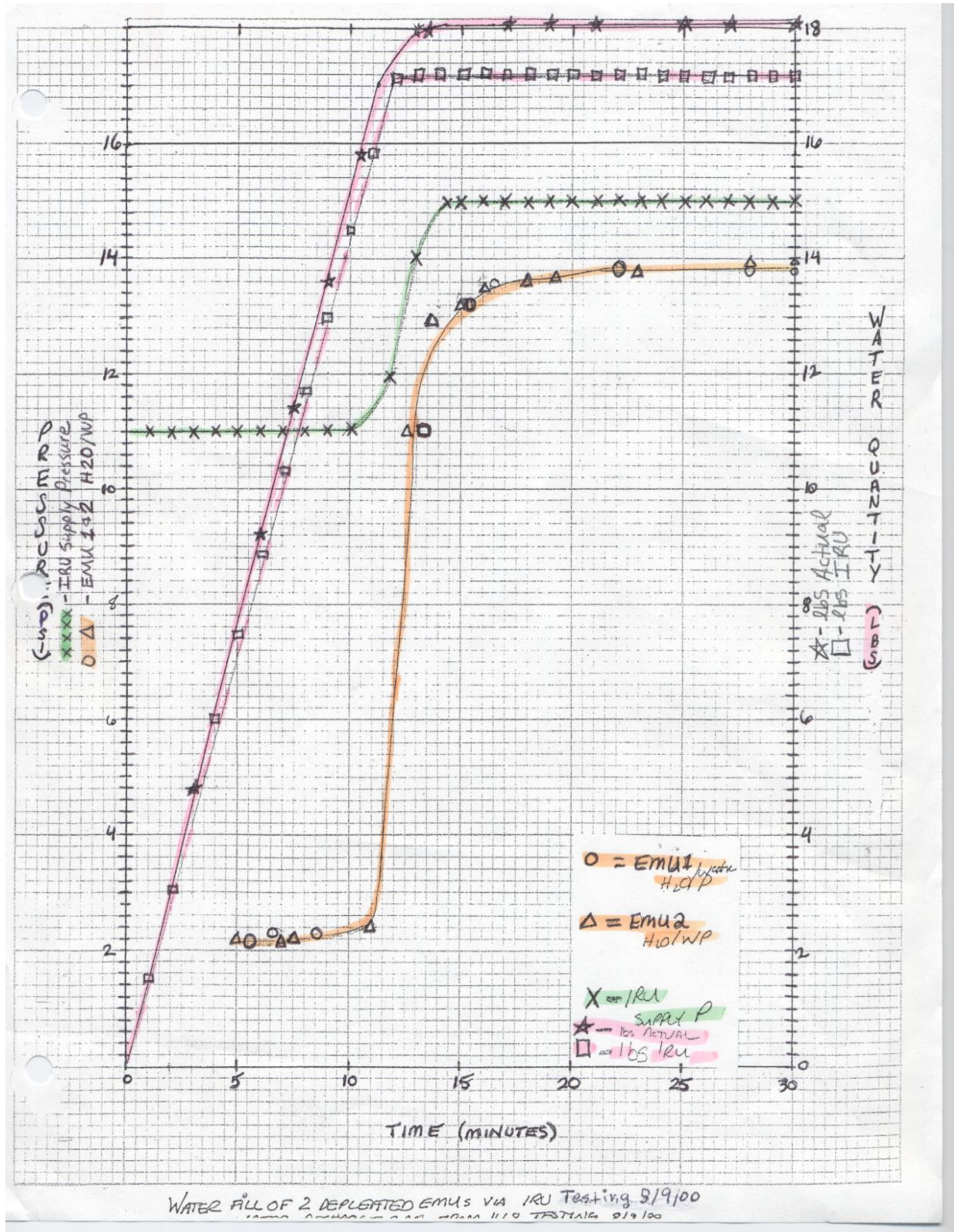


Figure 1.7-4. IRU ground test data

1.7.4.3 Electrical Power

Power is supplied to the IRU at 28 volts from the PSA, and is powered through RPCM AL2A3B B. The IRU draws 0.25 amps when the pump is activated. Overvoltage and overcurrent protection is provided by the PSA. Overcurrent protection to the IRU and the PSA utility power outlet combined is set at 7.8 amps.

1.7.4.4 Payload Water Reservoir (EMU Water Recharge Bag)

The PWR is a soft container used for the storage and transfer of fluid. For EVA purposes, it is used for transfer and storage of iodinated potable water for the charging of EMUs, and can be referred to as the EMU Water Recharge Bag. PWRs are also used for the transport to orbit and short term storage of Internal Active Thermal Control System (IATCS) resupply fluid.

PWR contents are identified by color-coded labels according to the type of fluid held in containment. For EMU purposes, the PWR has a white label.

PWRs replace the need for a potable water line plumbed to the Joint Airlock. The bags are filled from the orbiter galley. Water is currently certified to be stored and used in the EMUs for a maximum of 1070 days. The Russian galley cannot be used to fill these bags because Russian water contains a silver-based biocide, which is not certified for use in the EMU.

Table 1.7-3. Payload water reservoir specifications

Description	Specification
Bag dimensions: Expanded Collapsed	32 in by 18 in by 8 in 32 in by 18 in by 4 in
Weight (dry):	3.0 lb
Nominal capacity:	22.0 lb
Proof pressure	15 psid for 3 minutes
Burst pressure	25 psid for 5 minutes
Iodine compatibility	4.0 ± .05 ppm iodine for 3 months
Operating temperature	35° to 115° F This includes the surrounding air temperature and internal water temperature

The PWR consists of an outer restraint and an inner bladder. The restraint is primarily made from Nomex fabric and Nomex reinforced webbing, and is designed to provide protection against inadvertent external bumps, structurally contain any internal pressure forces, and contain various crew interface features such as handles, Velcro soft stowage, and labeling. The bladder is made from a thin, clear material, Teflon Front-End Processor (FEP), chosen for its compatibility with a large number of different fluids. The restraint is purposely made slightly smaller than the bladder so that under pressure the restraint will take the pressure load before the bladder does.

The only on-orbit fluid interface on the PWR is a 1/4-inch female Symetrics QD, located at one end of the PWR. This QD connection is the same for all PWRs, if it is used for EMU or IATCS recharging. At the opposite end of the PWR there is an outlet port with a plug that can be opened during ground processing. The outlet port is also used on-orbit during the PWR degas procedure to remove gas bubbles from the water prior to EMU water recharge. For soft-stowage while on orbit, there are 2-inch square pieces of Velcro on the PWR at various places. Crew interfaces include two handles and two adjustable straps. Refer to Figure 1.7-5 and Figure 1.7-6 for drawings and pictures of the PWR and to Section 1.1, EVA Water Systems, for more information regarding PWR usage.

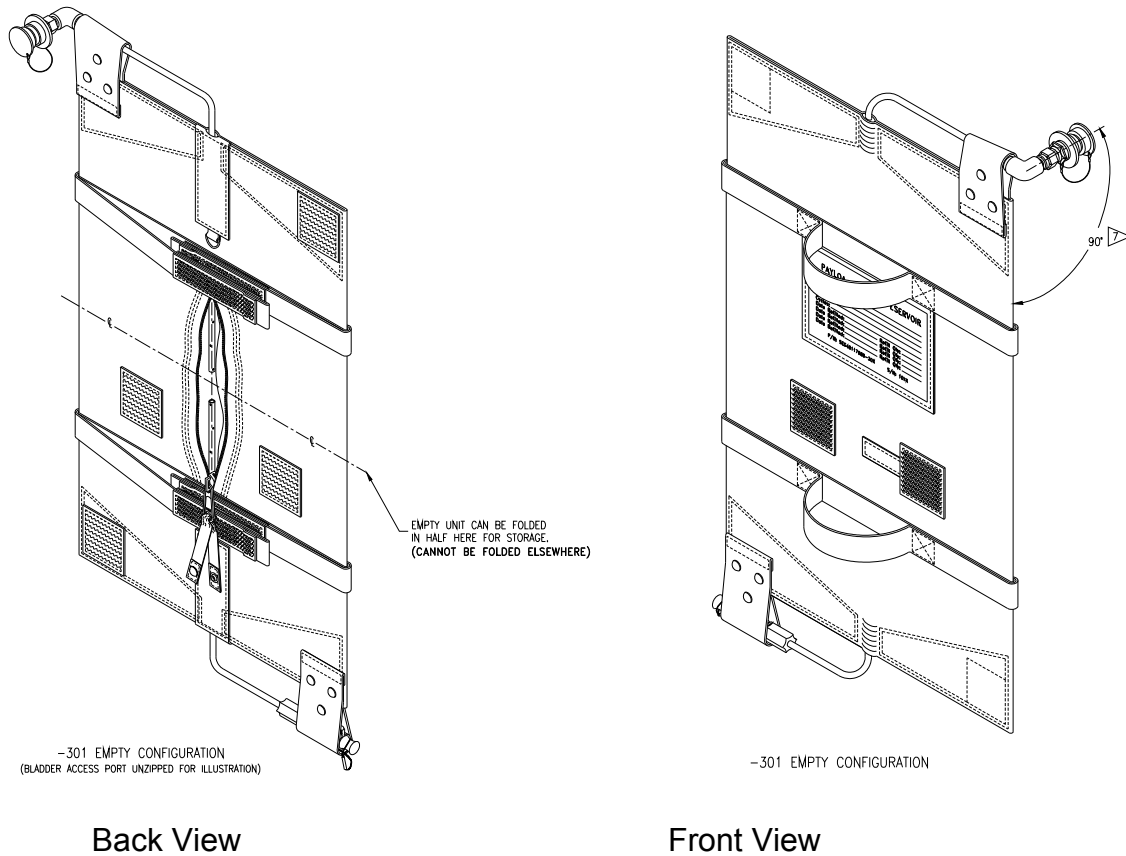


Figure 1.7-5. Collapsed PWR drawing



Figure 1.7-6. On-orbit payload water reservoir

1.7.5 System History

Test Data

During the EMI testing, the IRU flow meter counter exhibited susceptibility to induced electric fields at the following frequencies:

- 42.72 MHz to 56.38 MHz
- 222.266 MHz
- 361.86 MHz to 558.00 MHz

During this test, the IRU appeared to maintain flow but the counter stopped functioning. Additionally, the pump overtemperature indicator exhibited susceptibility at 278.15 MHz. At this frequency, the temp indicator light came on, even though an overtemperature condition was not present. The IRU is certified to operate at pressures ranging from 10.0 to 15.2 psia at a maximum PPO₂ of 3.35 psia. It is also certified to operate nominally after exposure to pressures as low as 5.5 by 10⁻¹² psia at a maximum pressure change rate of ± 1 psi/second. Based on a detailed analysis of the environment, there is a margin of 14 decibels (dB) from ground-based transmitters and the IRU has a 10 dB margin with respect to on-board transmitters (e.g., EMU radios). The frequencies listed above do not pose any interference risk at the current time with regard to induced electric fields that may be present on ISS; therefore, no operational workarounds or keep-out zone flight rules are required.

1.7.6 Related Documentation References

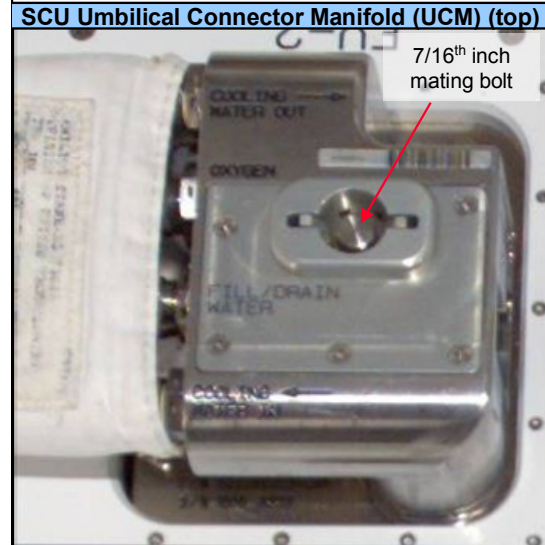
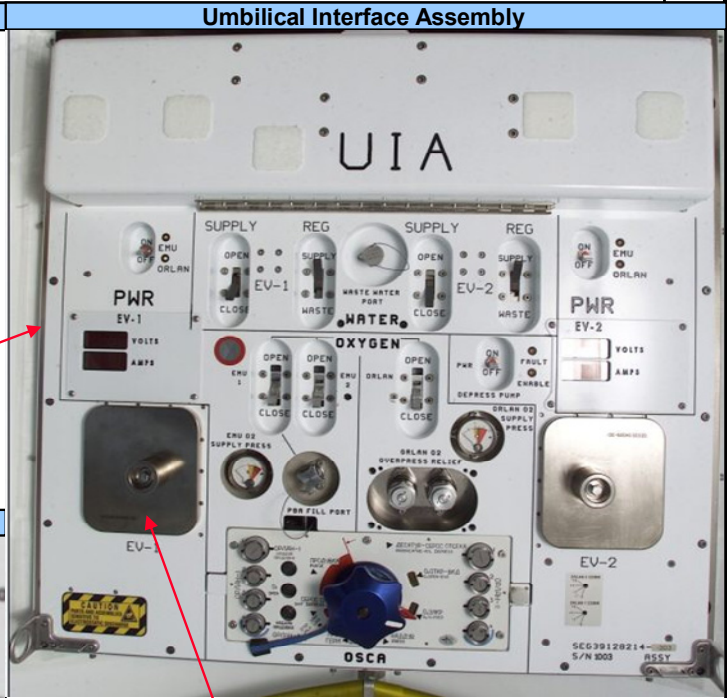
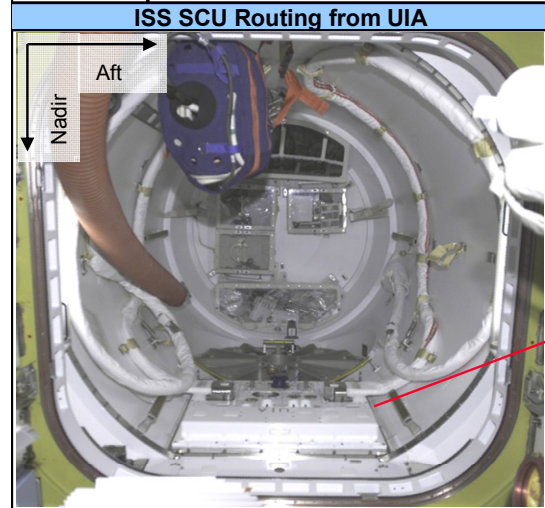
In-Flight Refill Unit FMEA/CIL Report; P104966, May 1998

In-Flight Refill Unit SAR Report; LMSO-P104967, April 1999

ISS Joint Airlock Systems Training Manual, Joint Airlock 21002, April 2001

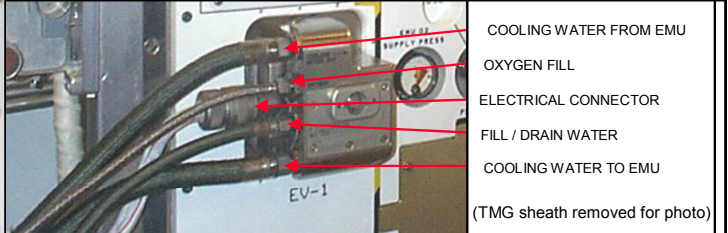
Project Technical Requirements Specification for the Payload Water Reservoir (PWR),
CTSD-SS-2350, February 2001

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ELEMENT AL	Umbilical Interface Assembly (UIA)		PAGE 1



UCB Connector Cover
(Prime UIA Launched & Spare UIA Config.)

SCU UCM connected to Umbilical Interface Assembly (UIA)



UIA and Related Part Numbers

UIA	SEG39128214-303 • Prime S/N 1003 • Spare S/N 1002	<u>Location:</u> Crewlock AL1F1 behind Avionics Rack closeout
Displays and Electronics powered by:	PSA	
Biocide Filter	SEG39128318-303	
OSCA		

ISS AIRLOCK SYSTEMS		Reference only
ELEMENT AL	Umbilical Interface Assembly (UIA)	
		PAGE 2
Description	Specification	Comments
Drawing Number:	SEG39128214-303	Lockheed Martin/Sustaining engineering ONE EVA
Operating & Survival Limits: Temperature Pressure	40-140 deg F Vacuum – 15.2 psia	Survival: Water lines must be drained if temperature approaches 32 deg F, else remove UIA from Crewlock or activate Crewlock shell heaters.
Input Over Current Protection: UIA Displays and Electronics	1.0 amps max	Over current protection provided by PSA. In this event, a PSA fault will not occur.
Output Voltage - EMU Supply	18.5 ± 0.5 Vdc	Supplied by PSA
Over-voltage Protection - EMU Supply	22 Vdc max	Function provided by PSA. PSA shutdown for each EMU channel was measured at 21.38 and 21.5 Vdc.
Output Current - EMU Supply	7.5 amps max	Supplied by PSA
Over-current Protection - EMU Supply	10.5 ± 0.5 amps	Function provided by PSA. PSA shutdown for each EMU channel was measured to be 10.2 and 10.32 amps.
UIA Interfaces		
UIA SCU Interfaces: UIA O2 Supply to SCU: UIA feedwater to/from SCU: UIA cooling water to/from SCU : UIA Electrical connector: 7/16 inch mating bolt:	1/4 in. Symetrics connector 1/4 in. Symetrics connector 1/2 in. Symetrics connectors 50 pin D-connector	•SCU UCM pins mate to UIA Umbilical Connector Block (UCB) floating connector sockets. Note: UCB connector housing seal/o-ring ensures proper electrical connector alignment. •Mating bolt requires 7/16" wobble socket (located: IV Bag) to engage locking tangs for removal/installation
UCM Mate/Demate:	verify O2 circuit vented (via OSCA)	Required to maintain o-ring integrity of the SCU O2 QD
OSCA Interfaces:	4 Orlan Umbilical hoses per suit	OSCA caps must be removed before mating hoses
PBA Fill Port:	verify O2 circuit vented (via OSCA)	Not currently used but Required to maintain o-ring integrity of the PBA mating O2 QD
UIA Operational Constraints		
Description	Operational Constraint	Comments
EMU Power Transition from SCU to BATT	Stagger EMU switch throws	Prevents inadvertent shutdown of PSA EMU power channel
SCU mate/demate	Verify EMU power is in BATT and UIA PWR is OFF before SCU mate/demate	Prevents hot mate/demate
Tethering Protocol	Only a single EV crewmember can be tethered to the UIA	Load limited to 200 Lbf due to UIA support structure bond strength with the Crewlock wall
Hardline Communication	PSA Power is required to activate UIA hardline communication electronics	
MAJOR COMPONENTS		
Biocide Filter Assembly	Umbilical Connector Block (UCB) Assembly	H2O Backpressure Regulator
O2 Manual Isolation Valve Assembly	O2 Regulator (Orlan)	EMU & Orlan O2 Pressure Gauge
Pressure Transducer Airlock	O2 Relief Valve Assembly	H2O Valve Assembly
Depress Pump Control & Status	Power Controls	Signal Conditioning, Displays & Power Status
Communications	Electrical Harness	

1.8 UMBILICAL INTERFACE ASSEMBLY

1.8.1 Quick-Look Reference Data

Table 1.8-1. UIA specifications

Description	Specification	Comments
Drawing: UIA OSCA Biocide Filter Assy	SEG39128214 2AK-7822-8100-01 SEG39128318	Lockheed Martin design RSA drawing number Lockheed Martin housing w/Hamilton Sundstrand bacteria filter and cartridge -303's installed in prime UIA, two -301's in back-up UIA + 2 spare -303's available
Dimensions: UIA OSCA Biocide Filter Assy	30 in. W x 30 in. H by 5.375 in. T * TBD 1.75 in dia by 7.65 in L	* Panel thicknesses do not include protrusions from panel surface plane (i.e., access door, tether rings, OSCA control knob, etc.)
Weight (dry): UIA OSCA Biocide Filter Assy	84.0 lb max 7 lb max 2.7 lb max	Includes OSCA and 2 Biocide Filters Each filter certified for 520 lbs H ₂ O, maintaining iodine concentrations from 1 to 4 ppm
Regulation Pressure: Oxygen Condensate Drain	900 ± 50 psia 16.5 psig	Airlock Hi-Pressure O ₂ Regulator supply pressure band 1 lb/hr min flow from the EMU (Also, manual drain capability @ 60 lb/hr min for 2 EMUs)
Connector Interfaces: (UIA to A/L) UIA-to-A/L O2 Supply UIA-to-A/L Feedwater/ Wastewater UIA-to-A/L Cooling Loop	3/8 in. Gamah connector P/N U14704-49 (UIA) 3/8 in. Gamah connector P/N U14705-43 (UIA) 3/8 in. Gamah connector P/N U14705-43 (UIA)	Note: Gamah connectors are not self- sealing. (Unlike QDs, it screws on to seal. Also, it needs a cap to close off.) Airlock side Gamah connector P/N NFA14704-AA-49 Airlock side Gamah connector P/N NFA14705-AA-48 Airlock side Gamah connector P/N NFA14705-AA-48
Connector Interfaces: (UIA/UCB side) O2 UCB to UCM Feedwater Cooling Electrical Connector	¼ in Symetrics QD ¼ in Symetrics QD ½ in Symetrics QD D-Sub connector - 50 receptacles	UCB connector: P/N 565606-T04G P/N 565606-T04W P/N 565606-T0906W NASA311P409-5S-B-12 (Amp P/N AMP206805-2)
Thermal Environment	+40 to +90 deg F +40 to +150 deg F	Operational Nonoperational

1.8.2 General Description

The Umbilical Interface Assembly (Figure 1.8-1) is the interface between the vehicle (Airlock) and the Extravehicular Mobility Unit (EMU)/Orlan-M space suits for transfer of hardline communications, power, and fluids from the Airlock to the suits via their respective umbilicals. The UIA includes controls and displays necessary for servicing the EMUs after an EVA, and for supporting egress and ingress activities for both the EMU and the Orlan-M spacesuits including pre-breathe. The UIA can support the operation of two EMUs, two Orlan-M space suits, or one of each. The UIA also houses the control and status indicators for operation of the Airlock depressurization pump and a pressure sensor for monitoring Crewlock absolute pressure. The UIA includes provisions for permanently mounting or installing the Russian-provided Onboard Spacesuit Control Assembly (OSCA), which controls oxygen to the Orlan-M. The OSCA is currently mounted on the UIA. The entire UIA is an Orbital Replaceable Unit (ORU). The OSCA is also designed as an ORU but there are no spares on-orbit. The UIA's two water biocide filter assemblies are limited-life items and are designed for easy replacement. No other lower-level breakdowns are needed for on-orbit maintenance.



Figure 1.8-1. Umbilical interface assembly

1.8.3 Subsystem Detail

1.8.3.1 Location

The prime UIA is located on the nadir side of the Crewlock port of the EV hatch. This location allows the EV crewmembers to control consumable flow through the Service and Cooling Umbilicals (SCUs) during all phases of EVA operations. The SCU is routed from the UIA through the IV hatch during EVA preparation and post-EVA maintenance activities, which are nominally performed in the Equipment Lock (E/L). One spare UIA is stowed in the E/L behind the Avionics rack (A/L1F1) closeout panel (see Figure 1.8-2). This back-up UIA provides ORU capability for the prime unit and also permits contingency operation in the E/L at vacuum in the event of a failed EV hatch seal. In preparation for using the E/L at vacuum, the back-up UIA is installed for this contingency operation at the tether staging area with closeout panel A/L1D2 removed.



Figure 1.8-2. Back-up UIA installed

1.8.3.2 Structure

The UIA panel is 30 in. by 30 in. and has a radius on the backside that conforms to the Crewlock wall, yielding a maximum thickness of 5.375 in. The piano-hinged access door on the upper portion of the UIA (reference Figure 1.8-1) protrudes 2.700 in. from the panel surface and opens to allow access to biocide filters, to fluid loop Gamah connectors, and to electrical J-connectors. The UIA is attached via 20 captive 1-inch long, hex-head screws (0.190-32UNF-3A) to a mounting bracket, which is in turn bonded to the Crewlock wall. Two tether rings are mounted to the lower corners of the panel; each ring is rated to 200 lbf; however, operational limits of these tether rings (UIA mounting bracket bond strength) permit only one EV crewmember to be tethered to the UIA at a time.

1.8.4 Oxygen Control

The UIA is connected to the Airlock's oxygen supply line via a single 3/8-inch Gamah connector. The Airlock's high-pressure oxygen tanks and regulators supply oxygen at 900 + 50 psi to the UIA for filling the EMU primary oxygen tanks and for crewmember metabolic use during suited operations while connected to the SCU. A pressure gauge indicates oxygen pressure upstream of the two UIA EMU oxygen shutoff valves and will read approximately within the green dial indicator range within this regulation band, if operating nominally. A Portable Breathing Apparatus (PBA) fill port is located next to the EMU supply pressure gauge. This port was originally included as a means to refill rechargeable PBA bottles after being used for EMU prebreathe; however, the design was rejected in favor of the Prebreathe Hose Assembly (PHA), therefore this port is no longer needed or used.

Controllers and Valves

Three manual shutoff valves control O₂ flow through the UIA to the respective spacesuit. A separate valve controls flow to each EMU SCU, no further controls are located in the flowpath prior to O₂ entering the SCU. Once the EMU oxygen shutoff valves are opened, oxygen then flows through each SCU to recharge the primary EMU oxygen tanks. Minimum O₂ flow rate to each EMU is 5 lbs/hour (at 800 psig supply pressure), restricted by an orifice in the SCU Umbilical Connector Manifold (UCM). The Airlock's high-pressure supply regulator (900 psi) also provides over-pressure protection to 1050 psia maximum (to the EMUs).

A single manual shutoff valve is opened to provide O₂ flow through two Orlan oxygen pressure regulators that step down the 900 psi supply to 70 ± 5 psi supply to the OSCA. The OSCA provides further O₂ flow controls for Orlan prebreathe and interfaces with the Orlan's SCU O₂ lines. The UIA contains two relief valves (located between the oxygen regulators and the OSCA) that open at 110 psid to protect the OSCA/Orlans from overpressurization if the UIA's Orlan O₂ pressure regulators fail. The OSCA also provides the capability to vent the UIA's oxygen system, which is required for EMU SCU mate and demate operations.

1.8.5 Feedwater Control

A separate feedwater supply shutoff valve allows feedwater supply from the In-Flight Refill Unit (IRU) to each EMU via the SCUs. A biocide filter in the UIA feedwater path introduces 1.0 to 4.0 ppm iodine to prevent bacteria growth in the EMU. Refer to Section 1.1 EVA Water Systems for details on EMU and Airlock water servicing.

1.8.6 Wastewater Control

The UIA supports a condensate drain overflow at a minimum of 1 lb/hr at 16.5 psig upstream pressure (suit side). Manual drain capability of 30 lb/hr minimum is maintained (60 lb/hr minimum for 2 EMUs) at 8.0 psig EMU supply pressure. Waste water from each EMU passes through a waste line biocide filter that adds 1.0 to 4.0 ppm iodine to the drain water effluent. This biocide filter prevents bacteria growth through the wastewater system to the EMU. Refer to Section 1.1 EVA Water Systems for details on EMU and Airlock water servicing.

1.8.7 Spacesuit Cooling Water Control

The UIA is a simple pass-through for the spacesuit cooling water loops. During EVA preparation activities, the spacesuit's water pump circulates cooling water from the Airlock's isolating heat exchanger to provide EVA crewmember cooling. The UIA cooling loop plumbing is specified to cause less than a .04 psid drop per loop, at 198.4 lbm/hr per EMU. These loops were launched dry and the EMUs provided fill (de-gassing) capability with iodinated water during STS-104 (7A). Note: the Airlock heat exchanger has a failure mode such that leakage from the primary LTL could potentially introduce 100 psi water into the EMU cooling circuit. For this reason, the SCUs are nominally disconnected from the EMUs.

Cooling Line Flushing

Orlan EVAs from the Joint Airlock are not being considered; however, should Orlan EVAs be required, the following scenario comes into play.

Due to an incompatibility of the EMU with the Orlan silver biocide (silver reacts w/iodine to form silver iodide precipitate that can clog EMU filters), the cooling loop lines must be flushed between Orlan use and EMU use of the Joint Airlock. This flushing process involves disconnecting the Orlan SCUs from the UIA Umbilical Connector Blocks (UCBs) and connecting the flushing fixture to both UCBs and the Waste Water Port. The UIA and IRU are then configured to flow a given quantity of iodinated water through the cooling loops via the flushing fixture (note, flight hardware is currently not available for flushing the suit cooling loops). The silver/iodine water mixture is then routed to the waste water system for reclamation, after which the flushing fixture is removed and the EMU SCUs are connected to the UIA for subsequent use.

1.8.8 Electrical

Power to either EMUs or Orlans is routed from the PSA through the UIA to the SCU. A floating 50 pin D connector (socket receptacles) on the UCB is common to both EMUs and Orlans, but each suit's SCU has different socket combinations dedicated to a specific PSA channel (i.e., precluding inadvertent powering of the EMU via an Orlan circuit). The backup UIA has two cover plates installed to protect the UCB connectors and fluid QDs.

The floating feature of the UCB connector housing provides exact SCU connector pin alignment during SCU mating operations. Therefore, the o-ring environmental seal surrounding the UCB connector housing must be inspected prior to installing an SCU. Prior to launch, these o-rings were replaced (on both the Prime and Back-up UIAs) as cracks were observed where this o-ring bends around each corner of the connector housing. A damaged or missing o-ring could prevent proper engagement of this electrical connector. The SCU (UCM) and UCB connectors were precisely aligned on the ground, so loosening either of these connectors on-orbit is not permitted.

1.8.9 Hardline Communications

During end-to-end testing at Marshall Space Flight Center (MSFC), the EMU Audio Control Panel (ACP) was determined to be incompatible with the EMU hardline signal (it was designed to an outdated EMU ICD with EVC vs. SSER interface requirements). A circuit was subsequently added to the UIA to provide EMU hardline communication with the EACP. The PSA must therefore be powered on to enable EMU hardline audio communication.

Two Orlan hardline communications volume controls are located on the UIA adjacent to the OSCA (refer to Figure 1.8-2). The volume controls (rheostats) are controlled by inserting a screwdriver through the access holes and adjusting the signal level appropriately.

1.8.10 Depress Pump

The Depress Pump is operated by the depress pump power switch. The switch is enabled by closing RPC 1 of RPCM AL1A4A via PCS or MCC command. The green “ENABLE” LED is illuminated once the RPC is closed. The yellow “FAULT” LED illuminates to indicate that the electronics unit has detected a vacuum pump off-nominal operating condition. Refer to the Depress Pump Assembly (DPA) zap card in Section 1.6.

1.8.11 Analysis/Test References

Table 1.8-2. Test results data

Description	Test results		Comments
Displayed Voltage/Amperage: PSA Powered only To EMU To ORLAN	EV-1 -00.0/-0.04 18.5/-0.01 27.8/0.45	EV-2 -00.0/-0.02 18.5/-0.01 27.5/0.52	

1.8.12 System History - TBD

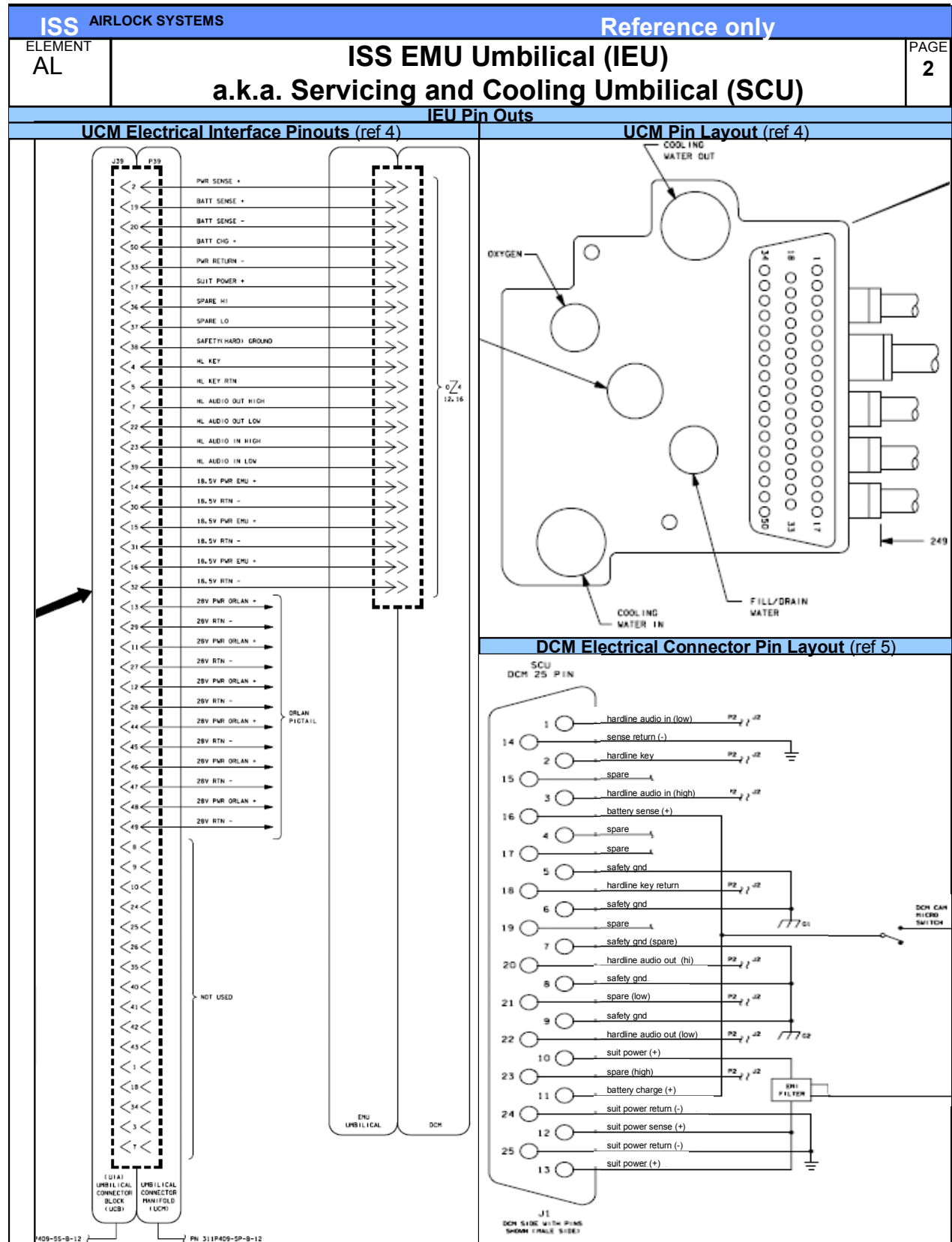
1.8.13 Related Documentation References

JSC-33237 Umbilical Interface Assembly to Airlock, July 1996

JSC-33281 UIA Contract End-Item Specification, July 1997

UIA CDR (SPCE CDR No. 3), July 1997

ISS AIRLOCK SYSTEMS		Reference only	
ELEMENT AL	ISS EMU Umbilical (IEU) a.k.a. Servicing and Cooling Umbilical (SCU)		PAGE 1
ref 2	ISS SCU Crewlock Routing	UCM connected to Umbilical Interface Assembly (UIA)	



ISS AIRLOCK SYSTEMS		Reference only	
ELEMENT AL	ISS EMU Umbilical (IEU) a.k.a. Servicing and Cooling Umbilical (SCU)		PAGE 3
ISS SCU Specifications			
Description	Specification	Comments	
Drawing Number:	SV819500	Hamilton Sundstrand design	
Flight units location: EV-1 position: EV-2 position: Spare SCU:	ID Scheme: 1" Double Red stripe S/N: 1003 B/C: 010336J 1" Green stripe 1005 010339J White TMG 1001 010337J	Part Number: SV819500-04 SV819500-05 SV819500-03 (previously used, EV2) •Stow w/ pouch & blue UCM RTV covers installed	
Ground units: Certification Unit: 2 Spare Flight Units: (one is SSATA unit)	ID Scheme: White TMG S/N: 1002 1" Double Red stripe 1004 1" Green stripe 1006	Part Number: SV819500-03 (Non-flight) SV819500-04 SV819500-05	
Dimensions:	21 ft long x 3.5-in. diameter	•Can reach 15-ft outside EV hatch (can reach ETSD or equip. lock handrails)	
Weight (dry):	30 lb max	Actual dry weights: 26.5 – 26.8 lb	
UCM Mate/Demate:	verify O2 circuit vented (via OSCA)	maintains o-ring integrity of the O2 QD	
UIA Interfaces: UIA O2 Supply to SCU: UIA feedwater to/from SCU: UIA cooling water to/from SCU : UIA Electrical connector: 7/16 inch mating bolt:	1/4 in. Symetrics connector 1/4 in. Symetrics connector 1/2 in. Symetrics connectors 50 pin D-connector	•UCM pins mate to UIA Umbilical Connector Block (UCB) floating connector sockets. UCB connector housing seal/o-ring ensures proper alignment. •mating bolt requires 7/16" wobble socket (located: IV Bag) to engage locking tangs for removal/installation	
SCU multiple connector interfaces: @ EMU Fluid interfaces (four poppet QDs) Electrical connector @ C/L SCU Pouch (3 pouches)	25 pin connector ILC P/N 0100-812231-02 S/N's: 004, 005, 007 B/C's: 010342J, 010343J, 010344J Loc's: installed, installed, A/L1D0	•Suit interfaces same as Shuttle SCU •Differences at hose interfaces (IEU TMG covering, raised cooling water elbows, hoses: ½-in. ID vs. Shuttle 3/8-in ID) •Protects SCU multiple connector from thermal excursions, debris and provides impact resistance	
ISS SCU Certification Test Data (ref. 1)			
Hose Description	PDA Specification	Actual Data/Comments	
Oxygen Circuit: Hose ID - .173-in. minimum Hose mfg. ratings (at room temp): 1500 psi nominal service 3000 psi proof pressure 12,000 psig burst pressure	Pressure Drop: 60 psid max @ O ₂ supply P 805 psia max & 5 lbm/hr Leakage: 30 scc/min. Max Operating Pressure: 1050 psia Proof Pressure (1.5 x MOP): 1575 psia Burst Pressure (2 x MOP): 2100 psia	Actual Pressure Drop: 13.22 psid @ O ₂ supply P 802.4 psia & 5.05 lbm/hr Actual Leakage: 4.9 scc/min. Actual Proof Pressure: 1625 psia (Only Cert unit is tested to Burst P)	
Cooling Water lines: (one flow circuit) Hose ID - .518-in. minimum Hose mfg. ratings 200 psig nominal service 300 psig proof pressure 800 psig burst pressure	Pressure Drop: 2.1 psid max @ H ₂ O supply inlet P 28 psig & 240 lbm/hr Leakage: 0.31 scc/hr Max Operating Pressure: 28.1 psig Proof Pressure (1.5 x MOP): 42.2 psig Burst Pressure (2 x MOP): 56.2 psig	Actual Pressure Drop: 1.4 psid @ H ₂ O Supply P 28.2 psig max & 246.6 lbm/hr Actual Leakage: 0.099 scc/hr Actual Proof Pressure: 44.2 psig	
Feedwater Line Hose ID - .280-in. minimum Hose mfg. ratings: 250 psig nominal service 375 psig proof pressure 1000 psig burst pressure	Pressure Drop: 1.1 psid max @ H ₂ O supply inlet P 28 psig & 30 lbm/hr Leakage: 0.17 scc/hr Max Operating Pressure: 17 psig Proof Pressure (1.5 x MOP): 25.5 psig Burst Pressure (2 x MOP): 34 psig	Actual Pressure Drop: 0.2 psid @ H ₂ O Supply P 28 psig max & 33.4 lbm/hr Actual Leakage: 0.029 scc/hr Actual Proof Pressure: 27.5 psig	
Calculated ISS SCU Data			
Description	Calculation	Comments	
Cooling Water line note: 2 lines per SCU	per line: vol = 49.19 in ³ → mass = 1.77 lbs per SCU: vol= 98.38 in ³ → mass = 3.54 lbs	Note: these volumes & masses do not include UCM and common multiple connector volume. Reference: Cooling water lines data supplied by EC, see file "Transport Loop Volumes.xls"	
Feedwater line calc: Vol/line=(r ² * 3.14) * 12 in/ft * 21 ft	=((.140) ² *3.14)*12*21=15.52 in ³ = 0.56 lbs	: Feedwater line calculated by DX35	

ISS AIRLOCK SYSTEMS		Reference only
ELEMENT AL	ISS EMU Umbilical (IEU) a.k.a. Servicing and Cooling Umbilical (SCU)	PAGE 4
References		
<p>1.) ISS EMU Umbilical S/AD; CEI 498, SV819500/2. NAS 9-17873. March 1999.</p> <p>2.) ISS Joint Airlock Systems Training Manual, Joint Airlock 21002, JSC-36344. Rev A. April 2001.</p> <p>3.) NASA Extravehicular Mobility Unit LSS/SSA Data Book. Hamilton Sundstrand. Rev L, September 2005.</p> <p>4.) International Space Station Systems Handbook, Mission Operations Directorate, Systems Division, JSC-36027, Basic, Revision C, PCN-1, January 16, 2004, drawing 12.2-2.</p> <p>5.) Space Shuttle Systems Handbook, Mission Operations Directorate, Systems Division, JSC-11174, Revision G, DCN-3, April 1, 2005, Errata April 25, 2005, drawing 21.11 sheet 1 of 2.</p>		

1.9 SERVICE AND COOLING UMBILICAL (SCU), I-498

1.9.1 Functional Description

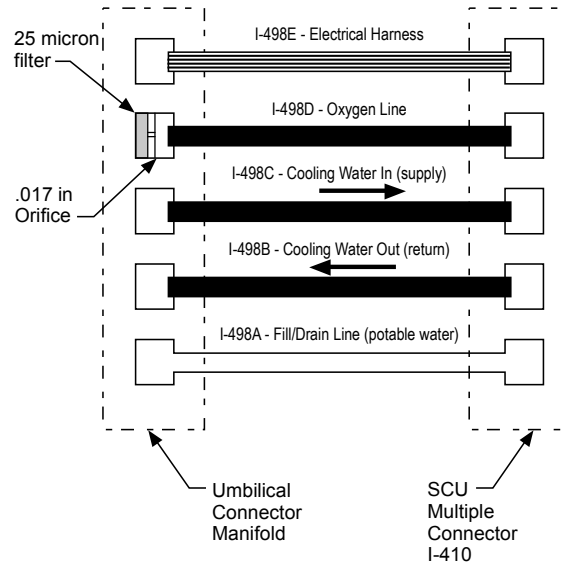
The purpose of the Service and Cooling Umbilical (SCU), also referred to in technical documentation as the International Space Station (ISS) EMU Umbilical (IEU), is to transfer oxygen, feedwater, cooling water, electrical power, and hardline communication to the EMU. These consumables are provided from the ISS through the Umbilical Interface Assembly (UIA). The SCU is bolted directly to the UIA to provide a flowpath for the various consumables.

1.9.2 Physical Description

The SCU is comprised of four 21-ft fluid lines and a 21-ft electrical harness terminating in an Umbilical Connector Manifold (UCM) at one end and an SCU multiple connector at the opposite end. The UCM end interfaces with the UIA and the SCU multiple connector end interfaces with the EMU Display and Control Module (DCM). The 30 lb maximum weight includes the UCM, an SCU multiple connector, four fluid lines, electrical harness, strain relief assembly (with tether hooks), and a Thermal Micrometeoroid Garment (TMG).

1.9.2.1 Mechanical Components

The four fluid lines consist of an oxygen line, two cooling water lines, a feedwater charging/drain line, and an electrical harness, (Figure 1.9-1). The oxygen line provides a flow path for recharging the oxygen tanks from the ISS O2 Hi-P supply tank. The cooling lines are for Liquid Cooling Ventilation Garment (LVCG) supply and return from the SPCU heat exchanger in the ISS airlock, and the feedwater line provides for filling and dumping the EMU feedwater tanks.



jsc20597_181.cvx

Figure 1.9-1. SCU fluid schematic

1.9.2.2 Electrical Harness

The ISS SCU can provide power and hardline comm to the EMU when connected (Figure 1.9-2). The ISS SCU has four pairs of power supply and return lines (at UCM P39 pins 14 and 30, 15 and 31, 16 and 32, and 17 and 33) from the UIA interface that splice into two pairs (and SCU multiple connector P1 pins 13 and 25 and 10 and 24) at the SCU multiple connector. The four splices, approximately one foot from the SCU multiple connector, are staggered along the harness and are configured to provide redundant power paths. The Orbital Replacement Unit (ORU) DCM incorporates two pair of supply and return lines to take advantage of this power configuration.

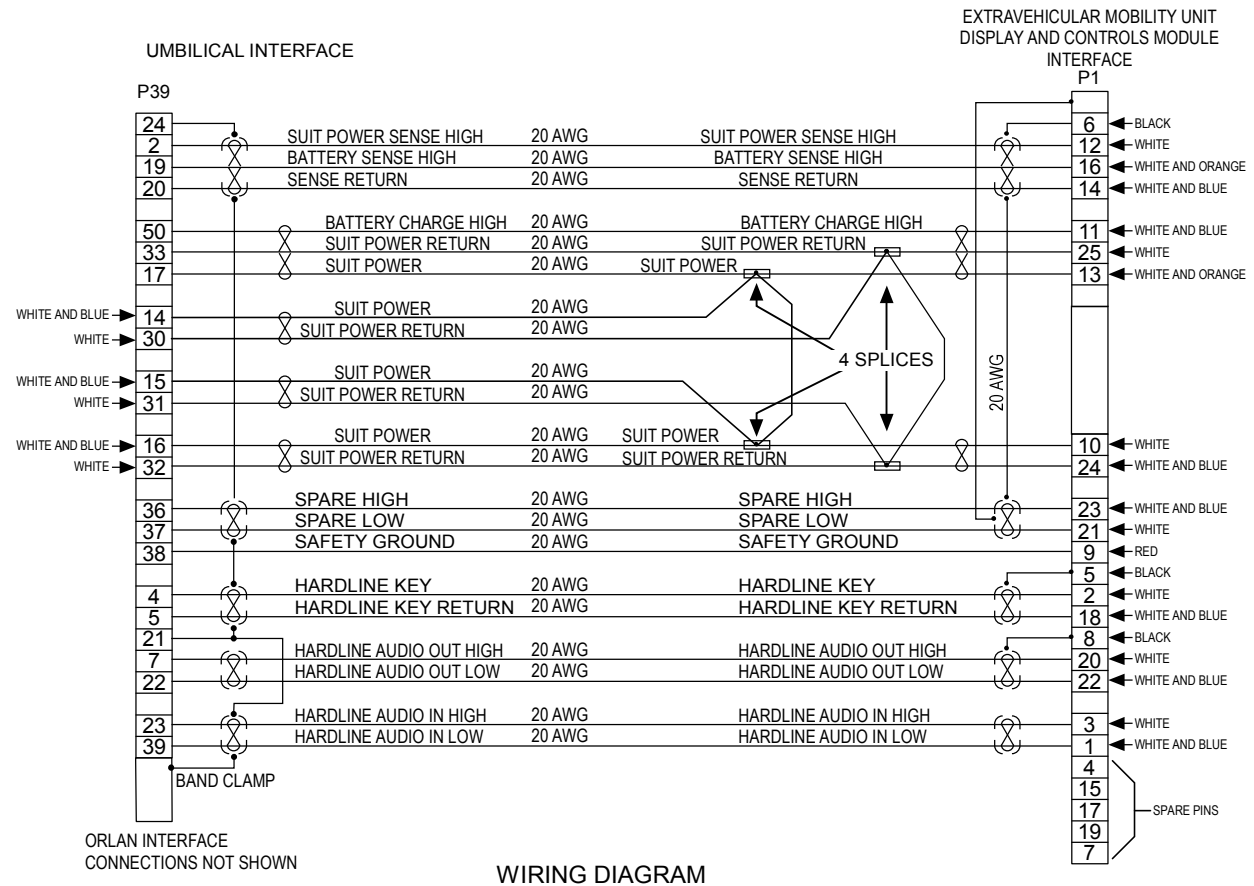


Figure 1.9-2. SCU electrical schematic

1.9.2.3 Umbilical Connector Manifold

The UCM is made from a stainless steel block consisting of four fluid Quick Disconnects (QDs) and an electrical connector. All QDs are built by Symetrics. Two are 1/2-in. cooling line QDs, one is a 1/4-in. feedwater water QD, and the other is a 1/4-in. oxygen QD. A fixed 50 pin electrical connector on the UCM connects to a “floating” mating connector on the Umbilical Connector Block (UCB) on the UIA.

When the SCU is removed or installed onto the UIA several steps are required. For the pressure integrity of the oxygen QD, the UIA oxygen circuit must be vented to ambient pressure prior to mating/demating the UCM. In addition, inspection of the o-ring on the UCB connector housing (for damage and proper installation within the o-ring groove) is required. Spare o-rings are available in the Service Performance Cooling Equipment (SPCE) maintenance kit.

A single docking bolt connects the UCM to the UIA. This bolt has a locking feature (integral to the UCM), which forces two spring-loaded latches into slots cut around the bolt head circumference. A 7/16-in. EVA wobble socket is needed to manipulate the

bolt latches when driving the docking bolt. The UCM will hard stop against the UCB, after approximately 15 turns.

1.9.2.4 SCU/DCM Interface

The SCU/DCM interface contains four QDs. One for feedwater, oxygen, and two for cooling (supply and return) lines. The electrical connector is a standard 25 pin connector, with the pins on the DCM side.

1.9.2.5 Strain Relief

Strain relief consists of a small crew hook at each end of the SCU, connected to the TMG by a nylon strap. The hook at the UCM end is connected to a tether ring in the crewlock and is certified for loads up to 200 lbf. The other hook, is normally held against the TMG with a Velcro strap, and is required to be connected to the EMU D-ring if the EMU is connected to the SCU outside of the crewlock. This is only required in the event of certain contingencies involving decontamination and crew rescue.

1.9.2.6 TMG

The TMG provides thermal protection, micrometeoroid impact resistance, and abrasion protection. A Teflon fabric inner liner minimizes internal abrasion between the lines and the TMG. The TMG runs the full length of the SCU. It is secured to the UCM fluid fittings and overlaps the SCU multiple connector fluid line elbows where it is secured.

1.9.2.7 Identification

Each SCU has a unique marking on the TMG, either no marking (completely white), a double red stripe, or a single olive green stripe along the length of the umbilical.

1.9.2.8 Nominal Stowage and Routing

The two prime SCUs are nominally stowed in the crewlock routed along the wall per Figure 1.9-3, each secured to the crewlock wall by 11 Velcro restraint straps. The Velcro restraint straps, one hook and one loop, are each fed through a slot at the bracket ends. The brackets are bonded to the crewlock wall. The SCU multiple connector is stowed inside a protective pouch, one located adjacent to and aft of the EV hatch opening for EV-1 (hatch operator) and the other pouch near the forward side of the UIA for EV-2 (UIA operator).

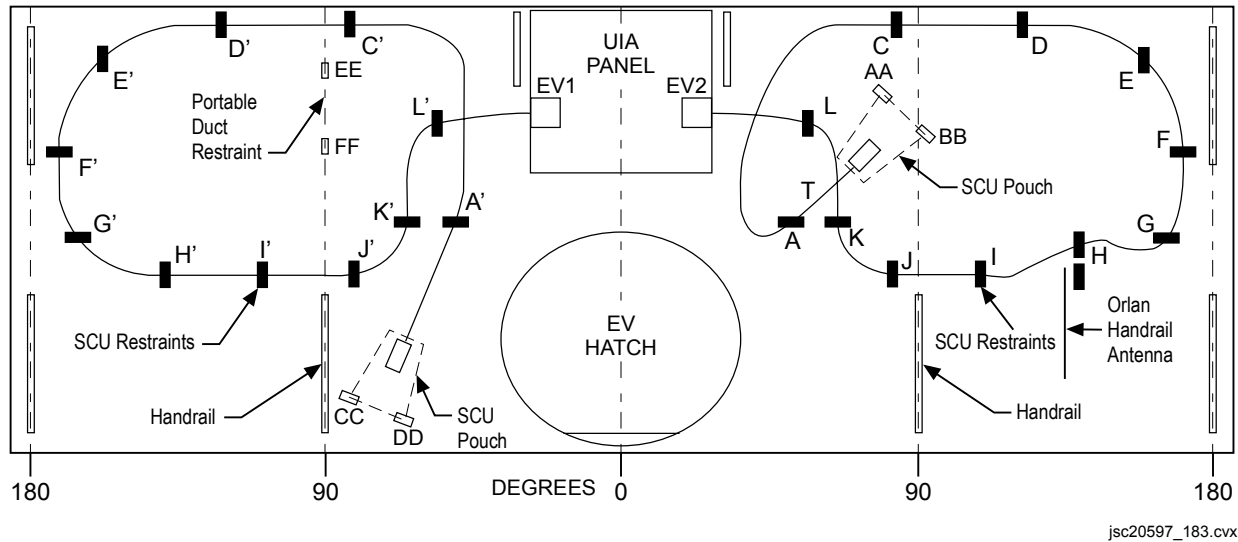


Figure 1.9-3. SCU routing schematic

1.9.2.9 SCU Connector Pouch

A soft pouch protects the SCU multiple connector from incidental crew contact, debris and thermal extremes when stowed (Figure 1.9-4). The pouch is constructed of TMG material and is fastened to the crewlock wall at the base by two SCU retention straps. A Velcro hook (3 in. by 8 in.) sewn on the back of the pouch secures it to the crewlock wall via a mating Velcro loop section. This allows the pouch opening to be pulled away from the wall to facilitate multiple connector insertion/removal during the EVA.

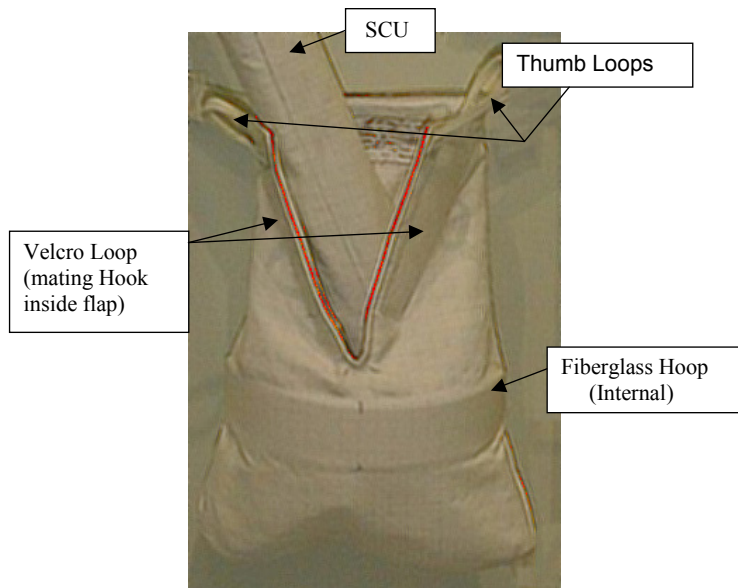


Figure 1.9-4. SSC connector pouch (shown open)

1.9.3 Operational Data

The oxygen line is constructed of a smooth Teflon inner core supported by an outer stainless steel wire braid. It is protected from adiabatic compression heating, due to rapid pressurization if the SCU were to be inadvertently pressurized while disconnected from the EMU, by a .017-inch diameter orifice located within the UCM just downstream of a 25-micron Nickel filter.

The two cooling water lines consists of a convoluted Teflon Polytetrafluoroethylene (PTFE) inner core surrounded by an outer green Nomex nylon braid. The line has a 1/2-in. inner diameter that reduces to 3/8-in. diameter at a raised elbow on the SCU multiple connector.

The feedwater line is also constructed of a convoluted Teflon PTFE inner core surrounded by an outer green Nomex nylon braid.

The complete SCU is certified to a 15-year operating life. It is certified for 60 install/removal cycles, defined as removing from an uninstalled coiled configuration, installed into the crewlock, and then back to an uninstalled configuration. Each SCU is designed for 1200 minutes of EVA exposure outside the crewlock.

1.9.4 References

ISS EMU Umbilical S/AD; CEI 498, SV819500/2, NAS 9-17873, March 1999.

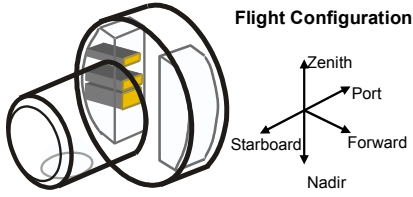
ISS EMU Umbilical PDA report; EMU1-21-022, March 1999.

1.10 CO2 REMOVAL

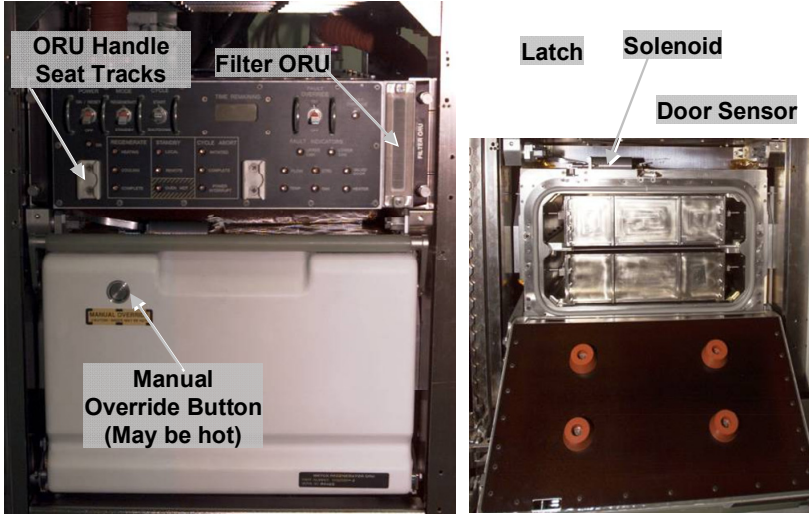
1.10.1 Description

TBD

ISS AIRLOCK SYSTEMS		Reference only	
ELEMENT AL	Metox Regenerator Assy & Contaminant Control Cartridge		PAGE 1



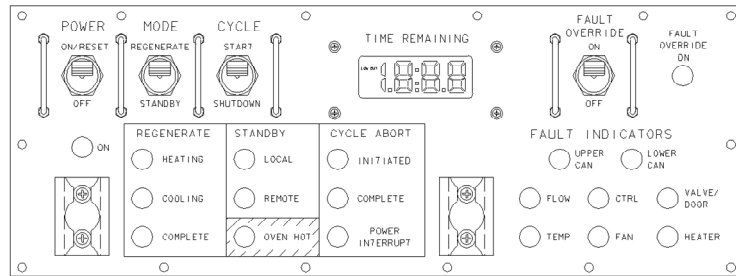
Flight Configuration

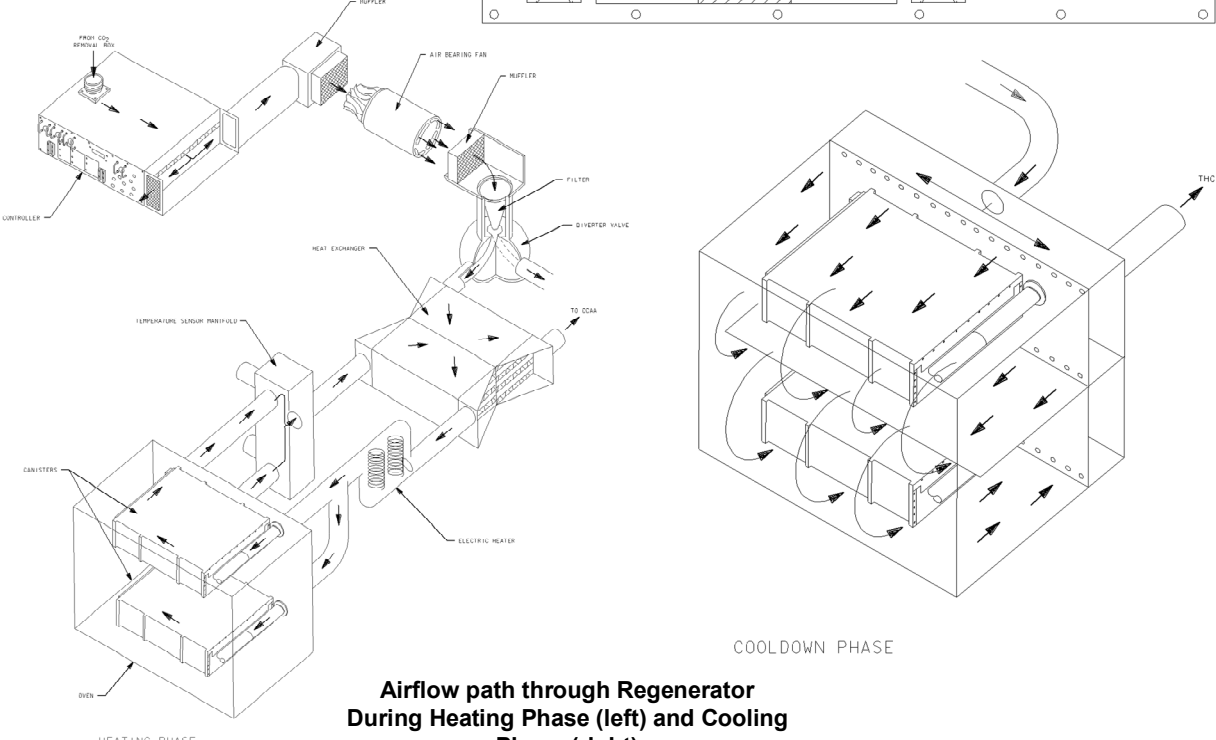


AL1A1 – Cabin Air Rack
Primary Metox Regenerator:
 P/N: SV822000-1
Spare Metox Regenerator:
 (Unpowered, located at AL1A1, above primary)

POWER PATH

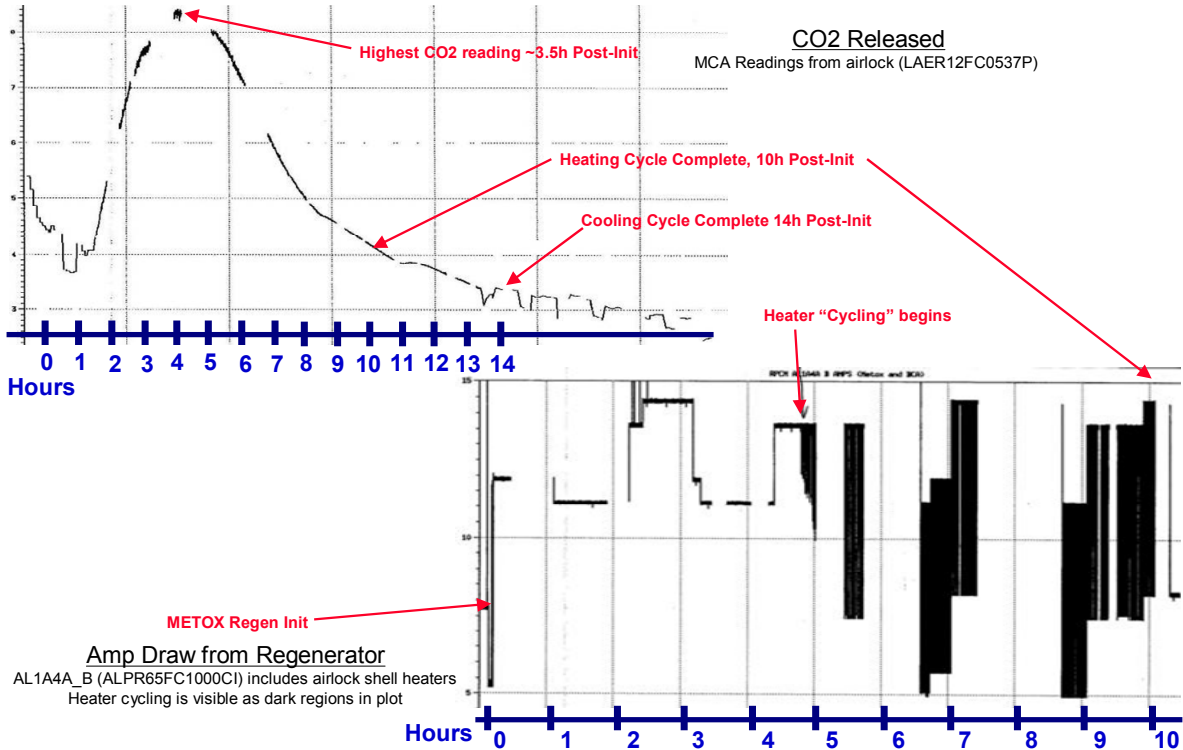
- P6 Solar Array: Channel 4B
- DCSU 4B: RBI 6 (Direct Current Switching Unit)
- IDA Z1-4B (Initialization Diode Assy)
- CID 1 (Circuit Isolation Device)
- DDCU: LA1A (DC-to-DC Converter Unit)
- RPCM LA1A4A-F: RPC3
- RPCM AL-1A4A-B: —RPC 17 Metox





Airflow path through Regenerator During Heating Phase (left) and Cooling Phase (right)

Metox Regeneration Parameters for a Typical Cycle



Known Issues (IFIs, ARs, Chits)				
Document	Increment	Signature	Impact	Workaround
IFI-0692	ISS-4	Crew reported smell from Airlock ~2.5 hours post-regen init.	Crew isolated U.S. segment to assess situation	Canisters will no longer be left inside the regenerator. Smell was attributed to buildup of harmful contaminants present in small quantities in ISS air. Diverter valve allowed this air to flow through affected canisters.

References
1. IFI Database
2. MetOx CO2 Removal System, Hamilton Sunstrand, 12/12/2000
3.
4.
5.
6.
7.

Metox Related OCADs

Hazard Description	Ops Control	Hazard Number
1.		
2.		
3.		
4.		
5.		
6.		

1.11 METOX REGENERATOR

1.11.1 Quick Look Reference Data

Table 1.11-1 provides the Metal Oxide (Metox) ORU specifications.

Table 1.11-1. Metox ORU specifications

Description	Specification	Comments
Dimensions	17.72 in. by 19 in. by 30 in.	Volume = 6 cu. ft.
Weight	105 lb max.	See Metal Oxide Regenerator User's Manual for individual component weights
Material	Nickel plated frame aluminum, stainless steel	See Section 1.11.3
Regeneration times: Heating	10 hr max.	Heating phase considered complete when outlet T > 350° F following 6 hours of operation
Cooling	4 hr max.	Cool-down phase considered complete when exit temperature equals inlet temperature
Airflow	15 cfm	This is the flow rate when the fan is operating
Power	750 W max.	
Max Current Draw	12.5 Amps	Max current draw during a startup transient Ref: ICD SVHS822000, note 20

1.11.2 General Description

The Metox Regenerator is used to regenerate (recharge) Metox canisters. Metox canisters are used to remove CO₂ from the EMU and from the Joint Airlock atmosphere.

The Metox Regenerator functions as an oven that bakes off CO₂ that has been absorbed in the Metox canisters. The regenerator heats cabin air in the oven to approximately 400° F (204° C) and passes the hot air through the canister. This heat weakens sorption bonds, which releases CO₂ and trace gases. Regenerator ducting directs gases into the airlock Common Cabin Air Assembly (CCAA) and associated interfaces as well as to the ISS cabin via Intramodule Ventilation (IMV), where it is conditioned by the ISS Environmental Control and Life Support System (ECLSS).

The regenerator system consists of the following components: controller and user interface panel (item 130), air filters (items 180 and 190), fan assembly (item 120), diverter valve (item 150), heat exchanger (item 140), heater assembly (item 160), oven assembly (item 110), and temperature sensor assembly (item 170). Although the entire Metox Regenerator system is designed to be an ORU, some individual components can be changed out in the event of a failure. These individual ORU components are the controller assembly, the heater assembly, and the temperature sensor assembly. While the fan assembly is not specifically designed to be an ORU, it can be changed out on orbit if required. Figure 1.11-1 shows an isometric layout of the regenerator.

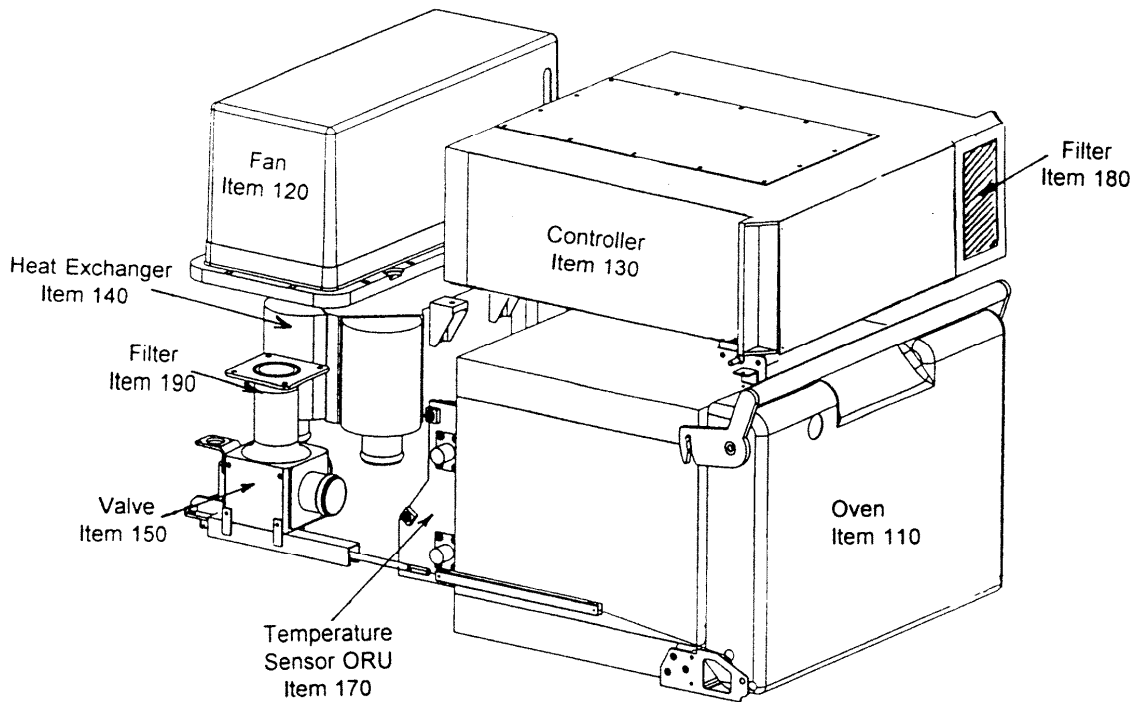


Figure 1.11-1. Metox regenerator layout

1.11.3 Location and Structure

1.11.3.1 Location

There are two Metox Regenerators located in the Cabin Air Rack of the Equipment Lock (E/L) next to the CCAA. The prime regenerator is located below the CO₂ Removal Box on the starboard side of the Cabin Air Rack. The spare regenerator is located directly above the CO₂ removal box and is not plumbed for operation.

1.11.3.2 Structure

The weight of the regenerator is 105 lb max. It occupies 6 ft³ and has the following dimensions: 17.72 in. by 19 in. by 30 in. The regenerator components are housed in a nickel plated frame. The controller is a dip-brazed aluminum box. The fan has an aluminum frame. The heater assembly has a stainless steel housing. The oven has a stainless steel inner liner covered with aluminized fiberglass and Kapton tape. The ducting in the regenerator is made of silicone rubber.

1.11.4 Regenerator Components

1.11.4.1 Controller

The controller ORU (item 130) is removable from the front of the regenerator. The interface panel is located on the front of the regenerator for easy access to displays and controls. The controller contains the logic for automated operation, fault detection, and emergency shutdown. Multiple parameters are monitored via the controller. Refer to Section 1.11.11, Fault Detection, for details on monitored parameters and error codes.

The controller box is divided into the following six compartments (Figure 1.11-2):

- Display driver
- Electromagnetic Interference (EMI) filter
- Air filter and distribution
- Logic
- Heater
- Fan driver board

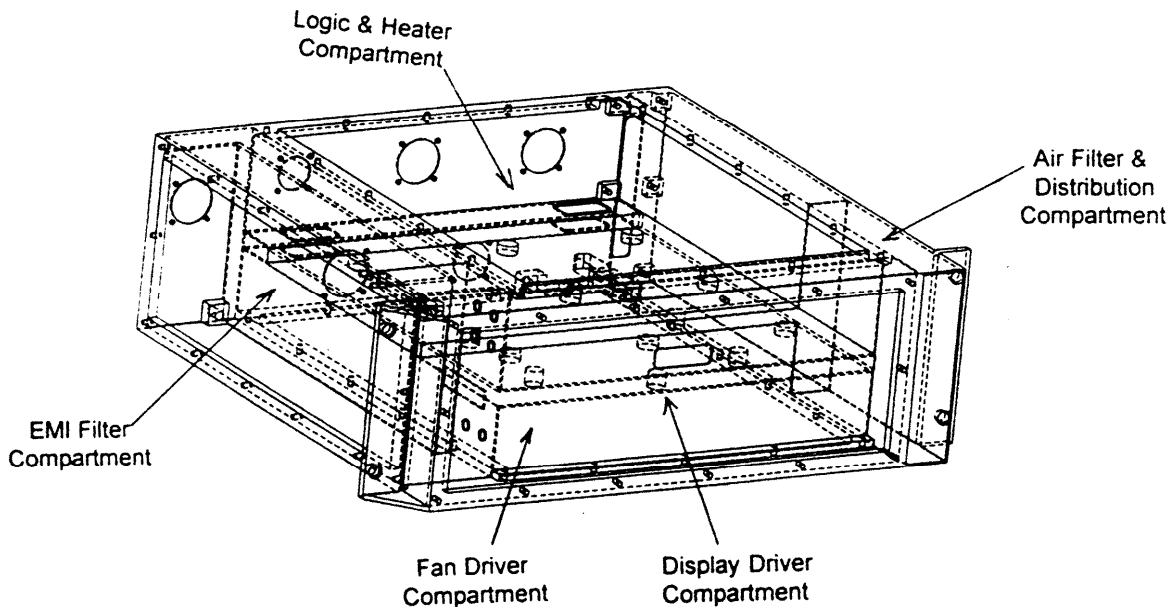


Figure 1.11-2. Controller box

The display driver compartment is located directly behind the display panel in front of the controller box. The EMI filters are located on the left side of the controller box, and the replaceable air filter is located on the right side (facing the rack). The logic and

heater driver compartments are located in the top portion of the controller. The fan driver compartment is located in the bottom of the unit.

The controller is cooled by airflow from the Temperature and Humidity Control (THC) system. Air enters the controller on the top left side and is split into two flow paths. One flow path is directed out of the back of the controller to the fan assembly. The flow rate when the fan is operating is 15 cfm. This air flow removes waste heat from the controller. The other flow path is directed into the airlock via the front panel air filter. When the fan is not operating, the pressure differential between the THC and the airlock results in a 5 cfm “reverse” flow through the front of the controller to the cabin, through the front panel filter (item 180).

The controller and filter can be replaced without removing the regenerator from the rack by performing the following:

Controller Replacement

- A. Disconnect six electrical connectors and the air inlet connection on the left side of the controller.
- B. Loosen four captive screws in the front of the controller.
- C. Pull controller out of the front of the regenerator.

Filter Replacement

- A. The filter on the front of the controller can be removed by loosening two captive fasteners on the front of the controller.
- B. Remove and replace the filter.

1.11.4.2 Heater

The heater ORU (item 160, Figure 1.11-3) consists of a coiled heating element, an outlet temperature probe Resistance Temperature Detector (RTD) (T3), a dual element probe RTD (T1, T2) for detecting over/under temperature conditions, high temperature insulation, and stainless steel housing. The temperature probes are platinum elements. The heating element is a 120 V, 550-watt cable wound in a circular coil. The center of the coil is shifted back and forth across the flow channel to minimize pressure drop while maintaining efficient convective heat transfer. The outlet temperature is controlled to 410 ± 5 °F by the heating duty cycle.

The heater assembly is removable from the rear of the regenerator. The assembly has captive fasteners on the flange mount, one mounting pin on the inlet side, and two electrical connectors that interface at wall mounted connectors. Removal of this item requires removing the regenerator from the rack.

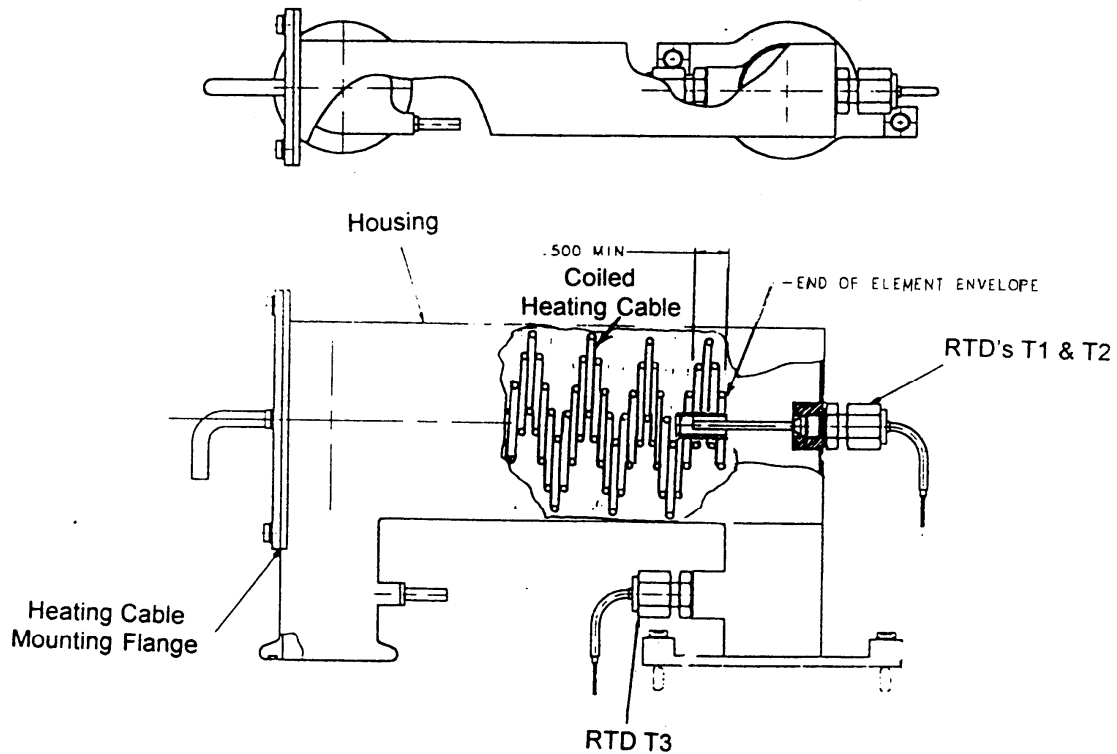
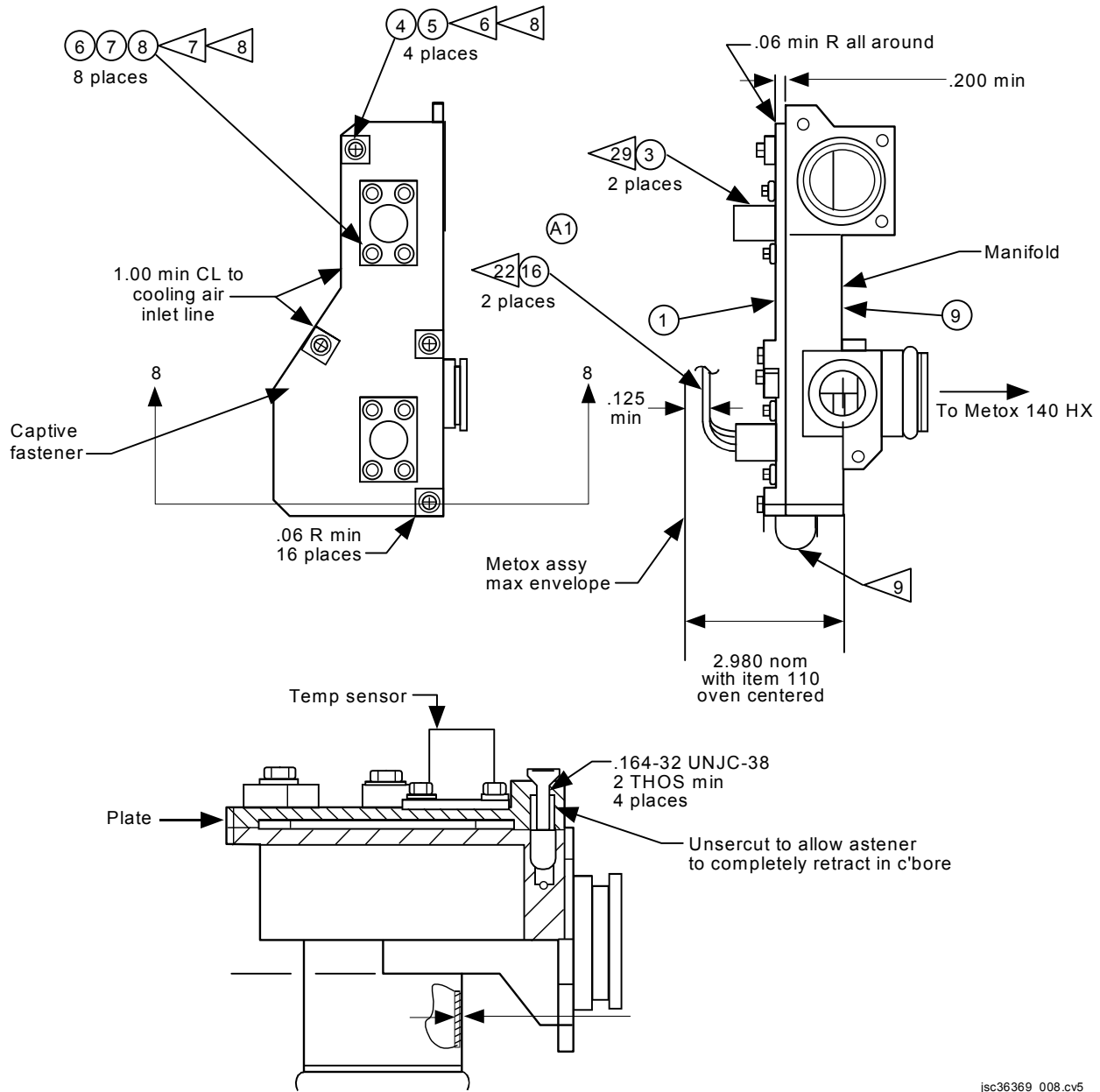


Figure 1.11-3. Heater ORU

1.11.4.3 Temperature Sensor

The temperature sensor ORU (item 170, Figure 1.11-4) consists of two dual element platinum probe RTDs (T4, T5 and T6, T7). The T4, T5 element provides fault detection and confirmation of regeneration for the upper canister, while the T6, T7 element provides fault detection and confirmation of the lower canister. Fault detection and confirmation of successful regeneration is determined by a combination of temperature and time criteria. The final and most important criterion is that the canister outlet temperature must reach at least 300° F.



jsc36369_008.cv5

Figure 1.11-4. Temperature sensor ORU

1.11.4.4 Fan

The fan assembly (Figure 1.11-5) provides hydraulic power to overcome pressure losses. The fan motor, temperature sensors, and air bearings are identical to those in the ISS Avionics Air Assembly (AAA) that are used for rack cooling; however, the assemblies are not interchangeable due to the requirement for the fan assembly impeller and housing to provide regenerator flow rate of 15 cfm (vs. the avionics flow rate of 100 cfm). The fan assembly contains two filters, one at the inlet and one at the outlet. The fan also has three temperature sensors that, along with fan current and speed, are used for protection against a temperature fault in the fan. The fan uses a 120 V dc brushless motor. The fan is not considered an ORU but can be independently

replaced on orbit if required. The fan has four captive fasteners, fluid connectors with large, soft seals, and an electrical connector mounted directly to the controller. No special tool is required for fan change out. The fan is accessed from the top of the regenerator. Even though it is possible to change out the fan on orbit, given a failure, the entire regenerator would probably be changed out first. Most likely, spare ORU parts will not be flown; therefore, changing out the entire regenerator is much easier than scavenging parts from the spare for replacement.

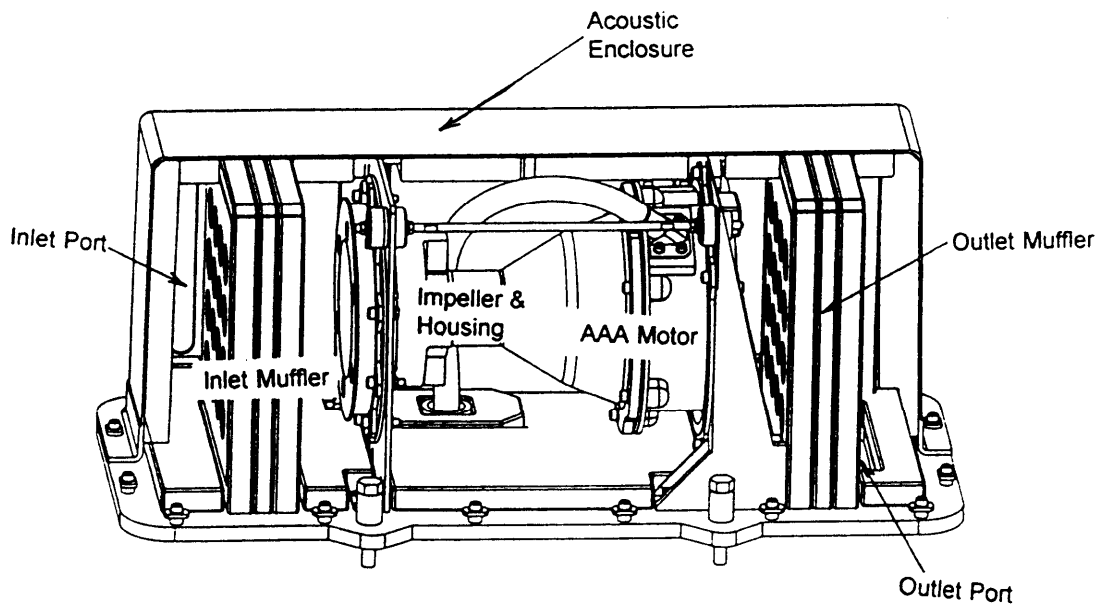


Figure 1.11-5. Fan assembly

1.11.4.5 Diverter Valve

During the heating phase of regeneration, a diverter valve directs airflow into the canisters (via the heat exchanger) and to the heater. For cooldown, this valve is reconfigured to circulate flow into the oven, around the exterior surface of the canisters. This valve, shown in Figure 1.11-6, has an aluminum ball and a valve body with a spring-loaded actuator. The valve is placed in the heating position and latched in place when the oven door is opened by greater than 90°. When the heating phase is complete, a solenoid valve is actuated, releasing the latch and allowing the spring to reposition the valve to the cool down position. For each position, the valve has a separate position indicator microswitch.

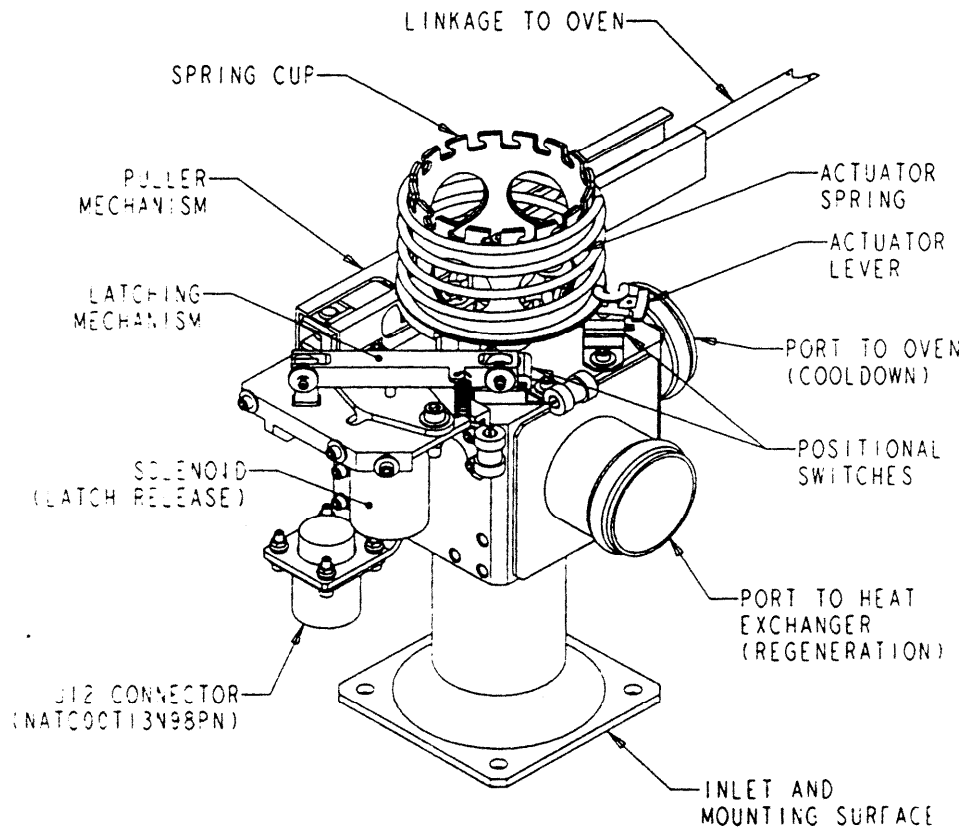
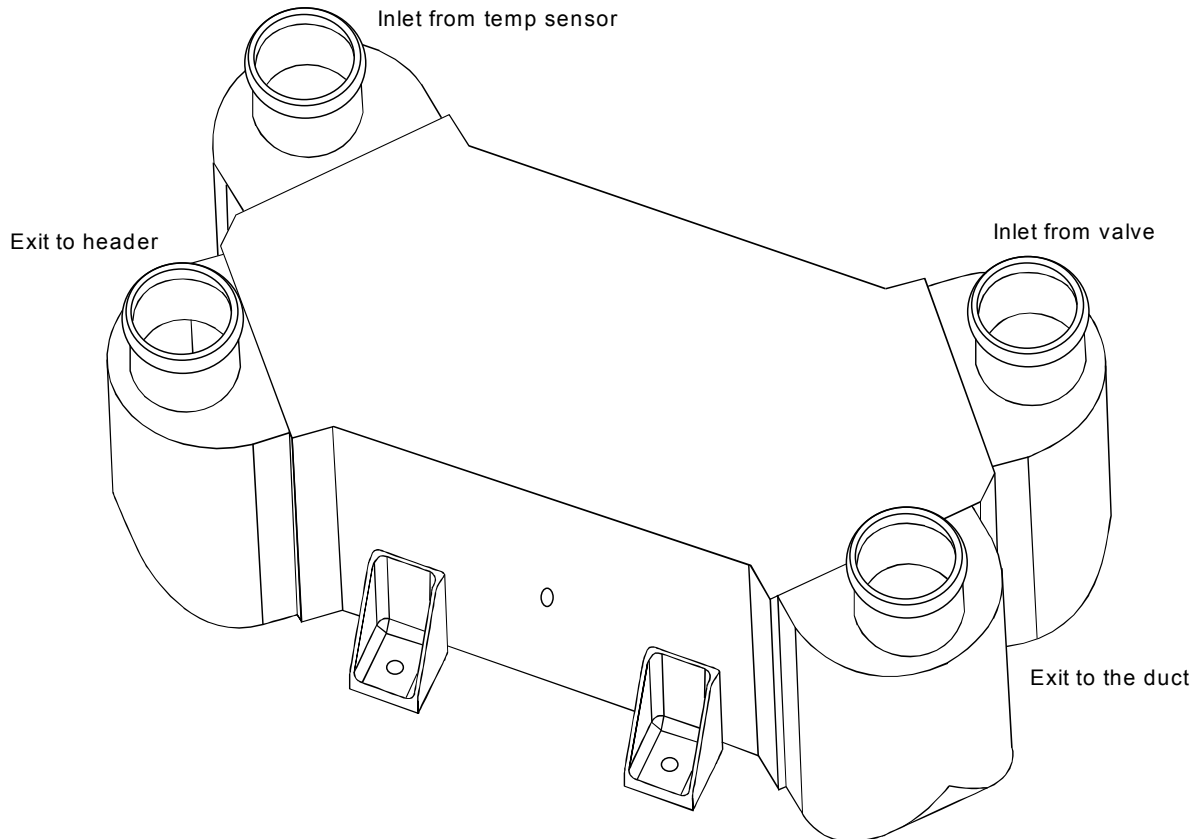


Figure 1.11-6. Diverter valve

1.11.4.6 Heat Exchanger

The heat exchanger (Figure 1.11-6) is an aluminum-brazed plate with fins arranged in a counterflow, single-pass pattern to achieve an effectiveness of approximately 90 percent. The purpose of the heat exchanger is to recover energy from the exhaust air, thus reducing required heater power and required total energy required for regeneration. The heat exchanger reduces the waste heat load on the ISS ECLSS.



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Figure 1.11-7. Heat exchanger

1.11.4.7 Oven

The inner chamber of the oven (Figure 1.11-8) has a stainless steel liner covered with approximately 1.5 in. of Solimide insulation. The oven chamber is separated into an upper and a lower berth to accommodate two canisters. There are guides inside the chamber to ensure proper canister installation. A bracket located in the upper and lower berths prevents improper canister installation by interfering with the state indicator. The canister must be installed properly to fully close the oven door and allow operation of the regenerator. The oven door has bumpers to ensure adequate seal of the canister's inlet/outlet ports with the regenerator hot air ports when the door is closed. Both the upper and lower berths are equipped with a solenoid to reset the canister's state indicator following regeneration. The upper berth contains the cooling air inlet manifold and the lower berth contains the cooling air exhaust manifold. The upper berth is equipped with shutoff caps to block the supply and return ports if only one canister is being regenerated. The lower berth contains a platinum probe RTD (T8) that is used to measure chamber and canister temperature. T8 is an ORU and can be removed by disconnecting an electrical connector and unscrewing the sensor from the oven. The T8 measurement provides detection of a failed cooling cycle and inhibits the door latch solenoid (on top of the oven) from opening until the interior temperature decreases to $105^{\circ} \pm 5^{\circ} \text{ F}$ ($41 \pm 2.8^{\circ} \text{ C}$). In the event of failure, however, a manual override located on the oven door can be used to unlatch the solenoid. If the manual

override is used, shutting the door again re-locks the door latch solenoid. The oven (Figure 1.11-10) is also equipped with a door position indicator switch for operational monitoring and fault detection.

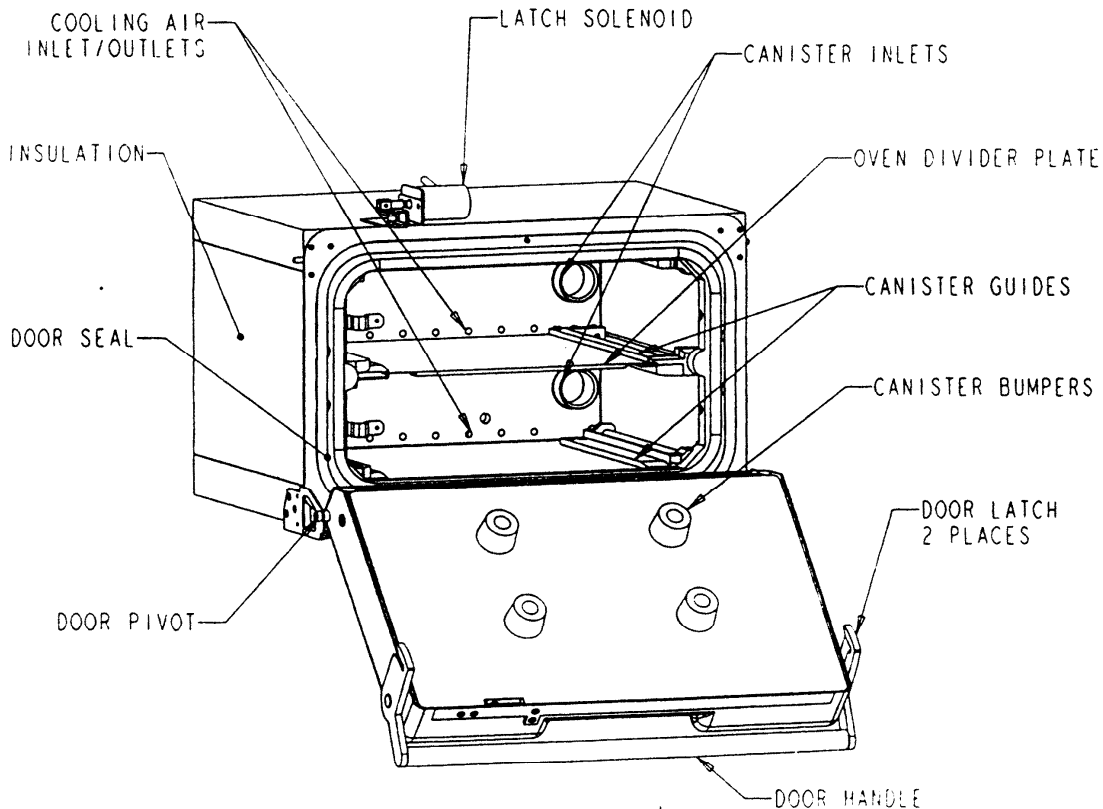


Figure 1.11-8. Oven assembly

1.11.4.8 Filters

In most cases, the regenerator will only be operated with the Common Cabin Air Assembly (CCAA) activated. In this instance, air is routed through HEPA filters at the base of the CCAA, thereby eliminating the need for inlet air filtering. However, if the system is operated without the CCAA activated (i.e., during ground testing, etc.), the airflow could be drawn in from either airlock or CCAA interfaces. The controller's ventilation air outlet is protected from particulate contamination by a 121 mesh (130 micron) hydrophobic filter (item 180). There is a small amount of flow through the controller front panel filter (item 180) during regeneration, and the flow is reversed when the regenerator is not operating. The reverse flow through the filter results in "self-cleaning," which reduces the frequency of filter cleaning; however, in the event of noticeable particulate buildup, filter cleaning is required. This filter is also an ORU and can be replaced in lieu of cleaning, if desired.

There is another filter located in the ducting between the fan assembly and the diverter valve. This 150 mesh (101 micron) stainless steel filter (item 190) is used to prevent particulate contamination, which could be caused by a failure of the fan foam mufflers at the inlet of the fan (Figure 1.11-5)

1.11.5 Regenerator Operations

1.11.5.1 Operations Overview

The regeneration cycle is comprised of two operating phases, heating and cooldown. The heating phase lasts up to 10 hours but varies according to the amount of CO₂ absorbed in the Metox canister. During the heating phase, the regenerator flows 400° F air at 7.5 cfm through each expended Metox canister (15 cfm or 7.08 by 10⁻³ m³/sec total flow rate). The heating phase of regeneration is considered complete when the canister outlet temperature is greater than 350° F following 6 hours of operation. Once the heating phase is complete, the cooldown phase begins. During cooldown, airflow is directed through the oven and over the external surfaces of the canisters to cool the hardware. The cooling airflow is directed over the canisters as opposed to through them, thereby precluding CO₂ contamination of the sorbent bed post regeneration.

Regeneration can be conducted for one or two canisters. If only one canister is to be regenerated, the upper berth inlet/outlet ports must be capped off because the single canister should be installed in the lower berth. Port caps are low-profile metal caps that are permanently located in the upper canister berth and can be rotated into place. During single can regeneration, the UPPER CAN LED (yellow) will be illuminated to indicate that regeneration is not taking place in the upper berth.

Prior to initiating the heating cycle, the regenerator door must be opened at least 90° to ensure that the diverter valve is moved to the heating position and to enable a canister to be installed in the lower berth. Once the canisters are installed, the regeneration cycle is initiated by powering up the regenerator, taking the MODE switch to REGENERATE and taking the CYCLE switch to START. The HEATING LED (green) should illuminate and the "TIME REMAINING" clock will read 14 hours (14:00). When regeneration is initiated, the controller will lock and latch the oven door via the door latch solenoid and activate the fan and the heater. The door will remain locked for the entire 14-hour cycle. The manual override for the door latch may be used to access the canisters prior to the end of the 14-hour cycle as required. This should only be done if the regeneration is completed early and the OVEN HOT LED is not illuminated or if a malfunction necessitates use of the manual override.

The controller panel is shown in Figure 1.11-9.

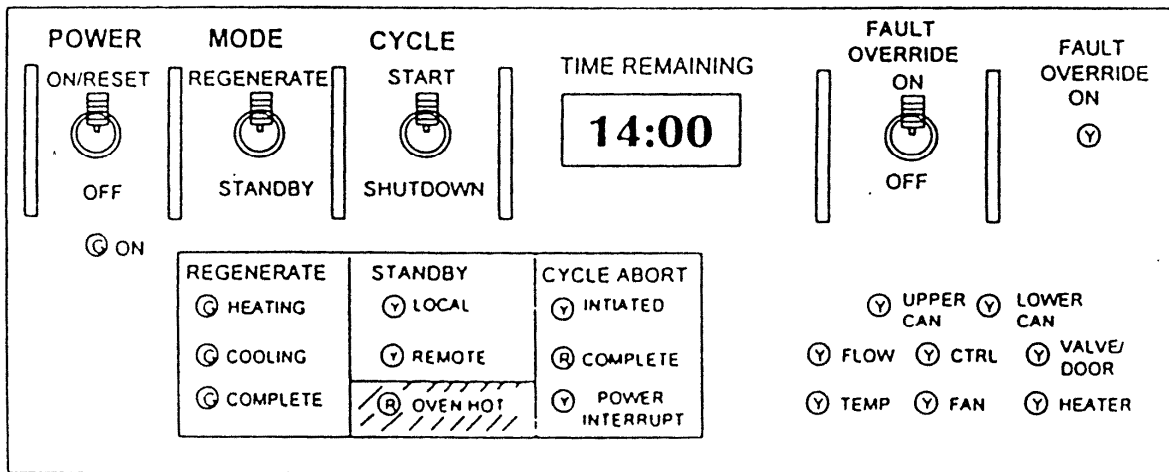
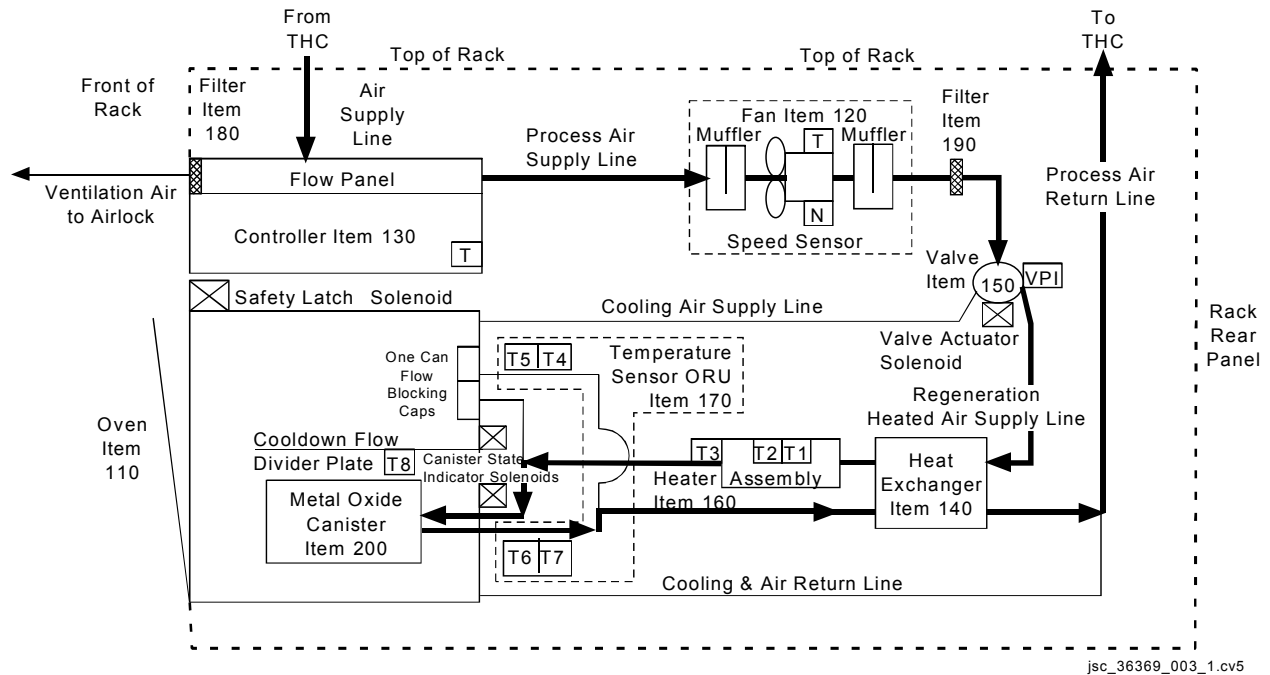


Figure 1.11-9. Controller Panel

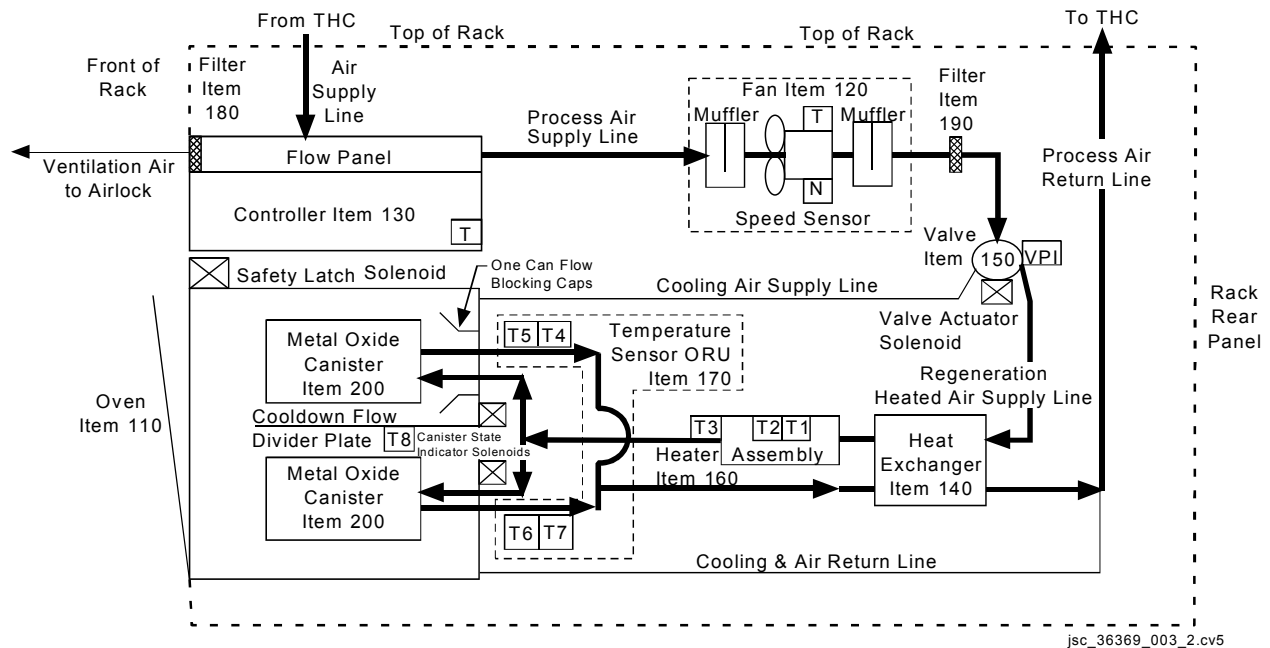
Reference the Metox software simulator located on \\jsc-mod-fs3\World\Divisions\DX\Eva\System\EVA System Simulators for PC\Metox to simulate regenerator operations and fault conditions.

1.11.5.2 Heating Phase

In the heating phase, the airflow is directed via the diverter valve to the heat exchanger and to the heater (*Figure 1.11-11*). Initially, the temperature increase across the heater assembly is limited to 110° F (43° C). As the temperature at the canister(s), and thus the oven exhaust temperature, increases, more energy is recovered by the heat exchanger. The temperature entering the oven rises until it reaches the desired 400° F design point. As the oven inlet temperature (T8) rises above 105° ± 5° F (41° C ± 2.8° C), the OVEN HOT LED (red) is illuminated. When the outlet temperature of the heater reaches its set point of 410° F ± 5° F (210° C ± 2.8° C), the heater duty cycle is reduced to prevent additional increase in the oven inlet temperature. The heater duty cycle is calculated by the controller and is based on the measured outlet temperature of the heater (T3). Heater operation is monitored by the controller continuously through measurement of heater current draw and heater temperature (T1, T2).



**Figure 1.11-10. Regenerator schematic – heating
(Airflow during one-bed regeneration heating)**



**Figure 1.11-11. Regenerator schematic – heating
(Airflow during two-bed regeneration heating)**

1.11.5.3 Cooldown Phase

Once the heating phase is complete, the diverter valve is moved to the cooling position and approximately 15 cfm of air is directed to the oven inlet cooling air manifold. The air is directed over the external surfaces of the canisters for cooldown.

Figure 1.11-12 shows the flow path during the cooldown phase. As air moves through the oven, the temperature will increase from a temperature of approximately 80° F at the inlet to 375°+ F at the outlet. As the canisters and the oven cool, the delta temperature decreases until the exit temperature equals the inlet temperature. Testing and computer simulations have demonstrated that this process will take approximately 4 hours under nominal conditions. The length of time required for cooldown increases at the minimum operating pressure (10 psi) and maximum ambient temperature (80° F) due to the decreased mass flow of air. When the lower berth temperature, T8, decreases below 105° ± 5° F (41° C ± 2.8° C), the OVEN HOT LED (red) shuts off. After 14 hours (10 hours heating, 4 hours cooling), the fan shuts down, the COOLING LED (green) switches off and the oven door unlatches. If T8 is not below its set point of 100° F (37.8° C) after 14 hours, the oven door remains latched, the FLOW LED (yellow) illuminates, and the OVEN HOT LED (red) remains illuminated.

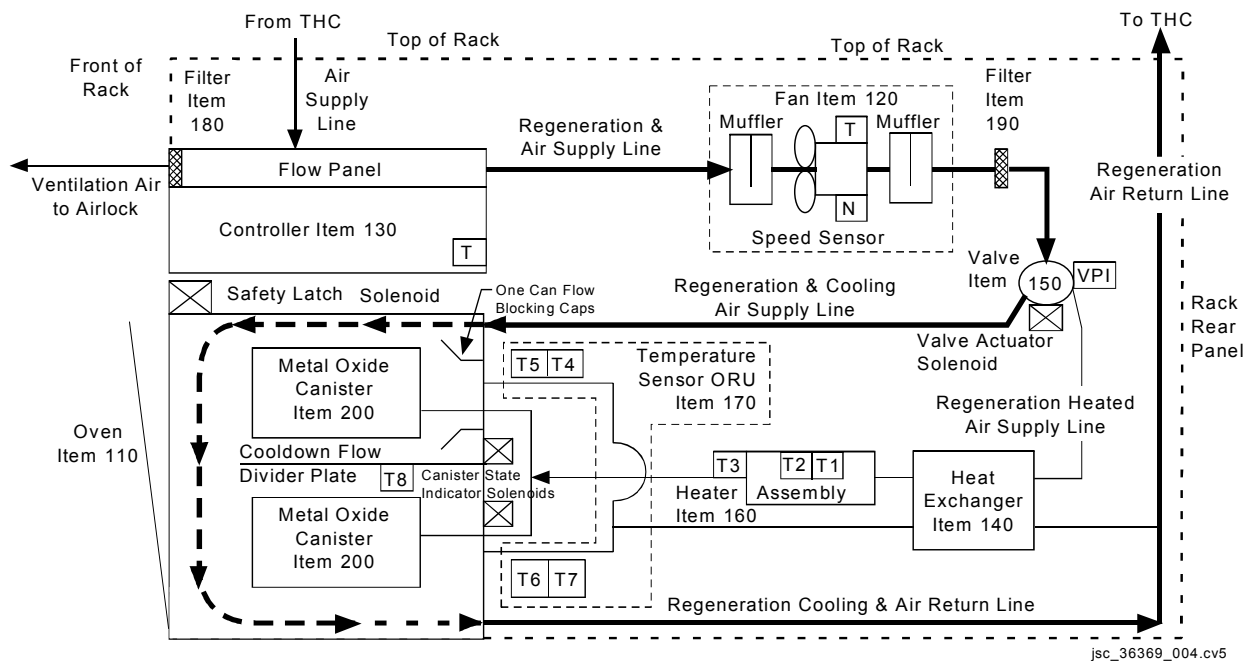


Figure 1.11-12. Metox regeneration schematic - cooldown

1.11.6 Standby Mode

The purpose of Standby Mode is to suspend regeneration during the heating phase to reduce ISS power consumption without aborting regeneration. Regenerator software allows for initiating Standby Mode remotely; however, the airlock MDM was not designed to accommodate this feature. The regenerator can be manually placed in Standby Mode for up to six hours. Once the hold exceeds 6 hours, the regeneration is

terminated. To initiate Standby Mode, the MODE switch is placed in the STANDBY position. If the regenerator is in the heating phase, the STANDBY LOCAL LED (yellow) will be illuminated, the heater and the fan will be turned off, and the TIME REMAINING clock will stop counting down. If the regenerator is already in the cooling phase, only the STANDBY LOCAL LED (yellow) is illuminated. If the regenerator is brought out of Standby Mode in less than six hours, this process is reversed except that the TIME REMAINING clock will not continue countdown until the lower canister outlet temperature (T6) is $> 250^{\circ}\text{F}$ (121°C). If the regenerator is brought out of the Standby Mode after 6 hours has elapsed, then the HEATING LED (green) will be switched off, and the CYCLE ABORT COMPLETE LED (red) will be illuminated.

1.11.7 Cycle Abort

The regenerator can be removed from the heating state by placing the CYCLE switch in the SHUTDOWN position. If the regeneration cycle is aborted (shutdown) during the heating phase, the diverter valve is moved to the cooling position and a six hour cooldown begins. If shutdown is initiated during the nominal cooldown phase, cooldown simply continues. The only difference from a normal cooldown is that the CYCLE ABORT INITIATED LED (green) is illuminated during the cooldown and when cooldown is complete, the CYCLE ABORT COMPLETE LED (red) is illuminated.

1.11.8 Regenerator Dynamics

During the first half hour of regeneration, the oven air inlet temperature increases from 65°F (18°C) to 240°F (116°C) as the oven outlet temperature increases from 65°F (18°C) to 135°F (57°C). After this half hour, the system heat-up ceases and both inlet and outlet temperatures remain constant. This pause occurs to allow the heat to be transferred from the airstreams to the metal oxide bed and evaporate water contained in the bed. The duration of the hold depends on the amount of water in the beds. The hold will last a maximum of 30 minutes. Once the water has evaporated, the system heats up for approximately 30 minutes, increasing oven inlet and outlet temperatures to approximately 350°F (177°C) and 260°F (127°C), respectively. Following this phase, a second pause occurs during which heat removed from the airstreams desorbs and evaporates CO_2 in the canister beds. The length of the pause depends on the CO_2 loading in the beds. Maximum CO_2 loading should result in a 1.5 hour hold. Following CO_2 removal, the heat-up continues until oven inlet and exit temperatures reach 400°F (204°C) and 350°F (177°C), respectively. Figure 1.11-13 presents the oven inlet and outlet temperatures based on a computer simulation of two-bed regeneration.

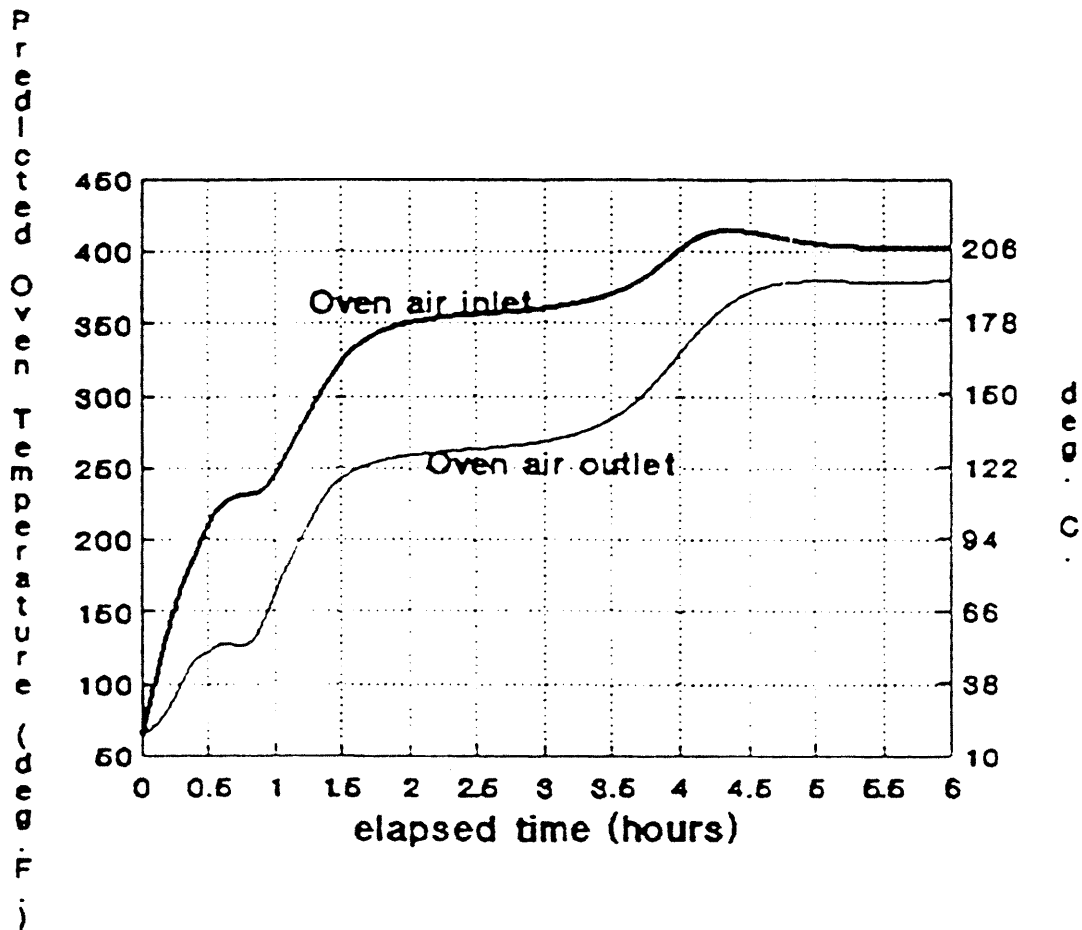


Figure 1.11-13. Regenerator oven temperature profiles during regeneration and heating

The regeneration process is monitored by the controller via oven air outlet temperature of both canisters (T4, T6). These values are compared with T5 and T7 to ensure the readings are reliable. Proper regeneration is assured if T4 and T6 are >250 °F (121° C) after 2 hours and are >350° F (177° C) at the end of the 10-hour heating phase. The time at each temperature is based on maximum CO₂ and water loading.

Regeneration is dependent on sorbent temperature as well as rate of thermal energy imparted to the canister. Higher energy flow results in shorter desorption time. Figure 1.11-14 shows CO₂ concentration at the canister outlet for various airflow levels. The curves represented in Figure 1.11-14 are for a constant temperature of 400° F (204° C). The regeneration is considered complete when the outlet CO₂ concentration level falls below 0.04% (0.03 mmHg). At a flow rate of 15 cfm, the canisters will be completely regenerated in 3 hours. Figure 1.11-15 shows the temperature and flow rate profile of a complete regeneration cycle for canister, bed, inlet and outlet airflows.

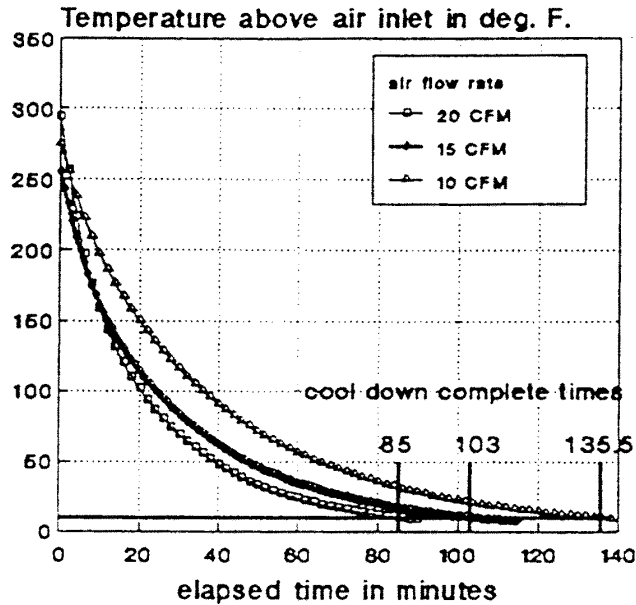
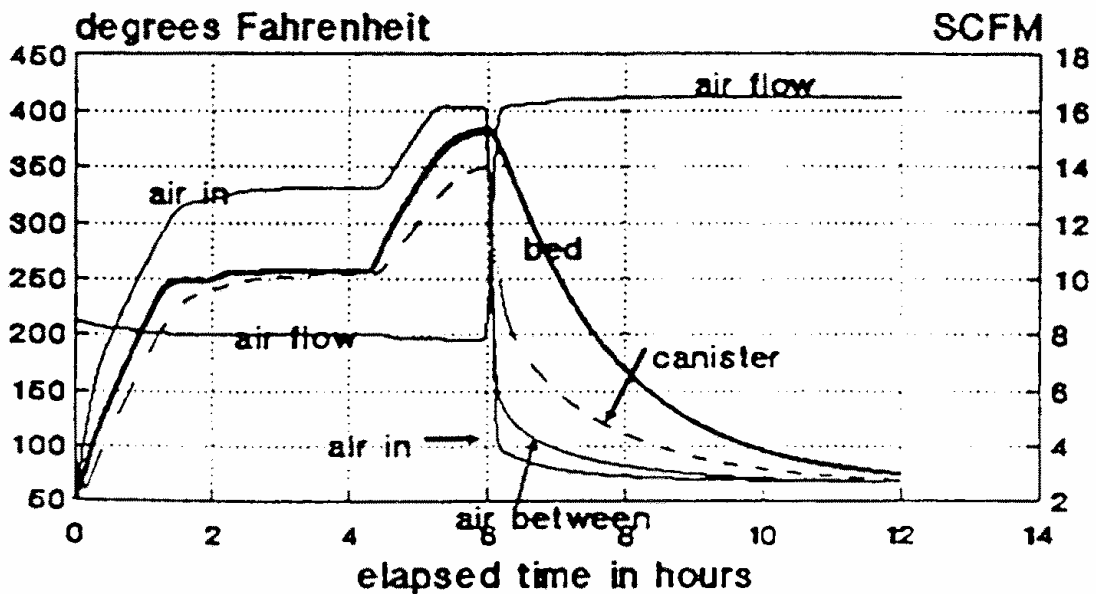


Figure 16. Canister Cool Down Performance

Figure 1.11-14. Regeneration C_0_2 desorption profile



14.7 psia ambient pressure and a
45 degree THC air supply

Figure 1.11-15. Temperature and flow rate profiles
for canisters and sorbent beds

As airflow increases, the time required to cool down the canister decreases, as shown in Figure 1.11-16. In this figure, the temperature between the inlet and outlet cooling air is plotted against time given three different flow rates. Canister cooldown is complete in 103 minutes at 15 cfm.

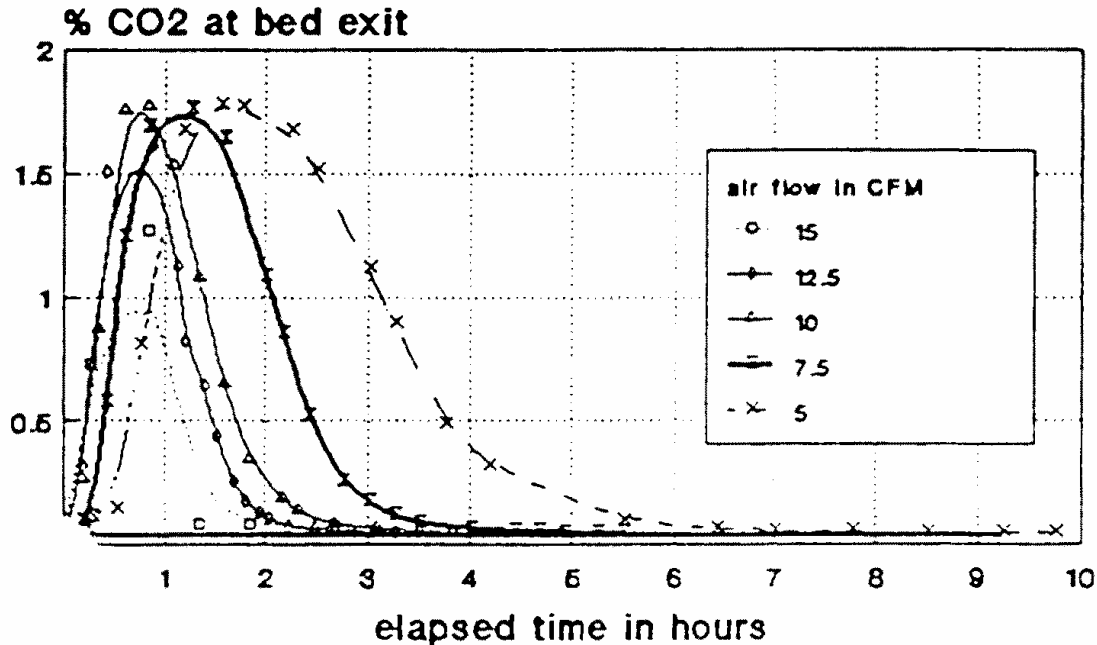


Figure 1.11-16. Canister cooldown performance

1.11.9 Firmware and Controls

1.11.9.1 Firmware

The controller utilizes an 80C186 microprocessor. The application software is reprogrammable by entering the TEST mode and positioning the BOOT discrete to the BOOT position prior to powering up the controller.

A serial PC interface from an RS 485 card is required to interface with the J2 connector on the back of the controller. The serial port provides time remaining, internal voltages, overcurrent status, system state, clock status, fan and heater drive status, and status of the canister state indicators. Additional information is provided on the discrete inputs/outputs, temperature sensor values, and fault codes.

A low power discrete is used to put the controller in low power mode. This mode turns the heater and the fan off and halts the time remaining clock.

A Built-in Diagnostic Test (BIT) is run when the regenerator is powered up. In addition to the BIT logic, the system has a Watch Dog Timer (WDT).

1.11.9.2 Controls

Displays and controls for the regenerator are located on the front panel of the controller box. Reference the Zap card at the front of this section for a layout of the controller display and controls. The function and description of each of the controls is listed below in Table 1.11-2.

Table 1.11-2. Metox regenerator controls

Controller Switches

Switch	Function	Position - Function
POWER	Two-position switch that supplies power to the regenerator	ON/RESET - Powers regenerator OFF - Removes power from regenerator
MODE	Two-position switch that controls the regeneration function	REGENERATE - Allows a regeneration cycle to occur STANDBY - Pauses regeneration cycle
CYCLE	Three-position momentary switch that initiates or stops the regeneration cycle	START - Starts regeneration cycle with heating cycle SHUTDOWN - Aborts heating cycle and starts cooling cycle
FAULT OVERRIDE	Two-position switch used to override faults and continue regeneration	ON - Bypasses non-hazardous faults, enabling regeneration cycle to continue OFF - Bypass not active

LEDs

LED	Function	LED (Color) - Condition
POWER	Indicates power status	ON (Green) - Power switch in ON position
FAULT OVERRIDE ON	Indicates fault override is on	FAULT OVERRIDE (Yellow) - Override switch in ON position
REGENERATE	Indicates phase of regen cycle in progress and when regeneration is complete	HEATING (Green) - Heating phase in process COOLING (Green) - Cooling phase in process COMPLETE (Green) - Regeneration cycle completed
STANDBY	Indicates regenerator is in standby mode	LOCAL (Yellow) - Regenerator put on standby using MODE switch REMOTE (Yellow) - Regenerator put on STANDBY from ground
OVEN HOT	Indicates oven is hot	OVEN HOT (Red) - Oven temperature > 105 o
CYCLE ABORT	Indicates aborted regeneration	INITIATED (Yellow) - User-initiated shutdown in progress INTIATED COMPLETE (Red) - Shutdown complete POWER INTERRUPT (Yellow) - Power interrupt occurred

Fault LEDs

LED	LED Color - Condition
UPPER CAN	Yellow - Fault associated with upper can
LOWER CAN	Yellow - Fault associated with lower can
FLOW	Yellow - Improper flow in upper or lower can
TEMP	Yellow - Improper temperature read by a sensor
CTRL	Yellow - Sensors out of range (sensor failed)
FAN	Yellow - Fan RPMs are high/low
VALVE/DOOR	Yellow - Door not opened wide enough to change the diverter valve from the cooling to heating position prior to starting a cycle
HEATER	Yellow - Heater temperatures out of range

Displays

Display	Function
CONTROLLER DISPLAY	Alphanumeric LCD that displays Time remaining of the 14-hour regeneration cycle Fault codes Start up test sequence

1.11.10 Controller Logic

The controller logic protects against flowing air through a regenerated canister and reloading the bed with CO₂ by setting a cycle initiation fault. The fault logic resets the diverter valve to the cooling position if the CYCLE switch is not moved to the START position within 15 minutes of closing the door and powering up the regenerator. Subsequently, if the CYCLE switch is moved to the START position with the diverter valve in the cooling position, the VALVE/DOOR LED is illuminated, "E02" (error code 2) is displayed on the controller, and the heater and fan are inhibited. To correct this fault, the oven door should be reopened at least 90°, regenerator power should be cycled, and the CYCLE switch moved to the START position.

1.11.11 Fault Detection

The controller uses data from sensors located throughout the regenerator system to monitor the health and operation of the regenerator. The controller monitors the parameters listed in Table 1.11-3 along with the fault detection requirements.

Table 1.11-3. Fault detection requirements

Sensor/Signal	Condition	Fault light	Clock	Shut down	Fault override	When enabled
T1	T1 Out of Range	Heater & Controller	Halt / Resume	Heater & Fan	Yes	Regenerator Powered On
T2	T2 Out Of Range	Heater & Controller	Halt / Resume	Heater & Fan	Yes	Regenerator Powered On
T1 & T2	Both T1 & T2 Out Of Range	Heater & Controller	Halt	Heater	No	Regenerator Powered On
T1 & T2	$T \geq 475^\circ \text{ F}$	Heater & Controller	Halt	Heater	No	Regenerator Powered On
	$T < 225^\circ \text{ F}$	Heater	Halt / Resume	Heater & Fan	Yes	at $2 < t < 9.5$ hrs
	$T < 290^\circ \text{ F}$	Heater	Halt / Resume	Heater & Fan	Yes	at $9.5 < t < 10$ hrs
T1 & T2	Delta T > 16° F when T1 & T2 between 350° F & 450° F range.	Heater	Halt / Resume	Heater & Fan	Yes	Regenerator Powered On
	Delta T > 27° F when T1 or T2 outside 350° F & 450° F	Heater	Halt / Resume	Heater & Fan	Yes	Regenerator Powered On
T1 & T2	$T < 225^\circ \text{ F}$, 2 hours after return to heating state	Heater	Halt / Resume	Heater & Fan	Yes	Return to Heating State
T1, T2, T5 & T6	For return to Heating State; T1, T2, T5 & T6 must meet or exceed stored values prior to leaving heating state	Heater (if T1 or T2 Requirement not met)	Halt / Resume	Heater & Fan	Yes	Return to Heating State
	Max value stored for T1 & T2 is 290° F; and max value for T5 & T6 is 300° F	Lower Can (if T5 or T6 requirements not met)				
T3	Heater Control to 425° F	N/A	N/A	N/A	N/A	Heating State
	T3 Out Of Range	Heater & Controller	Halt	Heater	No	Regenerator Powered On
T4 & T5	$T < 250^\circ \text{ F}$	Upper Can	Continues	N/A	N/A	At $4 < t < 10$ hrs
	$T < 300^\circ \text{ F}$ (Cannot be regenerated)	Upper Can	Continues	N/A	N/A	At $t = 10$ hours
T4 & T5	Delta T > 17° F when T4 & T5 between 250° F & 450° F	Temp	Halt / Resume	Heater & Fan	Yes	Regenerator Powered On
	Delta T > 27° F when both T4 or T5 outside the 250° F to 450° F range	Temp	Halt / Resume	Heater & Fan	Yes	Regenerator Powered On

Table 1.11-3. Fault detection requirements (continued)

Sensor/Signal	Condition	Fault light	Clock	Shut down	Fault override	When enabled
T4 & T6	Upper Light & Lower Can lights On	Flow, Upper Can, Lower Can	Halt / Resume	Heater & Fan	Yes	4 < t < 10 hrs
T6 & T7	T < 250° F	Lower Can	Continues	N/A	N/A	4 < t < 10 hrs
	T < 300° F (Can not regenerated)	Lower Can	Continues	N/A	N/A	At t = 10 hours
T6 & T7	Delta T > 17° F when T6 & T7 between 250° F & 450° F	Temp	Halt / Resume	Heater & Fan	Yes	Regenerator Powered On
	Delta T > 27° F when both T6 or T7 outside the 250° F to 450° F range	Temp	Halt / Resume	Heater & Fan	Yes	Regenerator Powered On
T4 - T7	Any or all of T4 - T7 Out Of Range	Temp	Halt / Resume	Heater & Fan	Yes	Regenerator Powered On
T8	T8 > 105° F and t = 14 hours	Oven Hot & Flow	0:00	Door remains locked	Manual Override	t = 14 hours
	T8 out of range	Controller	Halt / Resume	Heater & Fan	Yes	Regenerator Powered On
Fan Speed	RPM > 22,000 RPM	Fan & Controller	Halt	Heater & Fan	No	Regen Powered On and 2 min since fan shut off
	Fan underspeed 30,000 RPM	Fan & Controller	Halt	Heater & Fan	No	15 secs after fan startup
	Fan overspeed 60,000 RPM	Fan & Controller				
	Fan underspeed 40,000 RPM	Fan & Controller	Halt / Resume	Heater & Fan	Yes	60 secs after fan startup
	Fan overspeed 60,000 RPM	Fan & Controller				
Fan Current	High current to Fan	Fan & Controller	Halt	Heater & Fan	No	15 secs after fan startup
	High current to motor controller DC/DC converter (Hi current causes speed fault)					
Motor Temp (T10)	Motor temp > 185° F causes a speed fault	Fan & Controller	Halt	Heater & Fan	No	15 secs after fan startup
Valve Position Indicator	Position indicator out of configuration	Valve/Door	Halt / Resume	Heater & Fan	Yes	During Regen Cycle

Table 1.11-3. Fault detection requirements (continued)

Sensor/Signal	Condition	Fault light	Clock	Shut down	Fault override	When enabled
	Valve not in commanded position (i.e. In cooling after 15 minutes of idle)	Valve/Door	Halt / Resume	Heater & Fan	Yes	During Idle state
Door Position Indicator	Door not latched / Closed	Valve/Door	Halt / Resume	Heater & Fan	Yes	During Regen Cycle
Standby Mode Active	Standby Mode at cycle startup	Flashing Standby LED	Off	Prevents cycle startup	No	At beginning of cycle
Fault Override Active	Fault Override active at cycle startup	Flashing fault override LED	Off	Prevents cycle startup	No	At beginning of cycle
Controller Thermostat (T9)	Temp of controller > 100° C (212° F) Located on driver board	Power LED off	Off	Heater, Fan, Controller & Solenoids	No	Regenerator Powered On
Heater Voltage Feedback	Heater Voltage < Heater operating voltage	Heater & Controller	Halt	Heater	No	Heater On
	Heater Voltage > Heater Off Voltage	Controller	Halt	Heater	No	Heater Off
Heater Current Sensor	Heater Current > 6.2 - 12.8 amps	Heater	Halt	Heater	No	Regenerator Powered On
Controller Over-current Protection (External)	Controller current > 14.4 amps	Power LED off	Off	Heater, Fan, Controller & Solenoids	No	Regenerator Powered On
Upper & Lower Can Solenoids(2) Overcurrent	Solenoid current > 2.1 - 4.4 amps	Controller	Halt	Heater & Fan	No	Regenerator Powered On
Valve Solenoid Overcurrent	Solenoid current > 2.1 - 4.4 amps	Controller/Valve Door	Halt	Heater & Fan	No	Regenerator Powered On
Door Solenoids Overcurrent Protection (2)	Solenoid current > 2.1 - 4.4 amps	Controller/Valve Door	Halt	Heater & Fan	No	Regenerator Powered On
Severe Overcurrent	Current > 7.0 - 14.6 amps	Controller	Halt	Heater & Fan	No	Regenerator Powered On
Internal Controller Inputs	Controller Internal Self Health Test	Controller	Halt	Heater & Fan	No	Regenerator Powered On

Table 1.11-3. Fault detection requirements (concluded)

Sensor/Signal	Condition	Fault light	Clock	Shut down	Fault override	When enabled
Canister State Solenoid Feedback	Solenoid Voltage Low (Solenoid Off) - Solenoid command on. But no action	Controller	Continue	N/A	N/A	Solenoid should be active
	Solenoid Voltage High (Solenoid On) - Solenoid command off. But it is on	Controller	Halt	Fan and open sever switch	No	Solenoid should be active
Boot Discrete	Boot discrete active while Test discrete in-active	Controller	Halt	Heater & Fan	No	Regenerator Powered On
Regular & Watchdog	Time Difference > Allowable time step	Controller	Halt	Heater & Fan	No	Regenerator Powered On

The controller uses approximately 100 preprogrammed error codes to alert the user of a specific failure or off-nominal condition within the regenerator. These error codes along with their associated fault LEDs are displayed on the controller front panel for fault detection. There are various handling actions associated with the faults as listed in *Table 1.11-4*. The handling actions are described below:

Table 1.11-4. Faults and associated actions

OK_OVER	The fault can be overridden and the regeneration can be continued. The regeneration is halted until the FAULT OVERRIDE switch is activated or until 6 hours have elapsed since the fault appeared. After 6 hours, the regenerator will abort to the cooldown mode.
STATUS	This fault does not warrant stopping the regeneration; however, it makes the user aware of a potential problem further down the line and encourages the user to monitor the regeneration more closely.
ABORT	The regeneration has been aborted to the cooldown mode. The canisters may not be completely regenerated (inspect canister state indicators).
DEAD	Power to the fan and the heater is shut off. The regeneration cycle is terminated, and the canisters may not be completely regenerated (inspect canister state indicators). The power must be cycled before any further action can be taken.
NOSTART	The regenerator will not start until fault is cleared.

Table 1.11-5. Controller error codes

Error Code	Description	Handling	LED 1	LED 2
1	Start with door open	NOSTART	VALVE/DOOR	
2	Start with bypass valve in cooling position	NOSTART	VALVE/DOOR	
3	Start in standby mode	NOSTART	STANDBY- LOCAL	
4	Start in remote standby	NOSTART	STANDBY - REMOTE	
5	Start with fault override active	NOSTART	FAULT OVERRIDE ON	
6	Standby mode lasted too long (> 6 hours)	ABORT	STANDBY- LOCAL	STANDBY - REMOTE
7	BOOT without TEST switch	OK_OVER	CTRL	
8	RAM test failure	DEAD	CTRL	
9	ROM test failure	STATUS	CTRL	
10	Upper canister solenoid overcurrent	DEAD	CTRL	
11	Lower canister solenoid overcurrent	DEAD	CTRL	
12	Door unlock solenoid overcurrent	DEAD	CTRL	VALVE/DOOR
13	Door lock solenoid overcurrent	DEAD	CTRL	VALVE/DOOR
14	Valve solenoid overcurrent (diverter?)	DEAD	CTRL	
15	120V supply overcurrent	DEAD	CTRL	
16	?			
17	V1 reference is too high	DEAD	CTRL	
18	V2 reference is too high	OK_OVER	CTRL	
19	V1 reference is too low	DEAD	CTRL	
20	V2 reference is too low	OK_OVER	CTRL	
21	Zero 1 reference is too high	DEAD	CTRL	
22	Zero 2 reference is too high	OK_OVER	CTRL	
23	Zero 1 reference is too low	DEAD	CTRL	
24	Zero 2 reference is too low	OK_OVER	CTRL	
25	+12V too high	ABORT	CTRL	
26	-12V too high	ABORT	CTRL	
27	+12V too low	ABORT	CTRL	

Table 1.11-5. Controller error codes (continued)

Error Code	Description	Handling	LED 1	LED 2
28	-12V too low	ABORT	CTRL	
29	Upper can indicates regen; but commands expended	DEAD	CTRL	
30	Upper can indicates expended, but commands regen	STATUS	CTRL	
31	Lower can indicates regen, but commands expended	DEAD	CTRL	
32	Lower can indicates expended, but commands regen	STATUS	CTRL	
33	Watchdog never ready	ABORT	CTRL	
34	Watchdog reset too wide	ABORT	CTRL	
35	Fan < 20 KRPM	DEAD	FAN	CTRL
36	Fan < 40 KRPM	OK_OVER	FAN	CTRL
37	Fan > 65 KRPM	DEAD	FAN	CTRL
38	Fan > 60 KRPM	OK_OVER	FAN	CTRL
39	Fan did not turn off	ABORT	FAN	CTRL
40	Heater overcurrent	ABORT	HEATER	
41	Heater undervoltage when on	ABORT	HEATER	CTRL
42	Heater overvoltage when off	DEAD	HEATER	
43	Heater on after severe overcurrent	ABORT	HEATER	
44	Heater too slow	OK_OVER	HEATER	
45	Door open while regenerating	OK_OVER	VALVE/DOOR	
46	Valve not cooling	OK_OVER	VALVE/DOOR	
47	Valve not heating	OK_OVER	VALVE/DOOR	
48	Valve not at limit fault	OK_OVER	VALVE/DOOR	
49	Valve limits bad fault	OK_OVER	VALVE/DOOR	
50	T1 invalid low	OK_OVER	HEATER	CTRL
51	T2 invalid low	OK_OVER	HEATER	CTRL
52	T1 invalid high	OK_OVER	HEATER	CTRL
53	T2 invalid high	OK_OVER	HEATER	CTRL
54	T1 & T2 invalid	ABORT	HEATER	CTRL
55	T1 Overtemp	OK_OVER	HEATER	CTRL

Table 1.11-5. Controller error codes (continued)

Error Code	Description	Handling	LED 1	LED 2
56	T2 Overtemp	OK_OVER	HEATER	CTRL
57	T1 & T2 Overtemp	ABORT	HEATER	CTRL
58	T1 Undertemp	OK_OVER	HEATER	
59	T2 Undertemp	OK_OVER	HEATER	
60	T1 & T2 Undertemp	OK_OVER	HEATER	
61	T1 Undertemp at end of regeneration	OK_OVER	HEATER	
62	T2 Undertemp at end of regeneration	OK_OVER	HEATER	
63	T1 & T2 Undertemp at end of regeneration	OK_OVER	HEATER	
64	Heater Delta T	OK_OVER	HEATER	
65	T8 Invalid low	OK_OVER	CTRL	OVEN HOT??
66	T8 Invalid high	OK_OVER	CTRL	OVEN HOT
67	Flow	OK_OVER	FLOW	
68	Watchdog lost sync	ABORT	CTRL	
69	watchdog sync early	ABORT	CTRL	
70	T3 very hot	ABORT	HEATER	CTRL
71	T3 invalid low	ABORT	HEATER	CTRL
72	T3 invalid high	ABORT	HEATER	CTRL
73	T4 invalid low	OK_OVER	TEMP	
74	T5 invalid low	OK_OVER	TEMP	
75	T4 invalid high	OK_OVER	TEMP	
76	T5 invalid high	OK_OVER	TEMP	
77	T4 & T5 invalid high	OK_OVER	TEMP	
78	T4 undertemp	STATUS	UPPER CAN	
79	T5 undertemp	STATUS	UPPER CAN	
80	T4 & T5 undertemp	STATUS	UPPER CAN	

Table 1.11-5. Controller error codes (concluded)

Error Code	Description	Handling	LED 1	LED 2
81	T4 no heat spike	STATUS	UPPER CAN	
82	T5 no heat spike	STATUS	UPPER CAN	
83	T4 & T5 no heat spike	STATUS	UPPER CAN	
84	?			
85	T6 invalid low	OK_OVER	TEMP	
86	T7 invalid low	OK_OVER	TEMP	
87	T6 invalid high	OK_OVER	TEMP	
88	T7 invalid high	OK_OVER	TEMP	
89	T6 & T7 invalid	OK_OVER	TEMP	
90	T6 undertemp	STATUS	LOWER CAN	
91	T7 undertemp	STATUS	LOWER CAN	
92	T6 & T7 undertemp	STATUS	LOWER CAN	
93	T6 no heat spike	STATUS	LOWER CAN	
94	T7 no heat spike	STATUS	LOWER CAN	
95	T6 & T7 no heat spike	STATUS	LOWER CAN	
96	Lower can too slow	OK_OVER	LOWER CAN	
97	Upper can delta temp	OK_OVER	TEMP	
98	Lower can delta temp	OK_OVER	TEMP	
99	Hot at end of cooling	OK_OVER	FLOW	OVEN HOT

1.11.12 ISS System Interfaces

1.11.12.1 Electrical

The regenerator controller's J1 connector interfaces with the 120 V dc source via RPCM AL-2A3B-C. The J2 connector interfaces with the RS 485 cable for serial data.

The regenerator frame is nickel plated for ORU grounding. The electrical ground path can be referenced in the Regenerable Metal Oxide Based Extravehicular Mobility Unit (EMU) Atmospheric Control System Critical Design Review (CDR) package, p. 38. The wiring harnesses are also shown in the CDR package (pg. 43).

Table 1.11-6 provides a power summary for the regenerator components that draw power at various phases of operation.

Table 1.11-6. Power summary

MODE ITEM	Warm-up (heater 100%, fan 100%) MAX POWER	Heating mode (heater 65%, fan 100%) AVG POWER	Cooldown mode (heater off, fan 100%) AVG POWER	Standby (heater off, fan off) AVG POWER
Controller	16	16	16	16
Heater	550	358	0	0
Heater Drive	5.7	2.4	0	0
Fan	88	88	88	0
Fan Drive	17	17	17	0
Sever	1.6	0.7	0	0
EMI Filter	6.7	4.8	1.21	0.16
Total Power	685 Watts	486.9 Watts	122.21 Watts	16.16 Watts

1.11.13 ISS Environmental Control and Life Support System (ECLSS)

The ventilation flow through the airlock is configured for either 14.7 psi operations or for 10.2 psi campout operations. Nominally, the complete Metox Regeneration cycle will be accomplished during 14.7 psi operations post EVA. However, back-to-back EVAs will require performing regeneration during the EVA up through hatch closure for the campout in order to maximize the number of possible EVAs

In most cases, the CCAA fan will be activated to aid in circulating flow through the regenerator. Airlock air is pulled in through the HEPA filters via the CCAA fan and is routed through the CO₂ removal box to the inlet of the regenerator. The gas is then circulated through the regenerator for canister regeneration. The outlet gas of the regenerator is routed back to the CCAA, where the flow is split. Part of this flow is expelled to the airlock atmosphere via the supply diffuser and to the left port on the coupling panel. This part of the flow is then drawn in by the Node 1 fan through the right port on the coupling panel and directed by Intramodule Ventilation (IMV) to the ISS cabin for conditioning by the ISS Temperature and Humidity Control (THC) system, the Carbon Dioxide Removal Assembly (CDRA), and the Trace Contaminant Control

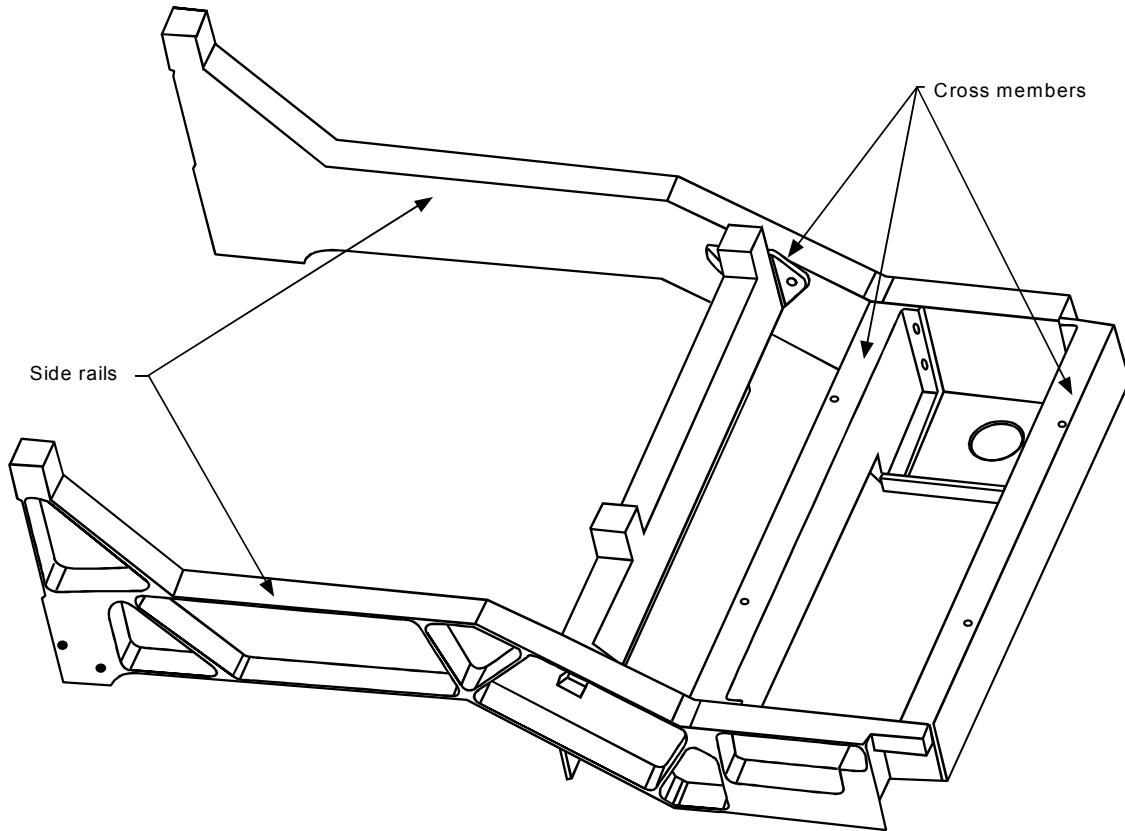
Subassembly (TCCS). Once air is conditioned by ISS ECLSS systems, it is then routed back to the airlock through the open hatch and re-circulated. The remainder of flow is redirected to the CO₂ removal box and regenerator.

In the event that back-to-back EVAs are required, the heating phase of regeneration can be started during the time that the previous crew is performing the EVA and continued during repress and post EVA operations, provided that the Node hatch is open. The Node 1 STBD hatch must be open during the heating phase to provide circulation via the ISS ECLSS systems. This configuration is necessary to prevent recirculating CO₂ laden air through the isolated airlock volume as CO₂ is being baked out of the metox canisters. Regeneration must then be interrupted until the next EVA has begun. During cooldown, airflow is circulated around the canisters (not through them) to cool them down following regeneration.

During campout, the airlock is isolated at 10.2 psi. and the CCAA is active to scrub CO₂ from the airlock environment. Airlock air is pulled in through HEPA filters via the CCAA fan and is routed through a CO₂ removal box. This box provides an interface to the metox canisters for atmosphere scrubbing. Refer to ISS Joint Airlock Systems Training Manual sections 8 and 9 for more information on the CCAA, ventilation plumbing and the CO₂ Removal Box. Currently, the design of the regenerator/CO₂ Removal box diverter valve precludes simultaneous regeneration and atmosphere scrubbing.

1.11.14 Mechanical

The regenerator is installed through the front of the rack using both static and manually actuated pins. The static pins are located on the back of the regenerator housing and engage brackets contained at the back of the rack. The manually actuated pins are located in the front of the regenerator housing and are installed when the assembly is aligned with the mating holes in the front rack posts. These pins are captive and are driven in by a threaded feature in the regenerator frame. A captive fastener is screwed in the front right side of the package, while a captive shimming device is screwed on the left side to remove the gap between the regenerator frame and the rack posts. The regenerator is housed in a nickel plated frame (*Figure 1.11-17*). The controller and the fan mount above the frame, while the oven, heat exchanger, and diverter valve mount below the frame.



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Figure 1.11-17. Regenerator frame assembly

If an ORU changeout is required, a procedure will need to be coordinated via CHIT since it is not a published procedure yet.

1.11.15 Test Data

TBD: Working on defining requirements for test data; HSWL in process of sending this information.

1.11.16 Related Documentation References

1.11.16.1 Flight Rule References

TBD




1.11.16.2 Malfunction Procedure References

TBD

1.11.16.3 Analysis/Test References - General References

- A. Development Status of the Metal Oxide Regenerable CO₂ Removal System for the NASA EMU; SAE Technical Paper Series, 972505; LeRoy B. Butler, Jr., Jeffrey J. Faszczka, Gretchen A. Thomas; SAE Technical Paper Series, 972505; 27th International Conference of Environmental Systems, July 1997.
- B. Critical Design Review Data Package, DRL8, METOX-8-001; Hamilton Standard Space Systems International, inc.; Tim Nalette; prepared for NASA, contract NASA 9-19520, July 1996.
- C. Critical Items List (CIL), DRL 16, Regenerable Metal Oxide Based EMU Atmosphere Control System; Hamilton Standard Space Systems International, inc.; Scott Schneider, July 1996.
- D. Failure Modes and Effects Analysis (FMEA), DRL 15, METOX-15-001, Rev. A. Hamilton Standard Space Systems International, inc.; Scott Schneider, April 1998.
- E. Hamilton Standard's ORU procedures
- F. SHVHER18042
- G. Regenerable Metal Oxide Based Extravehicular Mobility Unit (EMU) Atmospheric Control System (METOX) Critical Design Review, Hamilton Standard/NASA - JSC; August 1996.

EVA		Reference only	
ELEMENT	EVA Related Stowage		PAGE
AL			1
FEMU-R-003: On-orbit Memory Jogger			
Only previous issues are listed here (see FEMU-R-003 for comprehensive list)			
<p>Metox Canister / Metox Regen / CO2 Removal Box</p> <ul style="list-style-type: none"> o Do NOT stow cans in Regenerator for long periods o The CO2 removal box valve should be in removal position when the Regenerator is not in use. o WARNING PLACARD: Do NOT block outlet of CO2 removal box. 		<p>Magnetic Consideration: EMU Pump Rotor, SAFER HCM Hardmount MPLM</p> <ul style="list-style-type: none"> o May freeze, therefore nothing wet (LCVG, IEU, SEMU, DCM ORU, PLSS ORU, etc.) <p>SEMU</p> <ul style="list-style-type: none"> o <u>Covered:</u> Neck ring vent port, PLSS (TMG zipped), HUT MWC, DCM (flap up), Helmet (Durette) o <u>Installed:</u> Water sw guard, LiOH or vent port plug o <u>Interior Approved:</u> LCVG, MWC cover, DIDB, CCA, ECOK (see list in FEMU-R-004- only soft items) o <u>Not Installed:</u> ERCA, Helmet Lights, Metox Canister, MWS T-bar w/o foam o <u>Important Switches:</u> O2 Act / PWR / WATER / FAN - OFF, DCM Purge vlv - Open (up) o <u>In Airlock:</u> LTA Restaint Bag installed, attached to AAP, tightened with no loose hooks o <u>In Middeck:</u> All above plus 20-g crash bag installed. <p>SCU</p> <ul style="list-style-type: none"> o <u>Installed:</u> Attached to AAP (not EMU), strapped to wall o <u>Important Switches:</u> (AW82) EV-1,2 Water Waste vlv's (two) closed, H2O Waste regulator handle (two) in Regulating position. <p>AAP</p> <ul style="list-style-type: none"> o <u>Handle:</u> locked in 0-degree position (parallel to verticle strut, pull ring retracted.) <p>LiOH Canister</p> <ul style="list-style-type: none"> o <u>In EMU:</u> Properly oriented (idenification tag visible, flush with back of EMU), latches locked. <p>EMU Battery</p> <ul style="list-style-type: none"> o <u>In EMU:</u> latches locked. o <u>In Middeck/MPLM:</u> stow in launch location to insure proper protection; bagging is not generically req'd. <p>Metox Canister</p> <ul style="list-style-type: none"> o <u>Installed:</u> Port caps or Kapton tape o <u>Packaging:</u> specific foam or cushioning approved by Hamilton; Shall not be stowed in SEMU for landing. <p>ISS EMU Umbilical</p> <ul style="list-style-type: none"> o <u>Installed:</u> Hdwr specific protective covers on both ends o <u>Packaging:</u> must meet minimum bend radius req'ts <p>Loose SSA</p> <ul style="list-style-type: none"> o <u>Installed:</u> Hdwr specific protective covers o <u>LTA/ Waist Brief:</u> Scissors removed, nothing inside o <u>CCA:</u> protect microphone from bending. o <u>Glove:</u> specific foam or cushioning approved by HS <p>EMU ORU Component level (DCM, PLSS, HUT, SOP)</p> <ul style="list-style-type: none"> o <u>Installed:</u> component specific protective covers, bagging if possible water leakage o <u>Packaging:</u> specific foam or cushioning approved by HS 	
SAFER: Hdwr Return Memory Jogger			
<p>NOTE: Details are normally included on the Transfer List in "Constraints"; NOT covered by generic procedures!</p> <ul style="list-style-type: none"> o <u>Packaging:</u> Specific foam cut-out. ISS Airlock bag stays. o <u>Installed:</u> Power switch guard (from launched unit), Inhibitor Plug o <u>Not Installed:</u> HCM is NOT to be in HCM tray. <p>STS-114 EXAMPLE of Transfer List "PROCEDURES/Constraints/ **Comments":</p> <p>For launched unit: Needed for EVAs. Remove and stow sw itchguard in foam for returning SAFER. Transfer on FD10 per POST EVA TRANSFER AND RECONFIG (FDF: EVA FS, Airlock Config)</p> <p>For return unit: Remove SAFER from Stow age Bag and then transfer. Stow age Bag remains in ISS A/L. Stow switchguard on Hand Controller. Stow Hand Controller deployed, inhibitor installed. Remove and trash old SAFER Checkout Results Cue Card.</p>			

EVA		Reference only	
ELEMENT AL	EVA Related Storage		PAGE 2
		<ol style="list-style-type: none">2. FEMU-R-004, EMU Launch and Landing Stowage Requirements and Constraints (latest version available on MOD EVA Homepage)3. For hardware weights and volumes, see ESEL manifests on the XA Homepage: http://evaweb.jsc.nasa.gov4. For locating current stowage on ISS, consult the Inventory Management System (IMS) database, using one of these methods:<ol style="list-style-type: none">a. JEDI's Web-based IMS Search: find single piece of http://mod.jsc.nasa.gov/imsb. IMS Server Application (PC Download, Read Only Access): Search w/ tree structure e.g. Bag contents, etc. [Logon ID#1: ISSEVA1, Password = eva8591] [Logon ID#2: ISSEVA2, Password = eva8592]c. Contact ISO console (For EVA specific POC: see ISO Homepage link below)6. ISO Homepage: http://mod.jsc.nasa.gov/do5/iso/5. For STS Launch / Landing stowage locations a.k.a. Locker Layout, step (1) consult specific flight's "Locker Layout" summary at https://opo.jsc.nasa.gov/cs/ig/, then step (2) use drawing numbers to search EDCC database.7. ISS Location Code CBT: http://ta1.tx.usa-spaceops.com/ta_cbt/Loc_code/Location_Coding_start.htm8. Generic ISS Tool Stowage updates (on V: drive): \\Jsc-mas-is1\private\EVA\ISS Tool Configuration	
			
			

1.12 AIRLOCK STOWAGE

1.12.1 Quick look reference data

Table 1.12-1 provides the specifications for many of the ISS airlock stowage volumes.

Table 1.12-1 Stowage specifications

Description	Specification	Comments
Dimensions:		
Floor and ceiling bins	16.05"(l) by 14.4"(w) by 8.3"(d)	1.2 ft ³
CTBs		Cargo Transfer Bag (CTB)
Half	9.25"(h) by 16.75"(w) by 9.75"(d)	0.92 ft ³
Full	9.25"(h) by 16.75"(w) by 19.75"(d)	1.9 ft ³
Double	19.75"(h) by 16.75"(w) by 9.75"(d)	3.8 ft ³
M-02 Bag	21"(h) by 35.31"(w)20"(d)	8.5 ft ³
Crewlock Bag Assembly:		
EVA Bag	L17" by W12" by D7.5"	~ 0.9ft ³
IV/Staging Bag	L36" by W14"(9") by D7.5"	~ 1.2ft ³

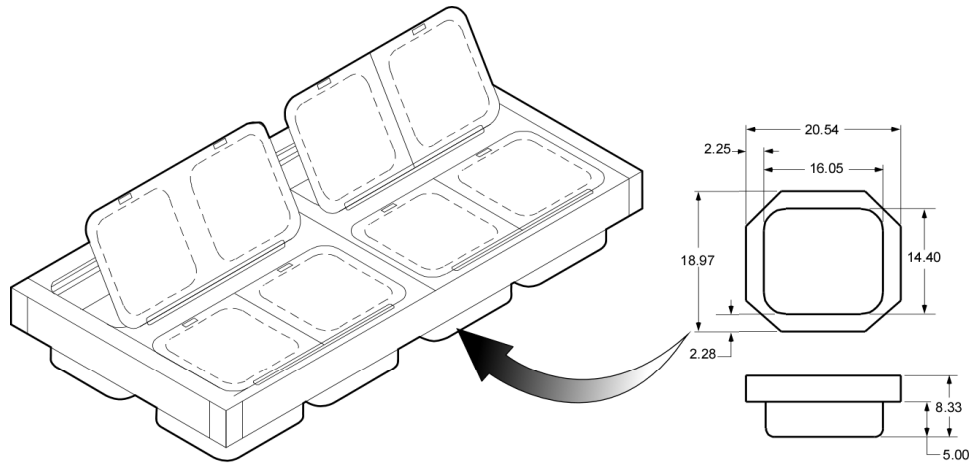
1.12.2 General Description

Four different types of containers provide stowage for the Joint Airlock: stowage bins, three sizes of Cargo Transfer Bags (CTBs), an M-02 bag, and a Crewlock bag assembly. There are 16 stowage bins, 8 are located on the floor, the other eight (8) are on the ceiling of the Equipment Lock (E/L). The M-02 bag and the CTBs are also located in the E/L. These bags are fabricated from Nomex with removable/moveable dividers used to transport, transfer, and store cargo for the ISS. The CTB (Figure 1.12-2) is available in four sizes, the M-02 bag in one. They have handles for transportation, contain clear pockets for identification labels, and have external Velcro to facilitate on-orbit stowage. The M-02 bag and the CTBs replaced the earlier design of two aisle stowage containers and six soft stowage bags referred to as 7-inch bags. This configuration was changed for a variety of reasons including better design, ease of use, similarity across ISS, etc. The Crewlock bag assembly is stowed in the endcone of the Crewlock. This bag assembly contains four EVA bags, an IV bag, and a staging bag. These bags are used to stow EVA items such as Mini-Work Stations (MWSs), tethers, caddies, EVA tools, cameras, thermal mittens, Display and Control (DCM) plugs, small ORUs, etc. The EVA bags are held in place by quarter-turn fasteners but can be removed and taken to work sites to facilitate equipment management by crewmembers.

1.12.3 Subsystem Details

1.12.3.1 Location and Structure

Sixteen stowage bins are located in the E/L; eight bins in the ceiling and eight bins in the floor. Piano-hinged doors that are unlatched by lifting and turning recessed rings on the doors cover these bins. There are two latches per door, each door covering two bins.



Equipment Lock Bins (1 floor, 1 ceiling)

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Figure 1.12-1. Equipment lock stowage bins

The M-02 bag and the various CTBs are attached to the airlock structure with the use of bungees. Figure 1.12-2 shows a typical stowage configuration.



Figure 1.12-2. Equipment lock stowage configuration

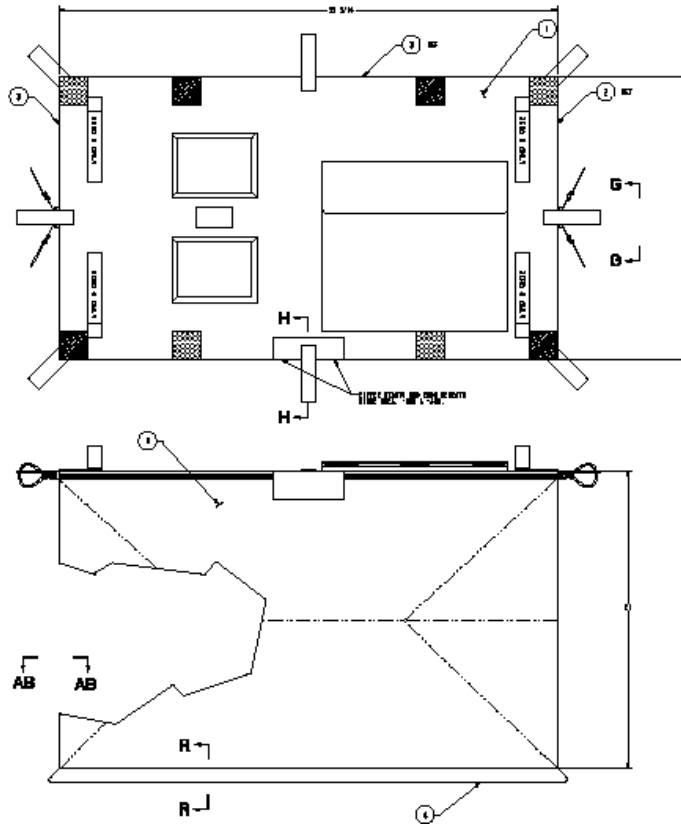


Figure 1.12-3. M-02 bag

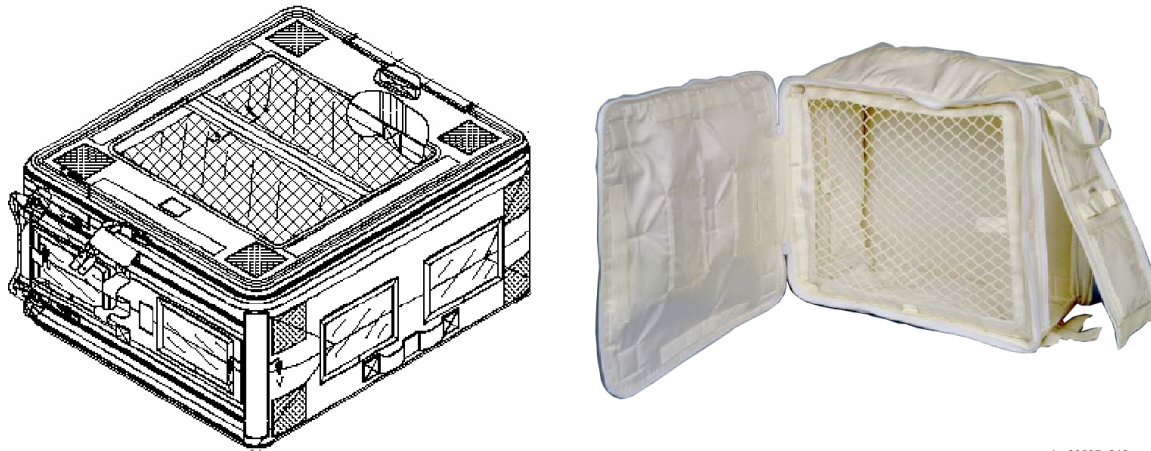


Figure 1.12-4. Single cargo transfer bag

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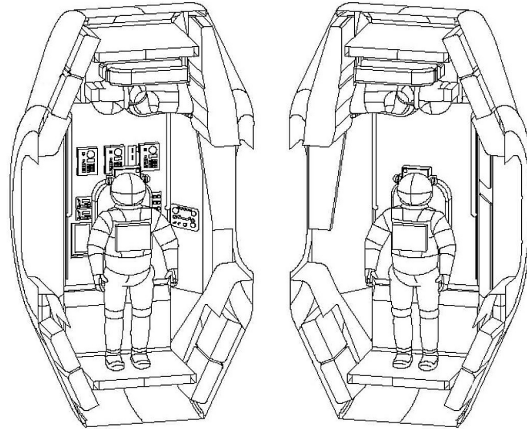


Figure 1.12-5. Stowage locations in equipment lock

The Crewlock Bag Assembly resides in the endcone of the Crewlock. This bag assembly is comprised of several smaller bags, including four EVA bags, a staging bag, and an Intravehicular (IV) bag.



Figure 1.12-6. Crewlock bag assembly



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Figure 1.12-7. Crewlock EVA bag

EVA Bags

Windowed doors made of clear plastic are attached at the top of the EVA bags via fabric hinges and provide both visibility of and access to bag contents. Each door is secured shut by two quarter-turn fasteners to prevent escape of contents. These bags can be taken to the worksite with the crewmember. Two versions of this bag are snapped together for stowage in the Crewlock. The -301 version had a row of male snaps along one bottom edge while the -303 version had a 2-inch protruding flap along the opposing bottom edge, which is equipped with a row of female snaps for interface with the -301 bag. Each bag contains equipment tethers and D-rings for equipment restraint when the bags are opened. The EVA bags can be attached to an equipment tether via a hook stitched to one bottom end of the bag. Alternatively, the bag can attach to the body restraint tether.

Staging Bag

The staging bag is rectangular in shape with a curved side. This bag lays in the endcone next to two of the EVA bags and contains items such as the DCM plug, contingency tools, etc. This bag is rounded on one side to follow the contour of the endcone circumference. This is the only bag that can be accessed with the EV hatch in the open position.

IV Bag

This bag is similar in size and shape to the staging bag, but lies on the opposite side of the EVA bags nearest the EV hatch. The IV bag contains EVA contingency items such as the contamination detection kit and contingency hatch tools.

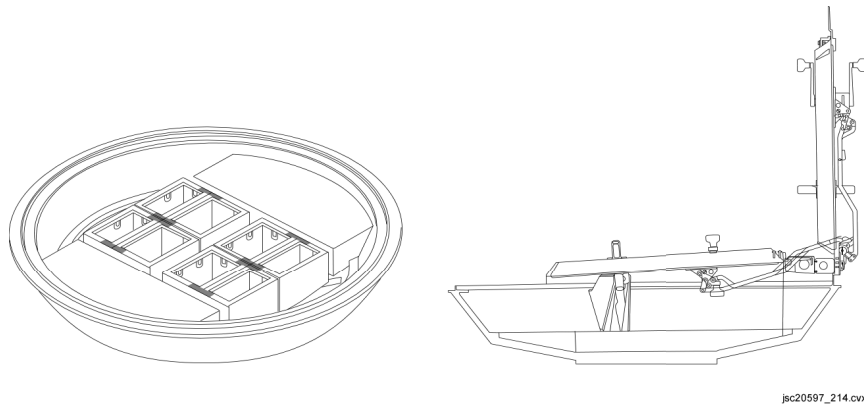


Figure 1.12-8. Layout of stowage bags

Stowage bins are an integrated structure of the Crewlock. All soft stowage bags are made of Nomex.

1.12.4 EMU Stowage

The EMUs should be stowed in a fully assembled configuration. Certain operational constraints may preclude such stowage. The two prime EMUs are stowed on the EDDAs, while the third EMU is stowed on the ceiling of the E/L between the Oxygen Recharge Compressor Assembly (ORCA) and the Aisle Stowage Container (ASC).



Figure 1.12-9. Typical EMU stowage configuration

1.12.5 EMU Don/Doff Assembly

Table 1.12-2 provides the EDDA specifications.

Table 1.12-2. EDDA specifications

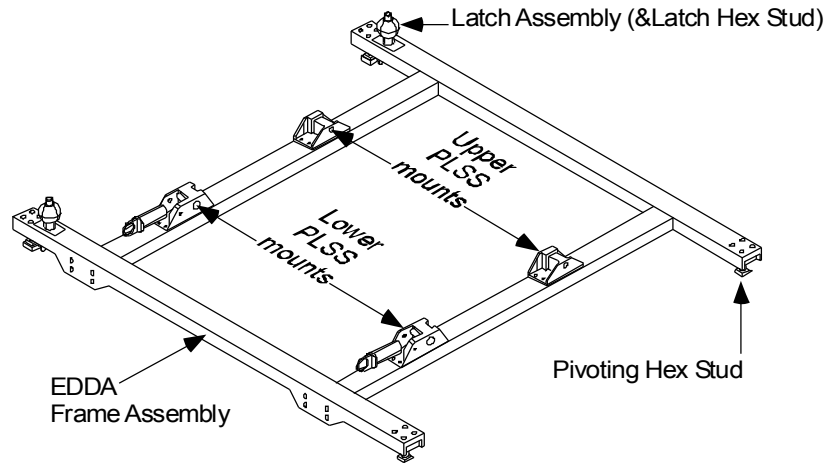
Description	Specification	Comments
Part number	SEG 39128210-301	
Dimensions (in)	40.00 by 42.00 by 5.87	±0.01 in.
Weight (lb)	24.0	<25 lbs max
Location	Avionics rack and Communications Carrier Assembly (CCA) rack in E/L	2 units. No spare on ISS
Manufacturer	Lockheed Martin	Houston, TX
Sustainable donning load (lb)	400 (vertical direction)	Design incorporates a 1.5 factor of safety
Inadvertent kick load (lb)	125	

1.12.5.1 Functional Description

The EDDA provides restraint of the EMU during EVA prep and post activities, as well as stowage of the EMU when it is not being used. The EDDA functions may be described briefly in one of three categories:

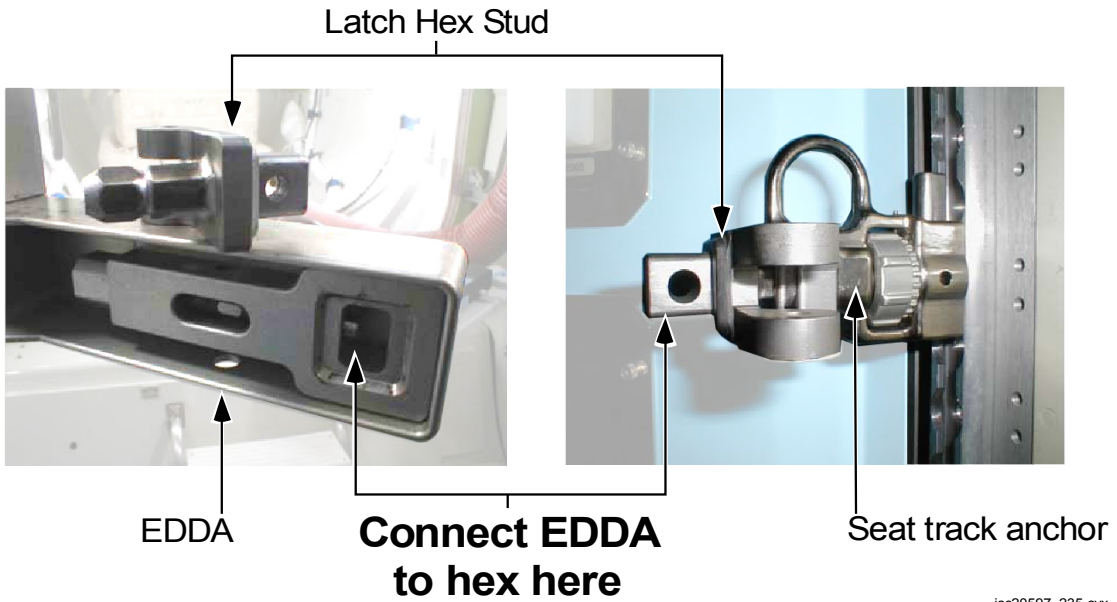
- A. EMU restraint during don/doff operations (Don/doff procedures may be performed without the assistance of the EDDA in certain cases)
- B. EMU restraint and access to the aft side of the Primary Life Support System (PLSS) for servicing
- C. EMU restraint in the Joint Airlock for long term stowage between EVAs

The common theme for each of these functions is restraint of the EMU with transfer of forces between the EMU and the Joint Airlock structure. Two basic interfaces are required: (1) an interface between the EDDA and the EMU; and (2) an interface between the EDDA and the Joint Airlock structure. These interfaces are provided along the following path: EMU to the PLSS mounts to the EDDA to the latch hex stud to the seat track anchors to the seat track (which is a part of the Joint Airlock structure). See *Figure 1.12-9* and *Figure 1.12-10*.



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Figure 1.12-10. The EDDA frame assembly



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**Figure 1.12-11. EDDA to latch hex stud (left);
hex stud to seat track anchor (right)**

In addition to these basic functions, each EDDA must allow access to panels located in the Joint Airlock rack to which it is mounted. For this reason, one side of the EDDA is hinged, allowing the EDDA to rotate and thus provide access to the equipment located behind it. In this configuration, IV crewmembers can access the panels and the back of the EMU for Metox canister or battery changeout. A locking strut located at the top of the EDDA frame provides restraint of the EDDA during these operations to prevent the EMU from impacting other hardware. Additionally, the pip pin may be removed from the locking strut to allow the EDDA to rotate beyond the full open position. This configuration will give the crew the ability to open and close the Battery Stowage Assembly (BSA) without moving the EDDA and its seat track anchors. On orbit, the crew has usually moved the seat anchors and EDDA up the seat track to get adequate access to the BSA as needed.

1.12.5.2 Physical Description

The EDDA assembly consists of the following components (see Figure 1.12-9):

- EDDA frame assembly
- Upper and lower PLSS EMU mounts (two)
- Pivoting hex stud (two)
- Latch assembly (two)
- EDDA strut assembly

1.12.5.3 EDDA Frame Assembly

The EDDA frame is constructed of anodized Al 7075-T7351 and is the basic structure to which the remaining components are secured. The EDDA frame assembly is designed to handle worst case donning loads of 400 lb with a 1.5 safety factor. The EDDA frame assembly pivots away from the avionics and Common Cabin Air Assembly (CCAA) racks to allow the IV crewmember to access the components behind the EDDA. The EDDA frame on the BSA rack pivots towards the IV hatch, and the EDDA frame on the Metox rack pivots towards the Node I Starboard hatch.

1.12.5.4 Upper and Lower PLSS Mounts

The EDDA attaches to the EMU PLSS via two passive pins and two active pins (see Figure 1.12-9 and Figure 1.12-11). The active pins are controlled by a simple release mechanism. To operate the release mechanism, the release handle is pulled away from the mount and then rotated. To release the EMU from the EDDA, the handle must rotate from a vertical (down) locked position through a 45° engage position to a horizontal released position. Each position has a small detent to lock the handle in place and in each position the active pin is retracted more. The crewmembers can individually operate the lower release mechanism from inside their EMU. The EMU to EDDA interface is the same mechanism as that employed on the shuttle Airlock Adapter Plate (AAP). These release mechanisms are manufactured by Hamilton Sundstrand.

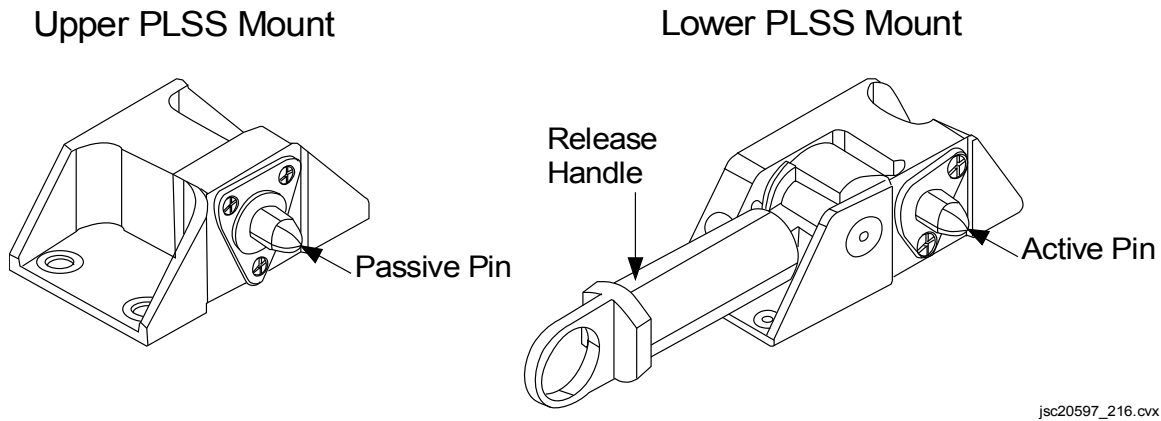


Figure 1.12-12. PLSS mounts with active and passive pins displayed

1.12.5.5 Pivoting Hex Stud

Two pivoting hex studs and two latch assemblies attach the frame to the seat track anchors. The pivoting hex studs are made of stainless steel and are attached at the top and bottom of the frame with a pin about which the frame swings.

1.12.5.6 Latch Assembly

The latch assemblies are located top and bottom on the opposite side of the frame from the pivoting hex stud. The latches are connected to the seat track anchors with latch hex studs which remain in the seat track anchors when the latches are released and the EDDA is allowed to pivot. These two hex studs have a knob-like structure with a through hole that allows the EDDA strut assembly to be connected to the pivoting hex stud with a pip pin. The top and bottom latch hex studs are interchangeable.

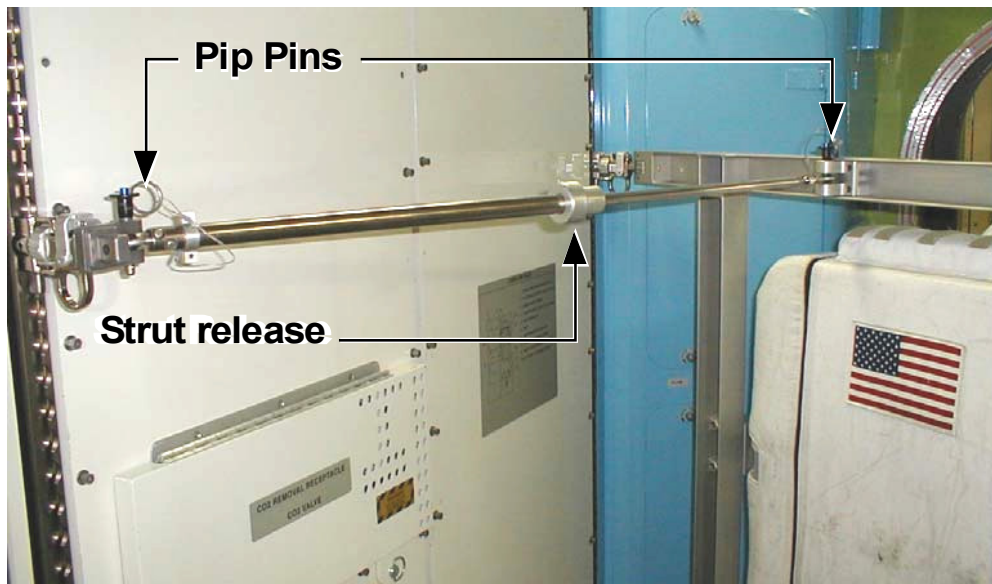
1.12.5.7 EDDA Strut Assembly

To access the back of the EMU or the panel behind it, the top and bottom latches must be actuated and the EDDA pivoted about its hinges to the full open position. The EDDA range of rotation is approximately 60°. The hinges are located on the opposite side of the EDDA from the latches. The EDDA strut assembly is attached at the top of the EDDA frame and shown in Figure 1.12-12.



Figure 1.12-13. EDDA strut assembly

This strut restrains the entire assembly in the full open position (~60°) (see Figure 1.12-13), preventing it from closing without actuating the strut release.



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Figure 1.12-14. EDDA strut assembly in the full open position (~60°)

The strut is connected at each end of the EDDA frame to the pivoting hex stud with pip pins (see Figure 1.12-12 and Figure 1.12-13). The pip pin on either end of the strut assembly may be removed to allow the EDDA to rotate beyond 60°. When reattaching the strut, particular attention must be paid to the location of the pip pin tether point on the strut. It is possible for the strut to be reinstalled with the protruding tether point facing the EDDA frame, thus inhibiting the proper latching of the EDDA onto the seat track anchors. Therefore, the protruding tether point must be facing towards the rack (away from the EDDA frame) for proper installation (see Figure 1.12-14).

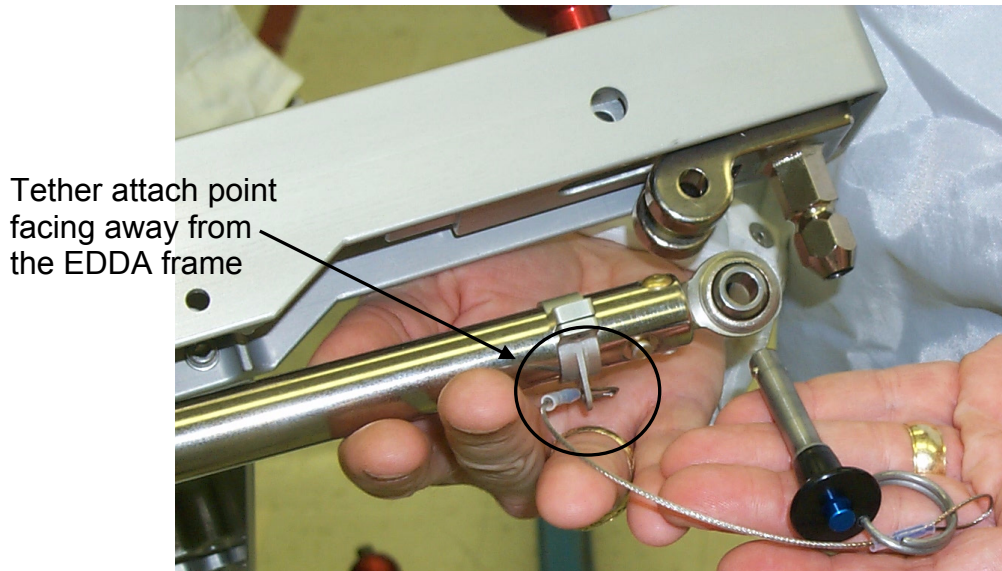


Figure 1.12-15. EDDA strut, pip pin, latch hex stud interface for quick release

1.12.6 Operational Data

The two EDDA flight units are nominally located in the E/L portion of the ISS Joint Airlock. They were launched in place secured to seat track anchors on the CCAA Rack and the Avionics Rack on ISS Flight 7A. There is no spare unit on the ISS. In the event that a replacement is required, it is doubtful that there is sufficient clearance for a unit to pass through the Androgynous Peripheral Docking System (APDS) hatch; therefore, an alternate transfer method would be required; i.e., Multipurpose Logistics Module (MPLM) or EV stowage.

There are two types of failures that could occur relative to the EDDA structure. The first failure type is if the EDDA were to become jammed on or off of the Joint Airlock structure. The workaround for this type of failure is to remove the PLSS from the failed EDDA and use the second EDDA serially for both EMUs. The other type of failure would be if the PLSS active pins would not release the EMU. The active pins are enclosed by the lower PLSS mounts and bolted to the EDDA with flathead screws. So the workaround would be to unscrew the lower PLSS mounts from the EDDA and leave them on the PLSS. The crewmember is still GO for EVA, but the SAFER will not be available since it attaches at the points that the PLSS mounts now cover.

1.12.7 Design History

When the EDDA was first being designed, the hinge points were configured on opposite sides. The problem with this design was that the Metox Regenerator door could not be opened without moving the EDDA on the seat track. So to provide easier access to the regenerator, the hinges were moved to the current location.

The current seat track anchors that attach the EDDA to the seat tracks may be redesigned because the BSA cannot be easily accessed with the EDDA installed on the avionics rack.

1.12.8 Related Documentation References

Analysis/Test References

CTB IDD – JSC-39233 Basic, Rev. C

[http://iss-www.jsc.nasa.gov/ss/issapt/opsipt/logmaiapt/JSC-39233C_CTB-IDD\(120199\).doc](http://iss-www.jsc.nasa.gov/ss/issapt/opsipt/logmaiapt/JSC-39233C_CTB-IDD(120199).doc)

CTB Data Sheets –

http://iss-www.jsc.nasa.gov/ss/issapt/opsipt/logmaiapt/cargo_home.html

Reliability and Maintainability Predictions Report, Extravehicular Mobility Unit DON/DOFF Assembly, LMSMSS Q105015, 9/98.

Failure Modes and Effects Analysis and Critical Items List (FMEA/CIL) Report, Extravehicular Mobility Unit (EMU) Don/Doff Assembly (EDDA), LMSO-P104975, 3/99.

Standard Interface Control Document, Extravehicular Mobility Unit Don/Doff Assembly-to-Airlock, JSC-33239, 7/96.

Contract End-Item Specification, Extravehicular Mobility Unit Don/Doff Assembly, JSC-33282, 9/96.

Engineering Drawings

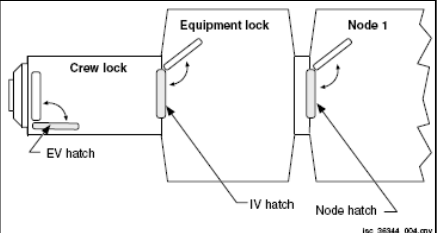
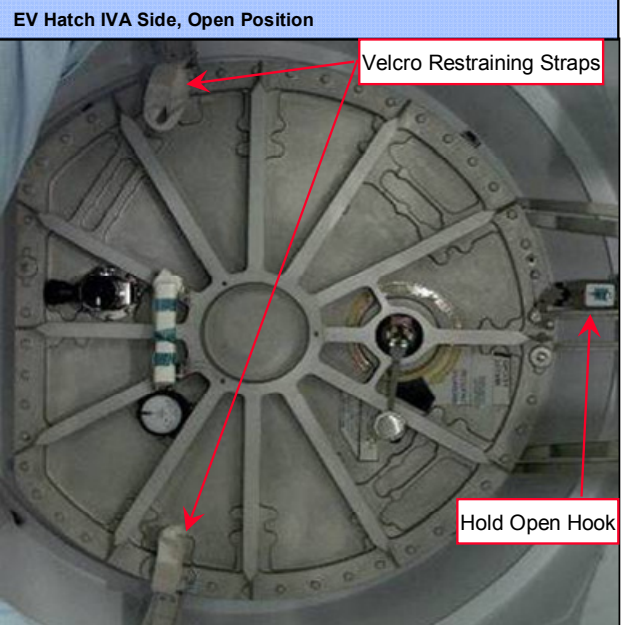
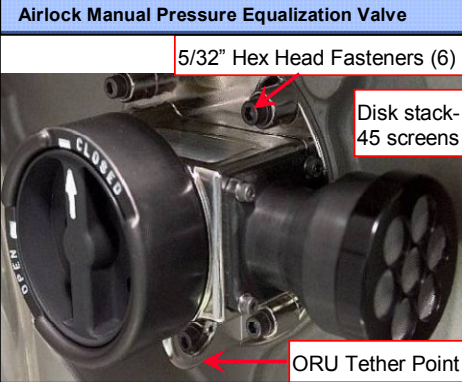
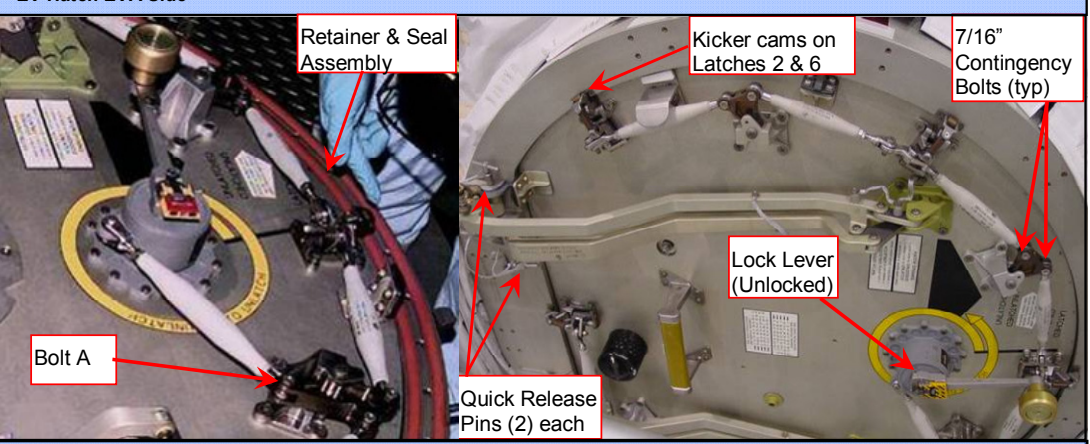
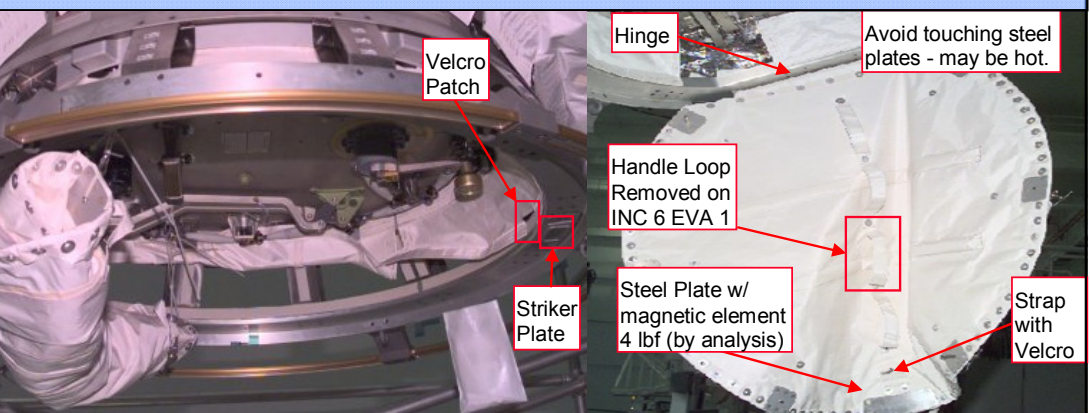
Crewlock EVA Bag – SEG33109669

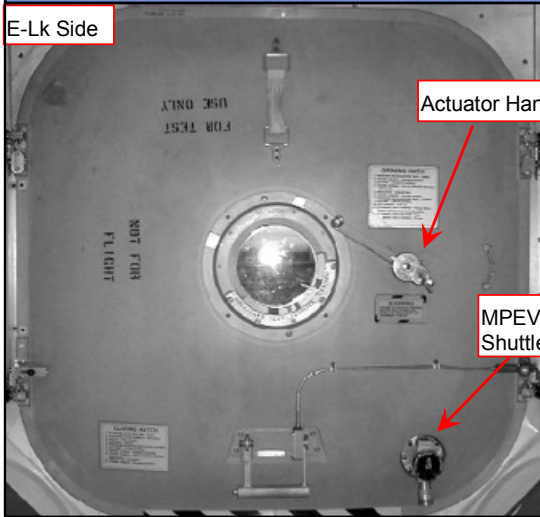
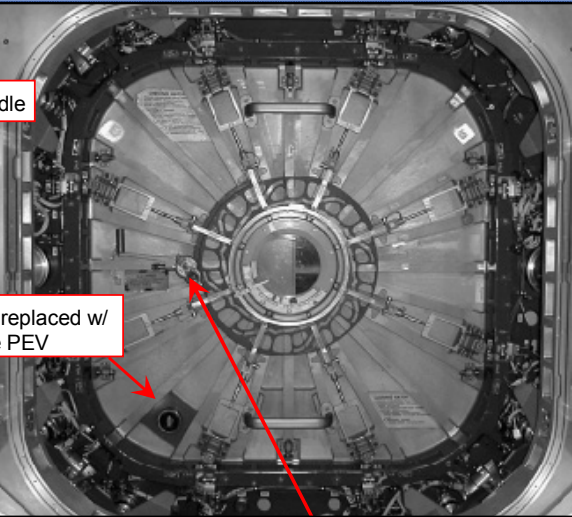
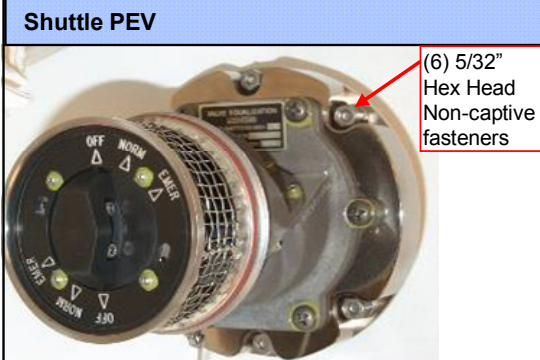


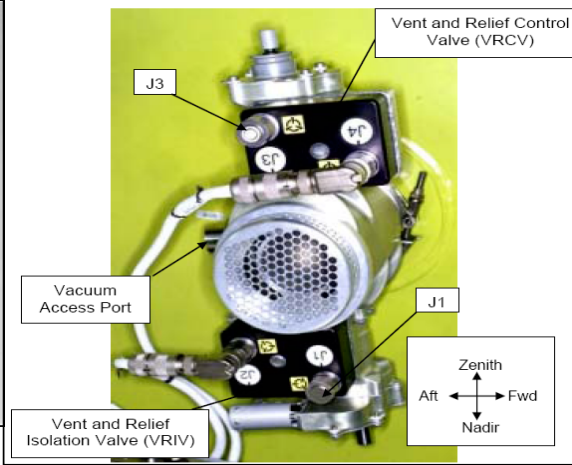
Airlock Stowage Bins – Boeing Drawing # 683-52050

M-02 Bag – SEG33111806

Cargo Transfer Bags – SEG33111836 through SEG33111839

Frame Components EMU Don/Doff Assembly SPCE Project, Drawing No. SEG39128216, 11/96.

ISS AIRLOCK SYSTEMS		Reference only	
ELEMENT	Airlock Hatches and Valves		PAGE
AL			1
		<p>EV Hatch IVA Side, Open Position</p> 	
<p>Airlock Manual Pressure Equalization Valve</p> 			
<p>EV Hatch EVA Side</p> 			
<p>Thermal Cover</p> 			

ISS AIRLOCK SYSTEMS		Reference only	
ELEMENT	Airlock Hatches and Valves		PAGE
AL			2
IV Hatch			
E-Lk Side			
 <p>Actuator Handle</p> <p>MPEV replaced w/ Shuttle PEV</p>			
Shuttle PEV			
 <p>(6) 5/32" Hex Head Non-captive fasteners</p>		 <p>Stow Handle before opening hatch</p>	
Emergency MPEV		Vent and Relief Assembly	
		 <p>Vent and Relief Control Valve (VRCV)</p> <p>J3</p> <p>Vacuum Access Port</p> <p>J1</p> <p>Vent and Relief Isolation Valve (VRIV)</p> <p>Zenith Aft ← → Fwd Nadir</p>	

ISS AIRLOCK SYSTEMS		Reference only		
ELEMENT AL	Airlock Hatches and Valves			PAGE 3
IV HATCH ASSEMBLY PN 683-13100		CREW LOCK HATCH ASSEMBLY Assembly PN V075-332603-009 Installation PN V829-593001		
Ref: OSO ISS Hatch Systems Brief, JSC 36333, Vol II		Ref: SODB Vol 1 4.2.3, SSSH 14.9 Sheet 2, & FR B15-14		
Dimension: Surface Area: Window PN 683-1303*:	53"W x 53"D IVA = 2652.6 sq in EVA = 2475 sq in 8 in diameter	Dimension: EVA Surface Area: Delta Pressure Gauge:	36"W x 40"D 1190 sq. in ISS - IV Side only, STS - IV & EV	
Seal Assembly: PN 683-13095 Hatch Lifetime: :	Dual dual on bulkhead, captive fasteners 3140 cycles, 15 years	Seals - PN V829-332615: Retainer -PN V829-332614:	dual seals on hatch 49 captive fasteners	
Latch/tension rods:	8 (PN 683-13010, & 12)	Latches-PN V070-593231/2 Hinges - PN V829-593002	6 total, double acting cams on 2 & 6 7/16" Contingency Bolts 4 Quick Release Pins total on 2 Hinges	
Actuator: Rotation: To open:	PN 683-13020 & 683-13023 ~ 3 turns to latch/unlatch 0.002 psid (0.02psi max = 50 lbf)	Actuator Rotation To open:	Lock Lever IVA handle can be removed 440 deg min, Force 25 lb max 0.2 psid max (<0.5 psid on gauge)	
SHUTTLE PEV Cap PN 683-42359-1 PN MC250-0004-0010		Thermal Constraints: Critical Item : Issue:		
Airlock Component Rates (approximate) Total A/L Vol - 208 ft ³ (Crewlock Volume - 188 ft ³) (from JSC-19935)		0°F to 160°F Hatch/Latch Actuator Lubricant spec Not thermal vacuum tested per SSP 41172 (cert'd to ambient)		
Valve Position	Cap Hole	Norm	Emer	
Hole Size (in) diameter	0.18	0.451	1.230	
Eff. Area	--	0.159	1.188	
Cd	0.59			
Orbiter/Airlock Press (psi)	Flow Rate (lb/hr)			
5	7.5	83	440	
8	12	132	705	
10.2	15	169	899	
12	18	199	1058	
14.7	22	243	1295	
Orbiter/Airlock Press (psi)	dP/dT (psi/min)			
10.2	+0.24	+2.66	+0.24 psi/sec	
14.7	+0.35	+3.82	+0.34 psi/sec	
		MNL Press EQL VLV, EV Hatch PN 3750243		
		Flow Rate Orifice Size Crew Lock volume Thermal constraint Modification	258.71 lb/hr 0.565 in fully open 188 ft3 -10°F to 120°F Muffler to reduce noise	
		Crew-Lock Depress time (Ref: ISS AL Crew Lock Depressurization Methods, Flight 7A)	5 psi to 0.5 psi = 40 minutes MPEV blows thermal cover off. May expose hatch > 10 minutes & exceed actuator thermal limits	
		Usage Limit:	Rotate Actuator to over-center position (between 60-90° from closed) prior to using EV PEV to depress	

ISS AIRLOCK SYSTEMS		Reference only	
ELEMENT AL	Airlock Hatches and Valves		PAGE 4
Crew Lock Equipment Installation PN 683-51960-2		Vent and Relief Assembly PN 2353026-1-1	
		<p>• Location: A/L1 AD0</p> <p>Vent Access Jumper (VAJ): Orifice size: 0.245 in. Length: 35 ft. Flow Rate @ 14.7 psia: 57.64 lb/hr</p> <p>Vent Relief Isolation Valve (VRIV): 3 Position Ball Valve: Closed, Low Flow, Full Flow Power supplied from PCA (RPCM AL2A3A A) Remains in last commanded position if power is removed</p> <p>Vent Relief Control Valve (VRCV): 2 Position Ball Valve: Closed, Open Power supplied from PCA (RPCM AL2A3A A) Automatically closes if power is removed Has manual override capability</p>	
		Manual Pressure Equalization Valve PN 3796549	
		<ul style="list-style-type: none"> • Flow Rate @ 14.7psia 509.38 lb/hr • Orifice Size 0.79 in. • If the valve is not completely opened/closed, the seal could develop a "set" in the material and may not seal properly as a result. 	
Depress Times ISS_Airlock_Crewlock_Depressurization_Methods , 04ICES-020		Depress Pump Man Isol VLV Cap PN 683-52059	
Depress Equipment	Pressure (psia)	Pressure (mmHg)	Time (min)
Depress Pump	14.2 – 5.0	734 - 258	~ 10
Depress Pump + EMPEV	5.0 – 2.0	259 – 103	~ 5
EMPEV	2.0 – 0.5	103 - 25	~ 14
		<ul style="list-style-type: none"> • Location: inside Crew Lock at Depress Pump Inlet • Same as ISS MPEV but with a high profile actuator (cap) • No Muffler; Gamah fitting is removed • If not closed, C-Lock will fail leak check. • Depress Pump does not hold pressure. • Also Covered in Depress Pump Zap 	
		EMER MPEV PN 3796549	
		<ul style="list-style-type: none"> • Location: A/L1 A3 at IMV Port • Same as ISS MPEV • IV access only 	

ISS AIRLOCK SYSTEMS		Reference only
ELEMENT AL	Airlock Hatches and Valves	PAGE 5
ISS References		
<p>FLIGHT RULES - ISS</p> <ul style="list-style-type: none"> • B15-11 Joint Airlock Configuration • B15-14 Airlock Hatch Cover Thermal Constraints <ul style="list-style-type: none"> • TABLE B15-14-I – Thermal Constraints • B2-113 Hatch Config During Maintenance • B10-351 Hatch Open/Close Config • B10-352 Crew Lock to Equipment Lock Hatch • B10-358 Hatch Safety when Isolating Crew from Return Vehicle <p>SSODB (http://iss-www.jsc.nasa.gov:1532/vmdbagnt/plsql/ssodb_tabular_index_oas)</p> <ul style="list-style-type: none"> • ECLS-002 ARS Airlock • SM-109 Common Hatch <p>DRAWINGS (http://usa1.unitedspacealliance.com/sfocdata/SELS/JSC/36027/12121.pdf)</p> <ul style="list-style-type: none"> • ISSSH 12.12 Airlock Hatches <p>OSO Console Handbook (http://mod.jsc.nasa.gov/df/df53/)</p> <ul style="list-style-type: none"> • Vol II: ISS Hatch Systems Brief • Vol IV: ISS Hatches; ISS Valves • OSO Joint Airlock Systems Brief, JSC-36333, Vol 2 <p>OSO Tool Database (http://mod.jsc.nasa.gov/df/df53/Databases/Consolidated_Tool_Page/Tool-Index.html)</p> <ul style="list-style-type: none"> • Airlock Contingency Tool Kit <p>Technical Reference</p> <ul style="list-style-type: none"> • ISS Airlock Crewlock Depressurization Methods, 04ICES-020 	<p>SODF</p> <p>ISS Cuff Checklist Procs</p> <ul style="list-style-type: none"> IV Hatch Latch Disconnect EV Hatch Latch Disconnect EV Hatch Hinge Disconnect <p>ISS EVA Systems Checklist</p> <ul style="list-style-type: none"> 4.150 Crewlock Large Leak Response at 5psia <p>IFM Airlock</p> <ul style="list-style-type: none"> 4.2.316 Airlock VRA Checkout 4.2.317 Airlock VRA Config for Contingency Ops 4.2.318 Airlock VRA Power Reconfig for 2 Man EVA 4.3.501 Airlock Leak Pinpoint <p>IFM Common</p> <ul style="list-style-type: none"> 1.1.521 US Hatch Seal Inspection 1.2.5 Hatch R&Rs and Adjustments 1.3.5.1 Hatch Mechanism Malfunction Procedure <p>IFM Reference</p> <ul style="list-style-type: none"> Appendix D.5 Ultrasonic Leak Detection - Generic Appendix E.4 Joint A/L Closeouts <p>Struc and Mech</p> <ul style="list-style-type: none"> 1.6 Nominal Hatch 	
STS References		
<p>FLIGHT RULES - STS</p> <ul style="list-style-type: none"> • A15-13 AIRLOCK CONFIGURATION • A15-201 EXTERNAL AIRLOCK HATCH THERMAL COVER <p>SODB (https://opo.jsc.nasa.gov/sodw/Main_public.cfm)</p> <ul style="list-style-type: none"> • Vol 1: 3.4.2.3 Thermal and 4.6.4 ECLSS Airlock • Or Search for Airlock or Hatches <p>DRAWINGS</p> <ul style="list-style-type: none"> • SSSH 14.9 STS Hatches • SSSH 14.9 STS Hatch Window <p>Console Handbooks</p> <ul style="list-style-type: none"> • Environmental Systems Console Handbook, Volume 5 – Airlock / EVA, Rev. C, Section 1.2.1.2, S.C. Doering (http://mod.jsc.nasa.gov/df/df82/cons%5Fhb/V%5F05%5FAirlock/rev%20d/) • DF52 MMACS Hatches Systems Brief Section 14.1 • Section 14.5 Hatch Anomalies (http://mod.jsc.nasa.gov/df/df52/hatches/hatches.html) 	<p>FDF</p> <p>EVA Cuff Checklist</p> <ul style="list-style-type: none"> • Airlock Latch Disconnect • Hinge Disconnect <p>Post Insertion</p> <ul style="list-style-type: none"> • Block 16 Airlock Setup for Ingress <p>Deorbit Prep</p> <ul style="list-style-type: none"> • Nominal Deorbit Prep <ul style="list-style-type: none"> • Block 3A Entry Airlock Config • Deorbit Prep Backout <ul style="list-style-type: none"> • Block 21 Airlock Prep for Ingress <ul style="list-style-type: none"> • PLBD Contingency EVA Timeline • Hardware Contingency EVA Timeline <p>IFM</p> <ul style="list-style-type: none"> • Ku-Band Antenna: Contingency Stow – w/EVA Antenna Gimbal Alignment <p>RNDZ</p> <ul style="list-style-type: none"> • APDS Airlock Fan Act, Bypass, Airlock Prep for Ingress – Bypass Config 	

1.13 JOINT AIRLOCK HATCHES AND VALVES

1.13.1 EV Hatch

The EV hatch enables the EV crewmembers to egress the International Space Station (ISS) to perform an EVA. The hatch is located on the Nadir side of the Crewlock of the ISS (Figure 1.13-1). The EV hatch is a shuttle “B type” hatch that has been modified for station. The hatch is comprised of six interconnected latches with a gearbox and actuator, a hinge mechanism with a hold-open device, a differential pressure gauge on the inner side, and a modified equalization valve. Refer to EVA Console Handbook Volume 2, Section 1.6 for details relating to the shuttle B hatch.

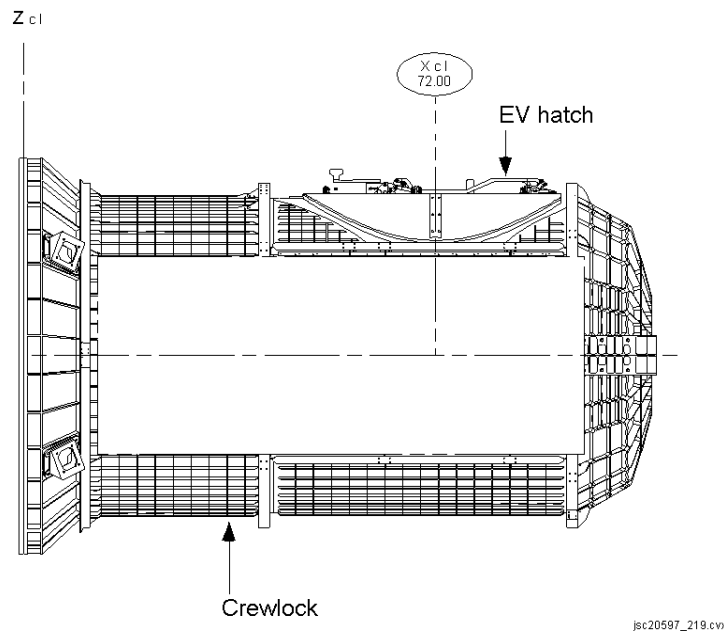


Figure 1.13-1. ISS Crewlock – EV hatch

1.13.1.1 EV Hatch and Shuttle B Hatch Comparison Table

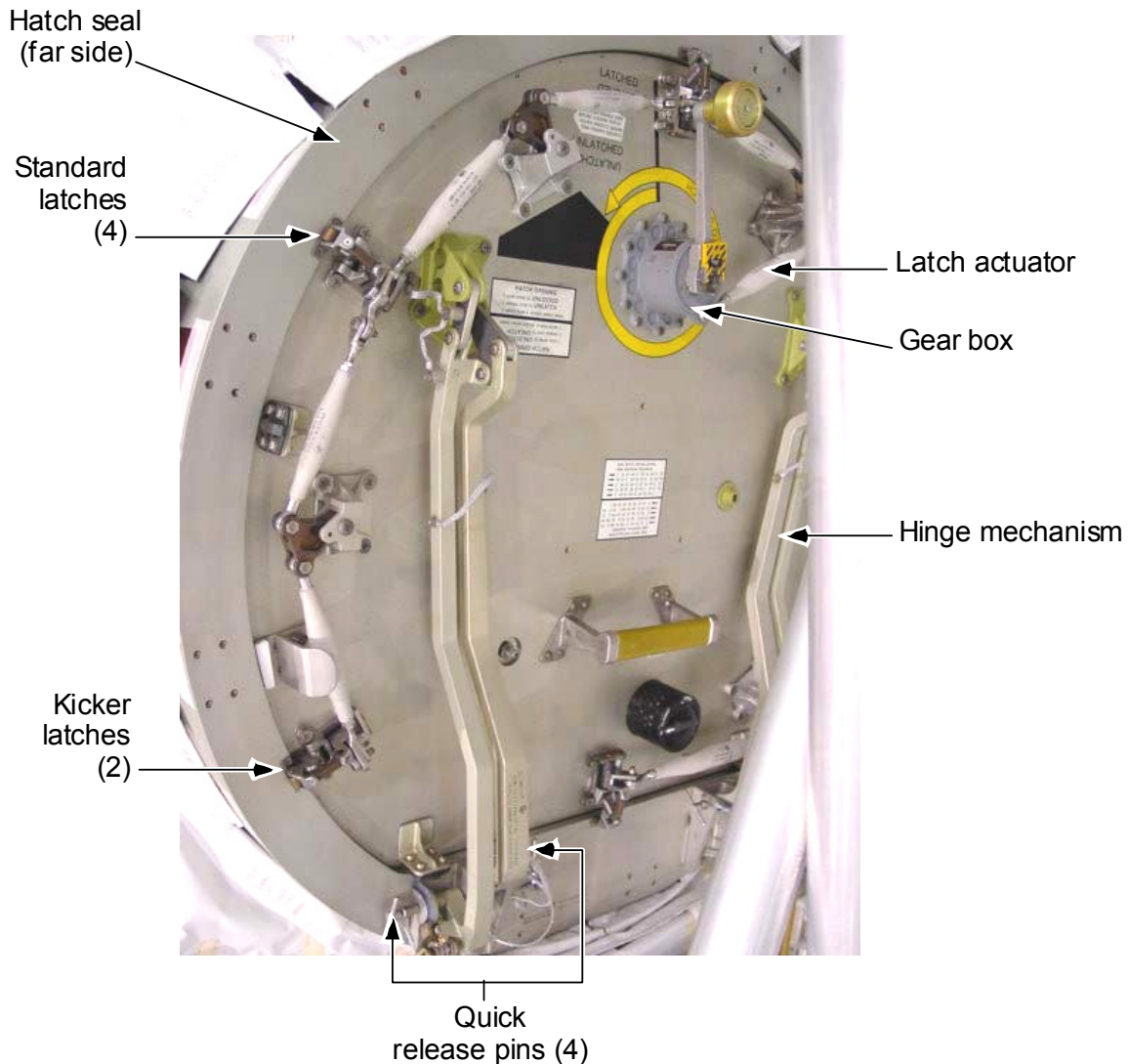
Like the shuttle B hatch, the EV hatch is D-shaped and opens toward the primary pressure source. This configuration uses the delta pressure across the hatch as a sealing force when closed. The hatch is 40 inches by 36 inches in diameter and can be locked/unlocked from either side. The hatch can be opened against a maximum pressure differential of 0.5 psid with a one-handed operation and is certified for 2000 open/close cycles.

Table 1.13-1. Comparison of EVA hatch and shuttle B hatch

Description	EV Hatch	B Hatch
Dimensions	D-shaped, 36 in. by 40 in.	SAME
Latches	6 latches on the low pressure side with 2 "kicker" latches	SAME
Hatch operation	Requires one-handed operation in a pressurized EMU	SAME
EVA replaceable hatch	YES	NO
Removable on-orbit	YES	SAME
ORU dual seal assembly	Tested to 1050 cycles (10 yr life). Verified sealing capability and seal durability	SAME
Equalization valves	1 modified pressure equalization valve	2 pressure equalization valves
Quick release pins	4 pins - Redesigned to provide increased durability	4 pins with the original design
Pressure seals	Dual pressure seals; both seals are attached to the EV hatch. Designed so that the EV hatch may be brought inside and the seals replaced on orbit	One seal is on hatch and one seal is on the airlock flange
Pressure gauge	1 delta pressure gauge – readable from interior	2 delta pressure gauges – readable from each side
Latch actuator	Designed for life cycles and age requirements (inspected and tested)	SAME
Hatch window	No window	4-in diameter window on the hatch centerline
Linkage and hinges	Mechanical	SAME

1.13.1.2 Hinge Mechanism and Hold-Open Devices

The hinge mechanism (Figure 1.13-2) for the hatch is designed to provide a minimum opening sweep. All hinges are designed for zero gravity operation and require the use of ground service equipment (GSE) to prevent damage in 1-g. Removal of the pip pins is required to perform in-flight removal of the hatch from the hinge mechanism.



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Figure 1.13-2. EV hatch mechanisms

The EV hatch has a hold-open hook, which snaps into place over a flange when the hatch is fully opened. The hook is released by depressing the spring-loaded hook handle and by pushing the hatch toward the closed position. To support and protect the outer hatch against the Crewlock endcone, the hatch has a Velcro retention strap. Refer to Figure 1.13-3 for hold-open mechanisms.

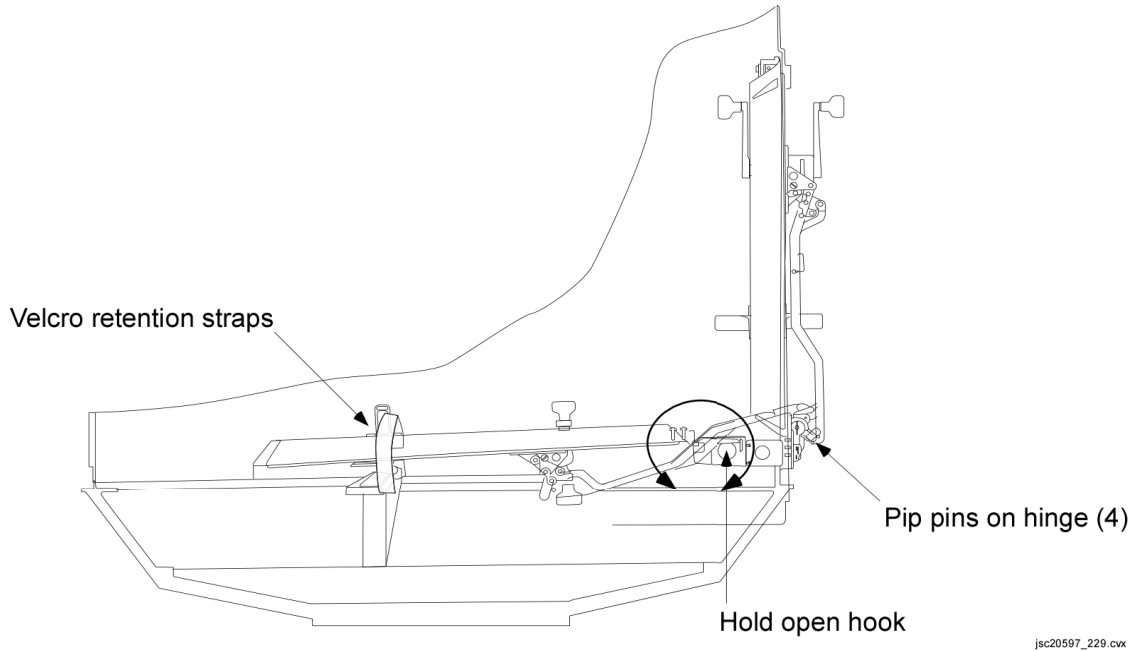


Figure 1.13-3. Hatch operation

Figure 1.13-5 shows flight photos of the hold open mechanisms in the Joint Airlock.

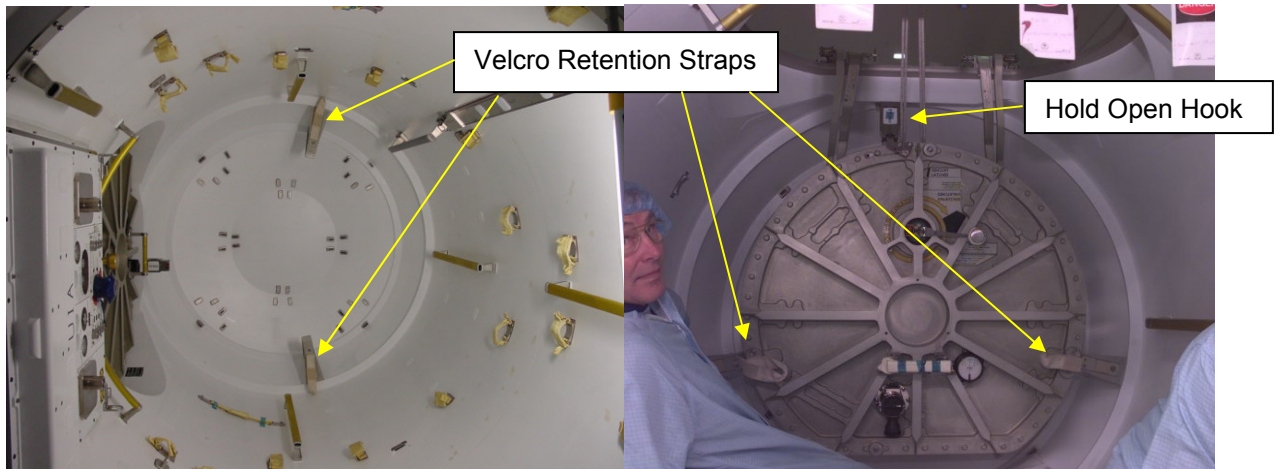


Figure 1.13-4. Hold open mechanisms in Joint Airlock

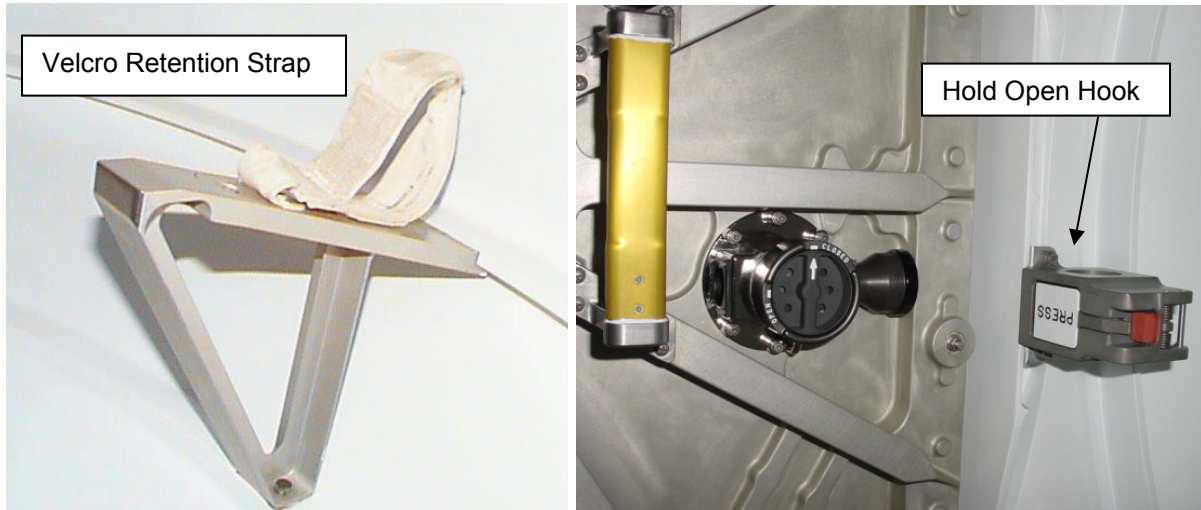


Figure 1.13-5. EV hatch closed/open with hold open devices

1.13.1.3 Pressure Gauge

There is a delta pressure gauge installed on the inner side of the hatch to monitor Crewlock depressurization. This gauge is mechanical and does not provide telemetry (Figure 1.13-6).

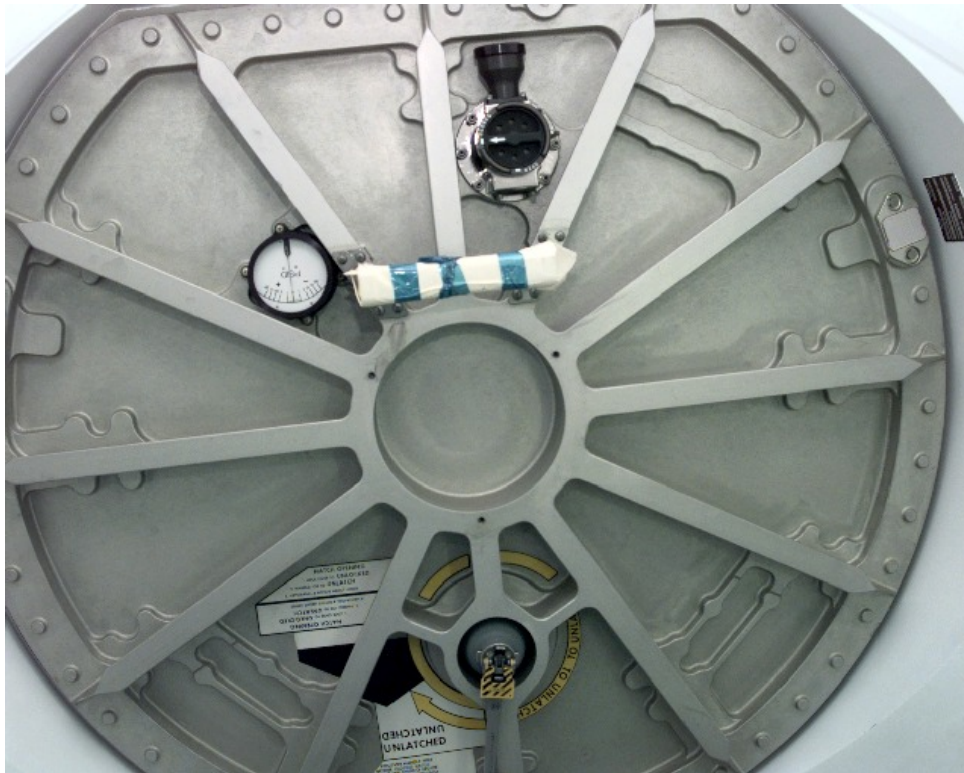
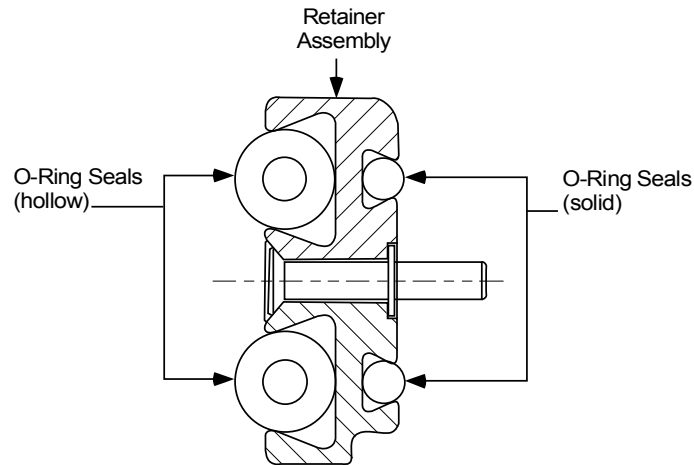


Figure 1.13-6. EV hatch IV side

1.13.1.4 Pressure Seals

The hatch has two sets of dual O-ring seals to maintain Crewlock pressure integrity. Both sets of seals are mounted on the EV hatch. The seals are bonded to a single, removable “D” shaped retainer assembly that is attached to the Hatch with 49 captive fasteners. The first set is two hollow O-Ring seals that interface with the airlock flange and are compressed by the 6 latches on the hatch. The second set is two solid O-Ring seals that are compressed by the 49 fasteners against the hatch. See Figure 1.13-7. These seals can be serviced on orbit by performing an Equipment Lock (E/L) EVA and taking the EV hatch inside. Once inside, the seals can be replaced by removing the retainer assembly and replacing it. The seals are made of silicone rubber designed to last 1050 cycles or 10 years. Hatch seal change-out is only required if seal damaged is incurred. Figure 1.13-8 shows a picture of the seals around the EV hatch.



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Figure 1.13-7. Dual pressure seals on EV hatch

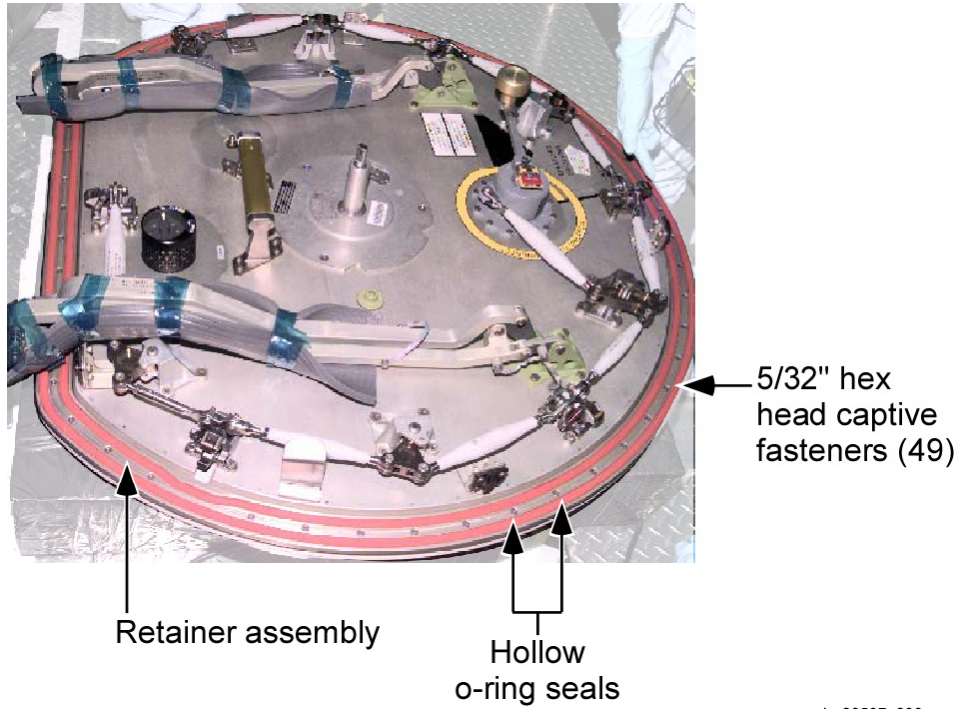


Figure 1.13-8. EV hatch EV side

1.13.1.5 Thermal Cover

The EV Hatch Thermal Cover protects against thermal constraints to the airlock. After running cooling water to cool the crewmembers in the EMUs, the lines in the umbilicals and UIA can quickly freeze. The thermal cover would keep the environment protected.

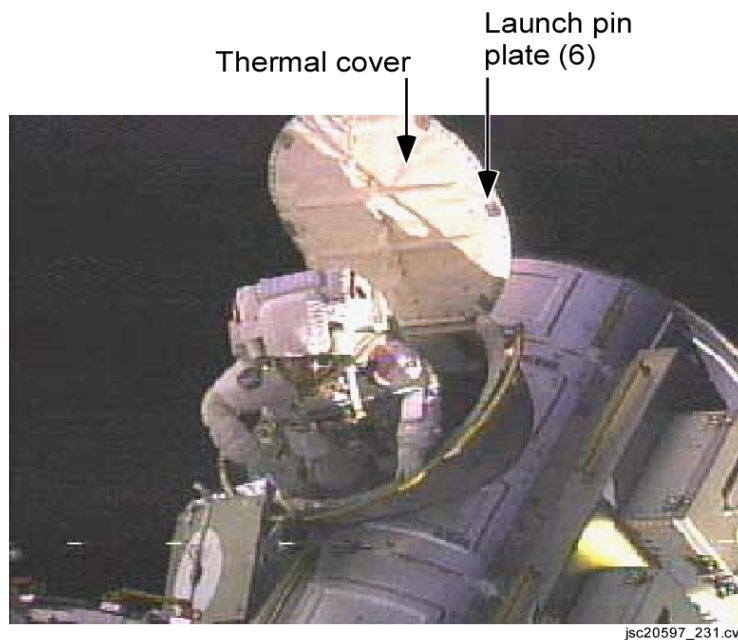


Figure 1.13-9. EV hatch thermal cover

1.13.1.6 Thermal Cover Securing Mechanisms

Figure 1.13-10 is photos of both sides of the thermal cover. It is secured in place by one magnetic catch and one Velcro strap. Six pip pins are used for securing the cover for launch purposes only. After launch they are stowed in the thermal cover under the flaps. The flaps are secured with Velcro and handles are provided to access them. The outer pull handle is connected to a steel plate with a magnetic element in it. This handle is used by the crewmembers to pull open the thermal cover.

The magnet is riveted to the thermal cover. It secures the thermal cover by sticking to the outer ring of the Crewlock. The hold-down force of the magnet as determined from test and vendor data is 3.25 lbf by test and 4 lbf by analysis.

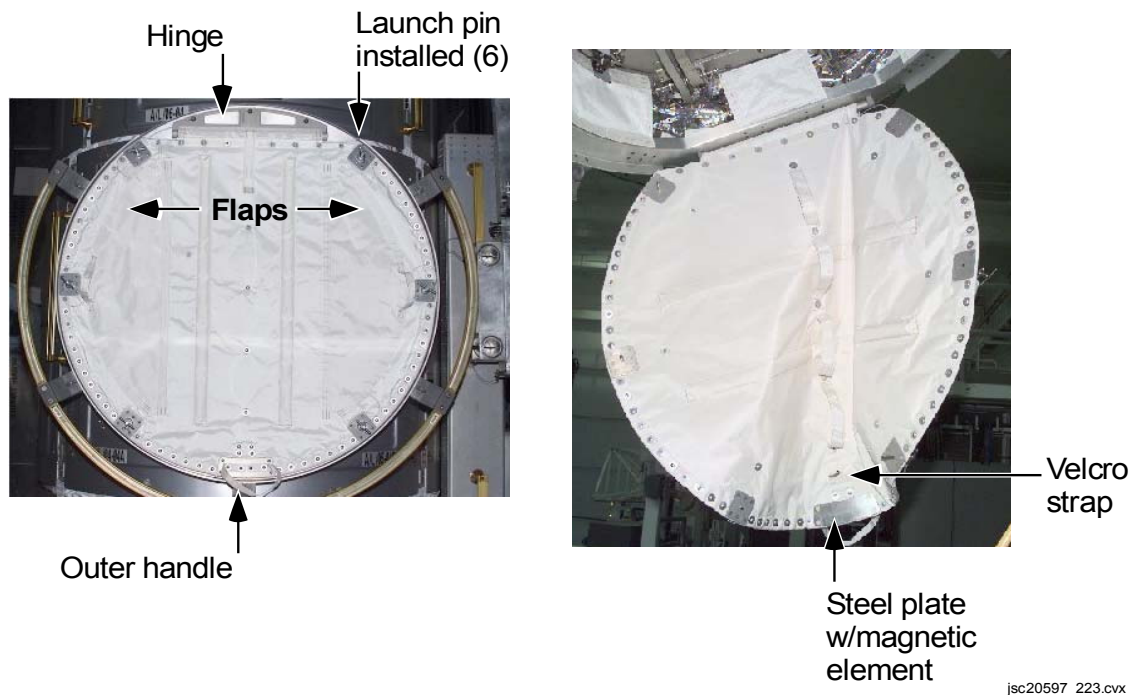


Figure 1.13-10. EV hatch thermal cover closed and open

Figure 1.13-11 and Figure 1.13-12 show the Velcro strap and how it is used to secure the thermal cover. This strap can only be used from the inside of the airlock. It attaches to a Velcro strip on the outer ring of the hatch area. The hold-down force of the Velcro catch as determined from test and vendor data is 27 lbf new, and 22 lbf after 100 cycles.

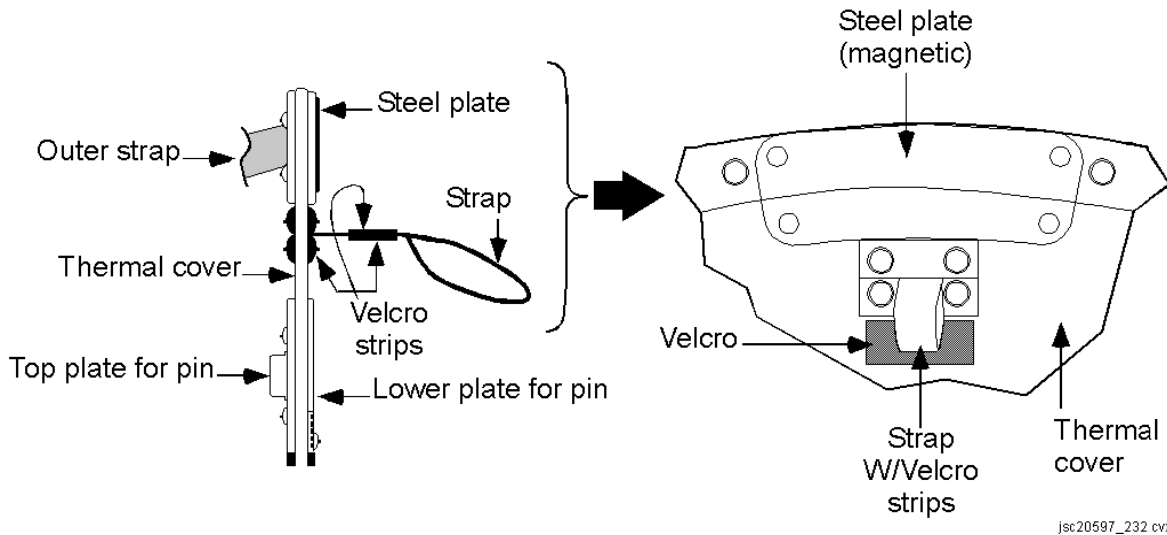


Figure 1.13-11. Velcro strap and magnet on EV hatch thermal cover

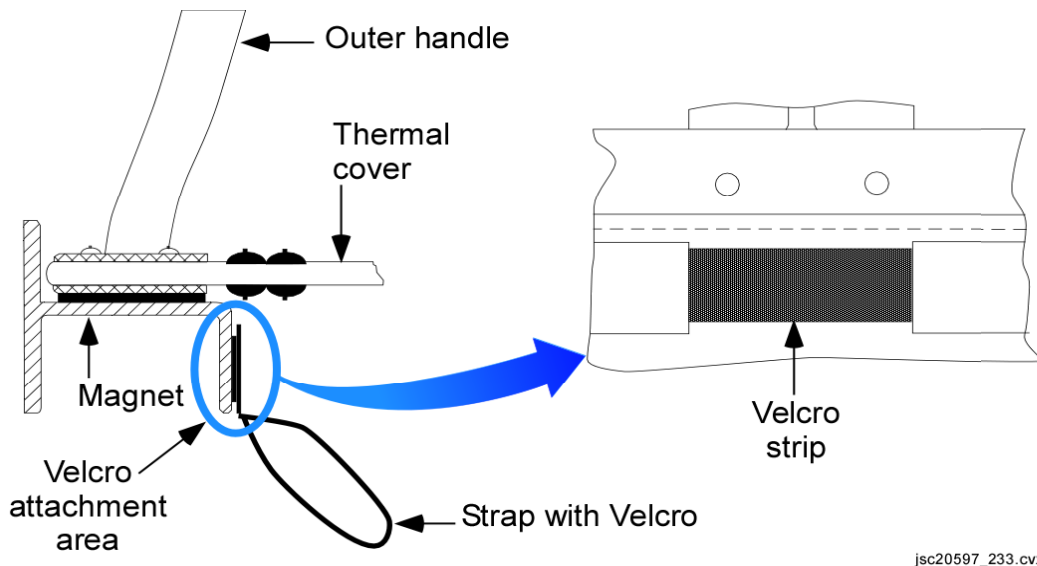


Figure 1.13-12. Velcro strap interface for EV hatch thermal cover

During depress the thermal cover has a tendency to blow open by the gas exiting the Airlock Manual Pressure Equalization Valve (AMPEV). This presents a concern since thermal predictions indicate that temperature acceptance limits can be violated in as little as 10 minutes to as long as 90 minutes depending on attitude and solar beta angle. The length of time depress takes is longer than 10 minutes: 15 minutes with the AMPEV and the Vacuum Access Jumper (VAJ), and 40 minutes with just the AMPEV.

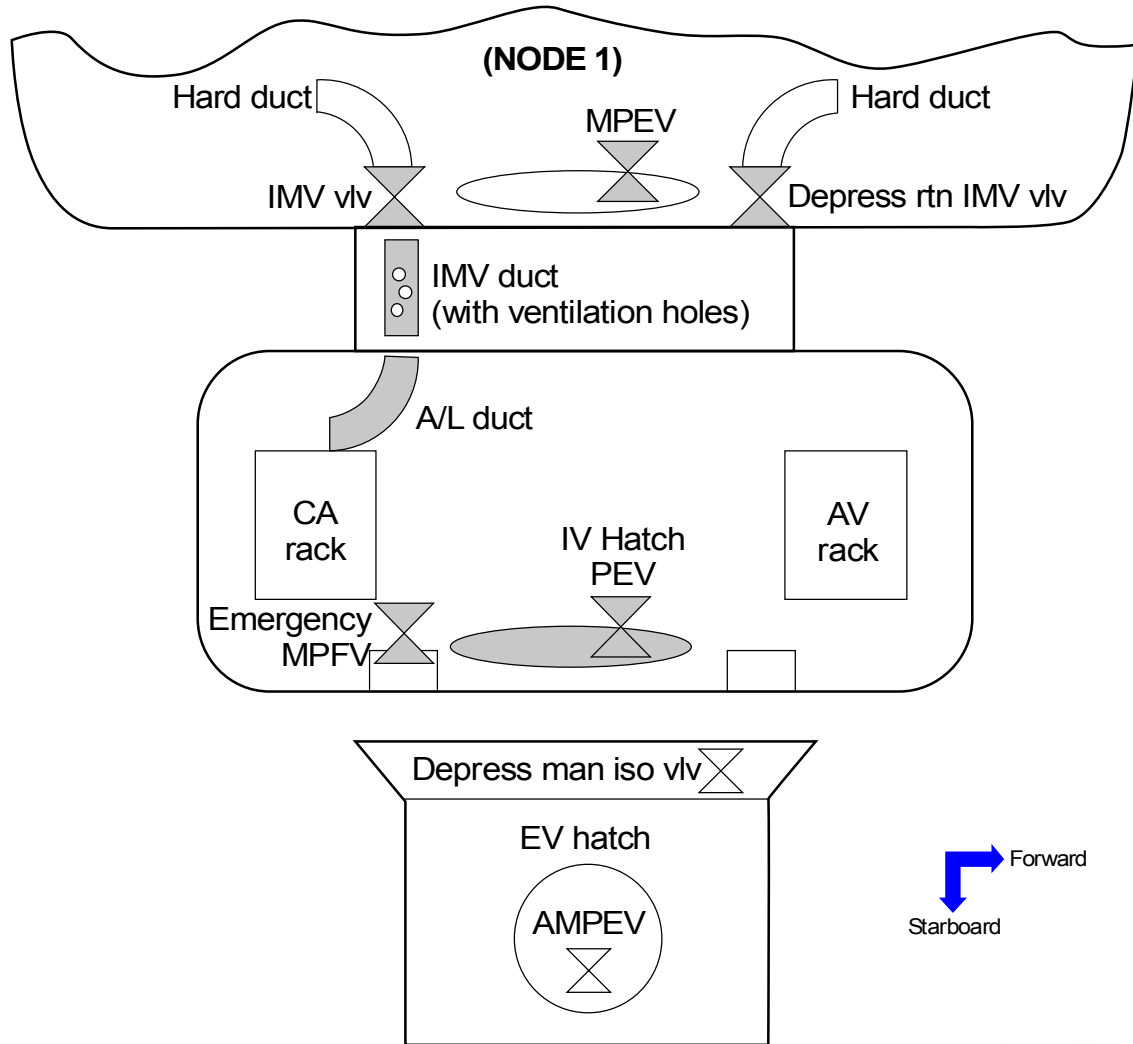
The thermal cover is stiff, so the catches may not be mating correctly. During the Flight 8A EVA3, the crew managed to wrestle with the thermal cover and latches enough so that on EVA4 depress, the cover did not blow open. During UF-2 the thermal cover blew open twice and once it did not. Billowing around the thermal cover edges were observed when it did not blow open.

1.13.2 IV Hatch and Node 1 Starboard Hatch

The IV and Node 1 Starboard hatches are standard USOS hatches, with the exception of the hatch pressure equalization valve on the IV hatch. The IV hatch divides the Crewlock segment of the joint airlock from the E/L segment, and the Node 1 Starboard hatch divides the E/L from the rest of the ISS. Use of the IV hatch allows the Crewlock to be depressed to facilitate nominal egress from the airlock, and use of the Node 1 Starboard hatch allows for nominal depress of the entire airlock for 10.2 psi operations. See the USOS Boeing Standard Hatch System Brief (JSC-36333 Volume 2) for a complete discussion on USOS standard hatches. The pressure equalization valve located on the IV hatch is a standard shuttle valve.

1.13.2.1 Pressure Equalization Valves

An equalization valve provides a pathway to equalize pressure across a hatch or between adjacent modules. Pressure equalization is necessary prior to actuation of a hatch exposed to a differential pressure. In most cases, a very small pressure differential (~0.2 psid) will prevent hatch actuation. There are two distinctly different equalization valves located in the ISS Joint Airlock: the Manual Pressure Equalization Valve (MPEV) and the Shuttle Pressure Equalization Valve (SPEV). The MPEV has a couple configurations, which are all iterations of the same design. The SPEV is identical to those used on shuttle. Figure 1.13-13 shows the location of the different pressure equalization valves. These valves are described in detail in the ECLSS and Emergency, Environmental, and Consumables Management (EECOM) systems briefs referenced at the end of this document.

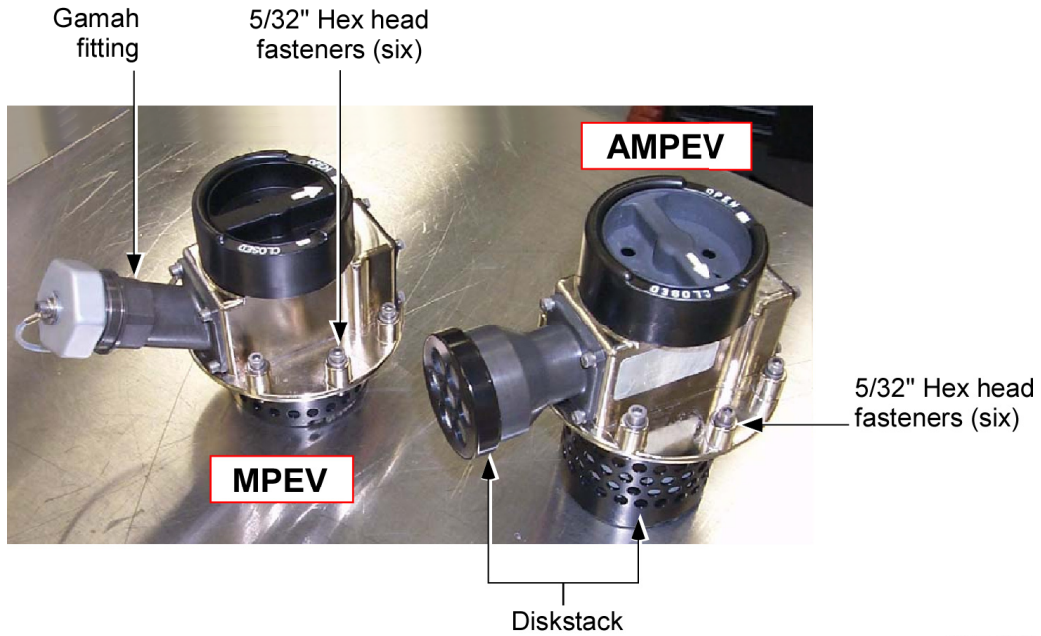


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Figure 1.13-13. Joint Airlock equalization valves

1.13.2.2 Node 1 Starboard Hatch Equalization Valve

A standard MPEV configuration is used in the Unity (Node) starboard hatch. The Gamah fitting inlet snout remains intact in this configuration and can have a muffler attached to further reduce acoustic levels. The obvious trade-off for reduced acoustic levels is reduced equalization rate from 509.38 lb/hr to 258.71 lb/hr at 14.7 psi. This valve is nominally used to repress Quest (the Joint Airlock) after 10.2 psia ops is complete. Six 5/32" hex heads are used to fasten the MPEVs to the structure. Figure 1.13-14 shows the standard USOS MPEV alongside the AMPEV. Figure 1.13-15 shows the location of the Node 1 Starboard Hatch MPEV.



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Figure 1.13-14. USOS MPEV and AMPEV

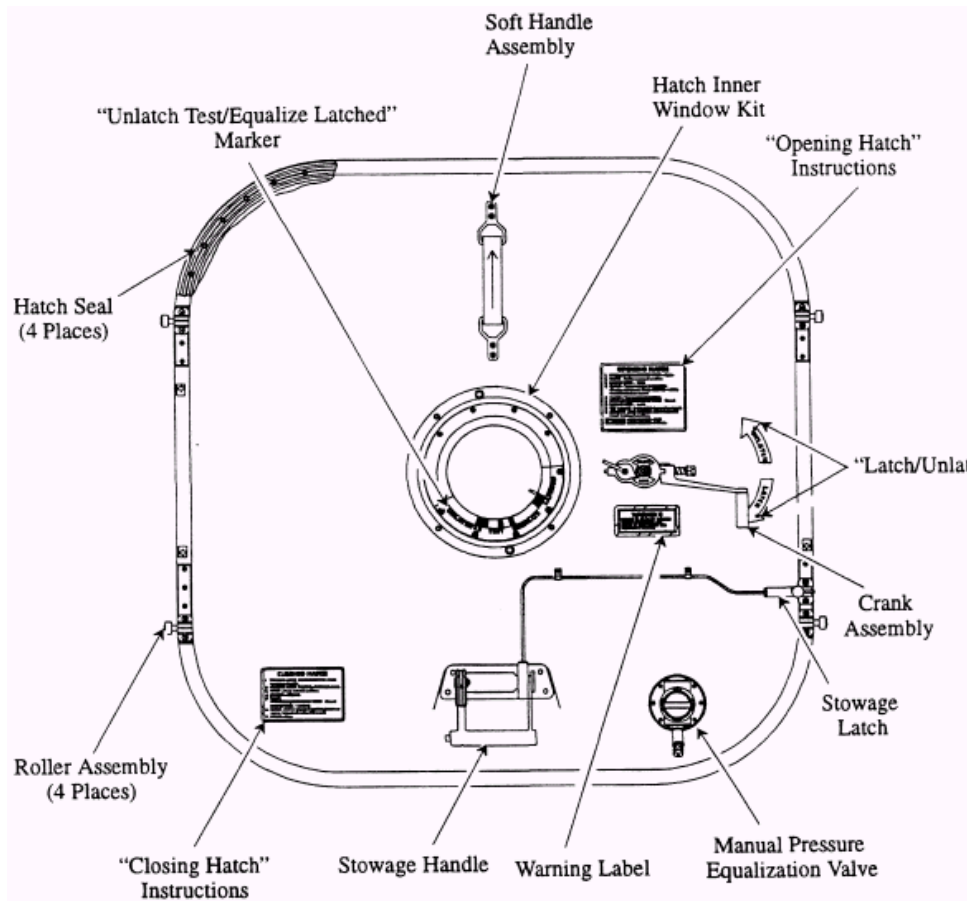


Figure 1.13-15. MPEV location on Node 1 starboard hatch

1.13.2.3 Emergency MPEV and VAJ

The standard USOS MPEV configuration is used in the Intermodule Ventilation Valve (IMV) port located between the Equipment Lock and the Crewlock. This valve is not nominally actuated during repress of the Crewlock but is a redundant equalization path between the E/L and Crewlock should the primary valve for repress (SPEV) fail. For that reason, it is also known as the Emergency MPEV. Although this MPEV has an actuation handle on both sides, the location of the IMV port only allows for actuation from the E/L module (IV access only).

This valve, ironically, now serves during Crewlock depress. It is used to supplement depress of the Crewlock through a VAJ to the Lab vent relief valve (Figure 1.13-16). The VAJ is a hose that connect to the Gamah fitting of the Emergency MPEV and the Airlock PCA (Pressure Control Assembly) VRA (Vent and Relief Assembly) VAP (Vacuum Access Port). For further information on connecting the VAJ to the Emergency MPEV, reference the procedures in the ISS EVA checklist, Contingency Airlock Depress Using VAJ.

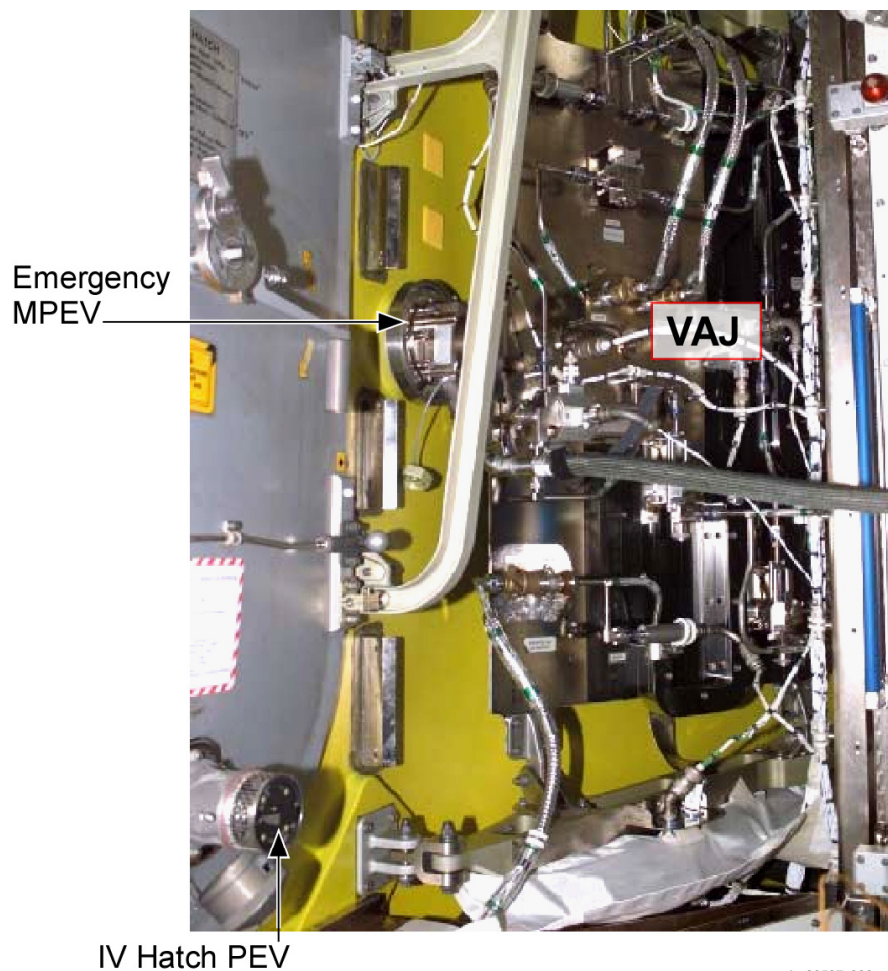


Figure 1.13-16. Emergency MPEV with VAJ attached

1.13.2.4 Depress Pump Manual Isolation Valve

A standard USOS MPEV configuration is used at the inlet of the depress pump. The valve actuator has a cap fitted on it to allow a gloved hand to operate it (Figure 1.13-17). The Gamah fitting is also removed. This valve is closed during the startup of the depress pump, allowing the pump to wind up. Depress is then controlled by opening and closing the valve. Nominally, the pump is used during depress until the Crewlock is 5 psi. At lower pressures, the depress pump does not work as efficiently, the depress manual isolation valve is closed, and the remaining gas is vented overboard using the Emergency PEV and VAJ setup in an effort to save time. This procedure minimizes the amount of consumables vented overboard. If the manual isolation valve is not closed, then the Crewlock will fail its leak check. The depress pump itself does not hold pressure.

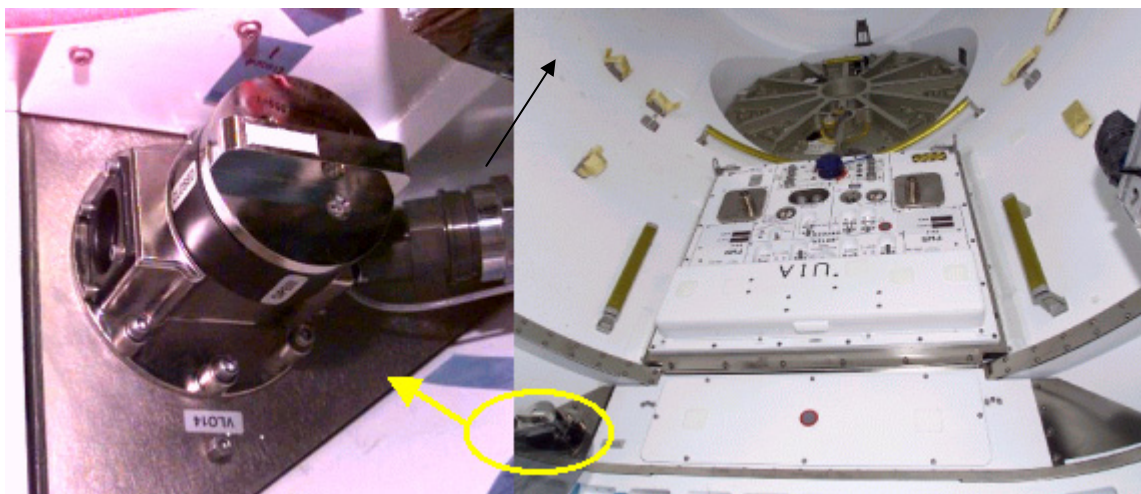


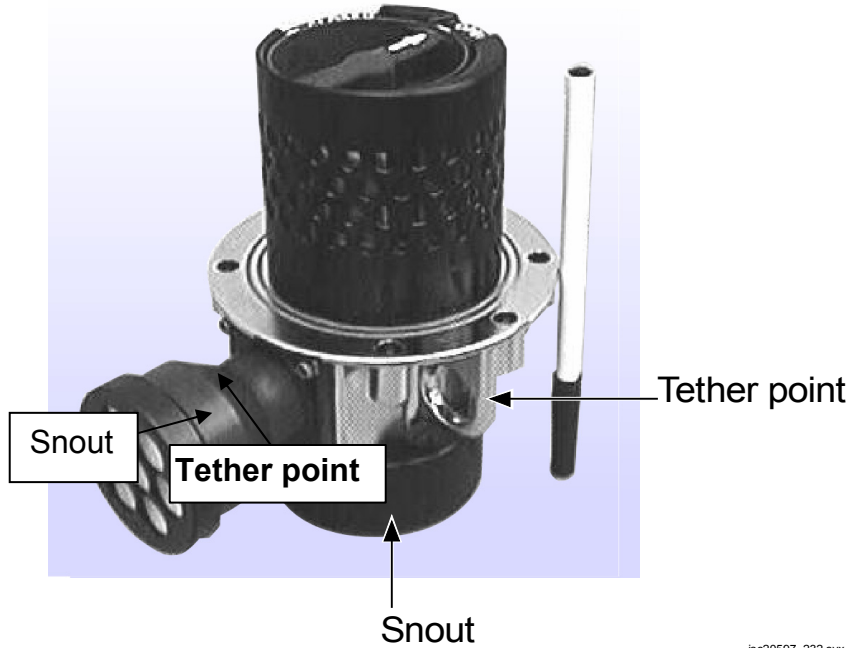
Figure 1.13-17. Depress manual isolation valve

1.13.2.5 Airlock Manual Pressure Equalization Valve

The AMPEV is also called the EV Hatch Equalization Valve or EV MPEV. The valve has two positions: CLOSED and OPEN. The effective diameter of the valve opening in OPEN is 0.23 inches and closed in the CLOSED position. Figure 1.13-18 is a comparative photo of the AMPEV and the standard USOS MPEV. For MPEV drawing, refer to ISSSH Drawing 12.12 (Preliminary A/L Hatches).

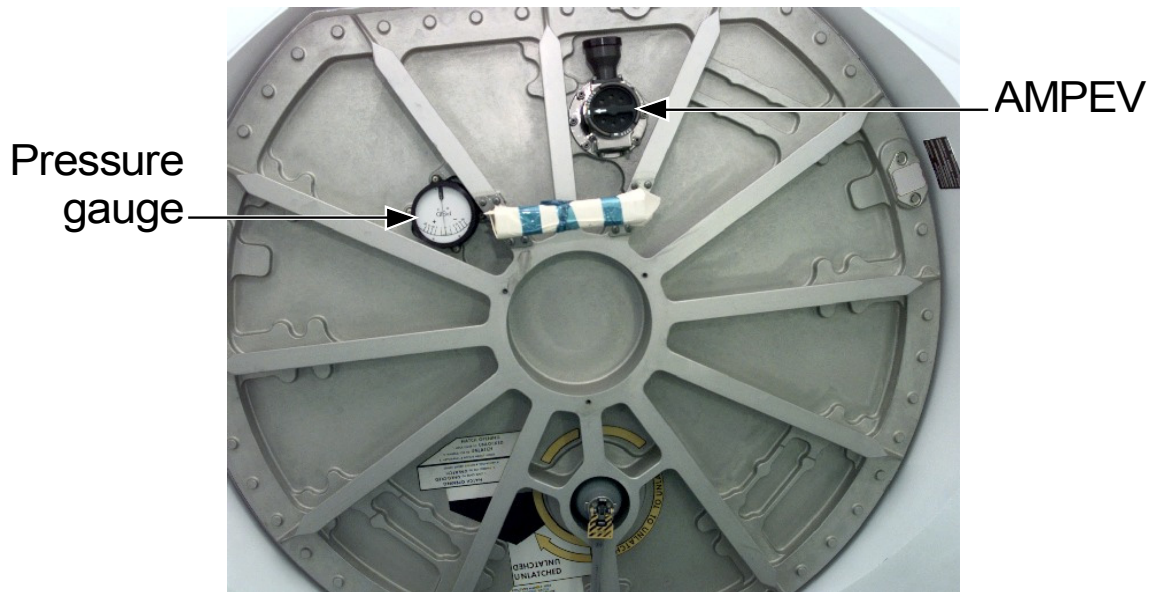
The AMPEV utilized in the Crewlock EV hatch is the only valve of its kind on ISS. This configuration has a diskstack added to minimize acoustic levels. Additionally, the inlet design is different from the standard valve to avoid EVA snag hazard concerns identified during design reviews. As a result of this change, there is no inlet interface or Gamah fitting like the one employed in the standard configuration. A tether point (Figure 1.13-18) was also added to meet EVA ORU tethering requirements, not for restraining the crewmember. The AMPEV uses six 5/32" hex head fasteners to attach to the EV Hatch like the other USOS MPEVs. Figure 1.13-19 shows where the AMPEV

is located on the EV hatch, and Figure 1.13-20 shows the flow path through the AMPEV. The flow goes in the snout and diffuses nonpropulsively into vacuum.



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Figure 1.13-18 Tether point



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Figure 1.13-19. AMPEV on EV hatch

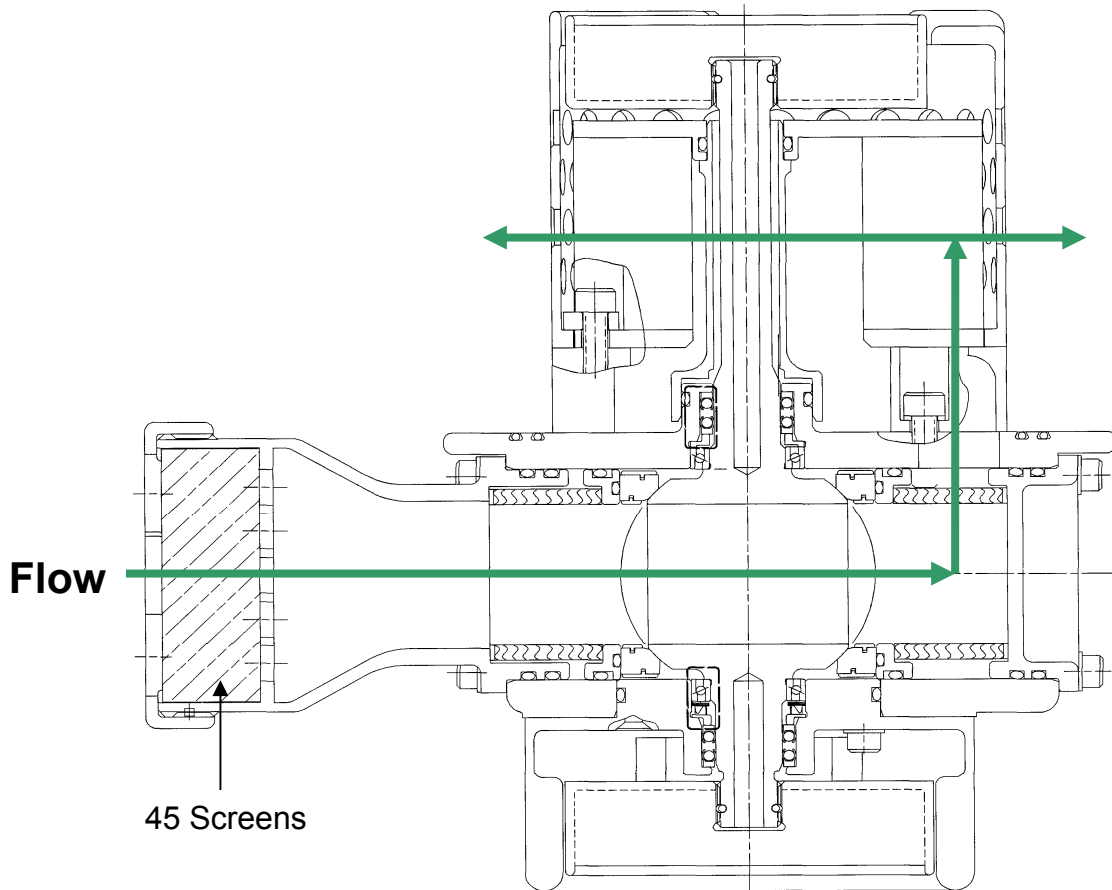


Figure 1.13-20. Flow path through the AMPEV

The flow rate through the AMPEV is much smaller than expected. It takes about 40 minutes to depress from 5 psi to 0.5 psi in the Crewlock using just the AMPEV to depress. This depress rate did not match the rates obtained from ground testing, which were at least twice as fast as on orbit. It is not clear why the on-orbit AMPEV is so much slower. It is suspected that by removing the 45 screens from the inlet of the snout that the depress rates will improve. Figure 1.13-22 shows the removal of the screens. More information on this procedure should be referenced from the OSO procedure Airlock EV Hatch MPEV Modification.



Figure 1.13-21. Removal of the 45 inlet screens on the AMPEV

The screens have not yet been removed, as the crew have been unable to remove the cap retaining the screens (as of 7/02/2002, post UF-2). A tool has been flown to help remove the cap, but due to clearance issues with the hatch, they have not been able to squarely mate. With the tool partially mated, the crew did attempt to remove the cap, but the force required exceeded 100 in-lbs. Not wanting to damage the AMPEV, the crew discontinued efforts at removing the screens. Figure 1.13-22 shows the tool used.



1/4" Ratchet
Interface

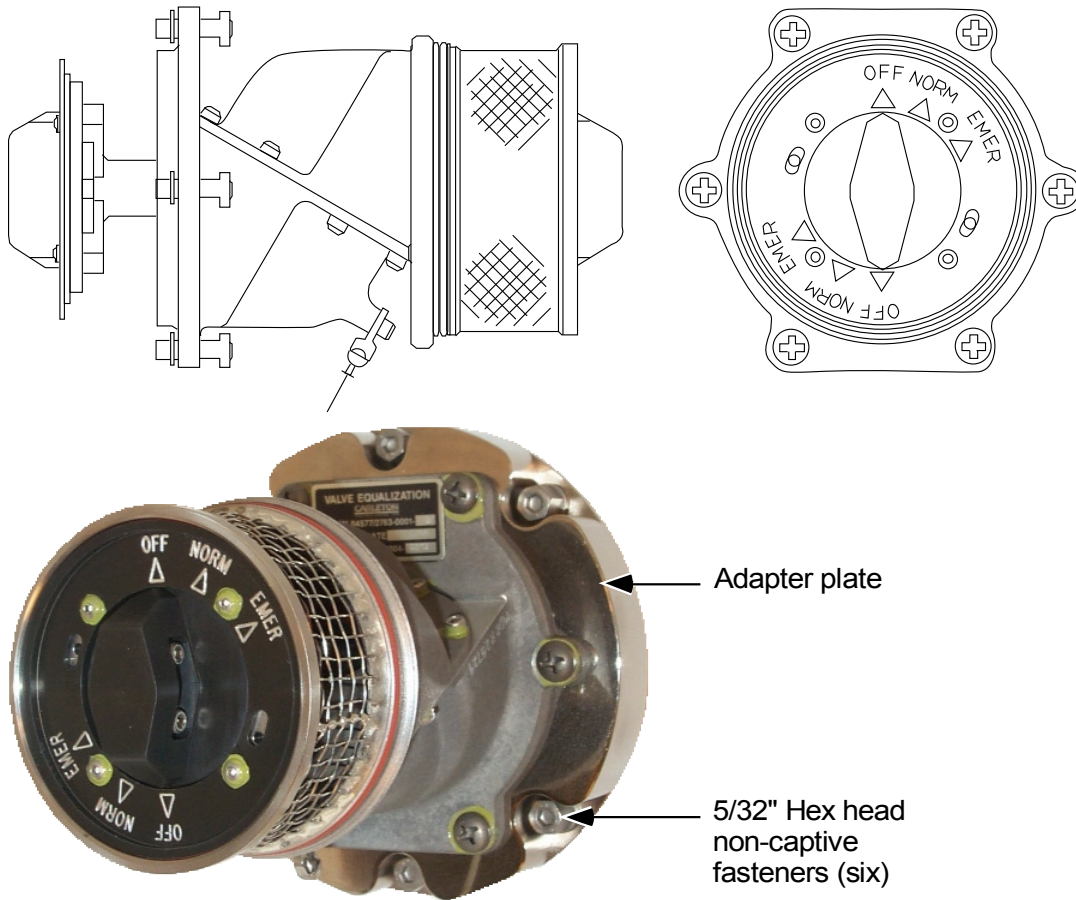
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Figure 1.13-22. Tools for screen removal

1.13.2.6 Shuttle Pressure Equalization Valve

Figure 1.13-23 shows the SPEV used in the USOS hatch between the E/L and Crewlock. Figure 1.13-24 shows the location of the SPEV on the IV hatch. The SPEV was selected in order to meet the EVA 80-second emergency repress requirement that

could not be met by the USOS MPEV. Since the USOS MPEV was originally slated to be installed in this hatch, an adapter plate is required for the installation of the SPEV in its place. This plate is attached to the hatch by six 5/32-inch hex head fasteners. This valve does not meet NC50 (58 dba) acoustic noise emission requirements set forth by ISS Program and is flown on a waiver. The USOS MPEV with diskstack was put in place to meet acoustic requirements (CR 719) on ISS. For SPEV drawing, refer to SSSH Dwg 14.9 (Hatches).



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Figure 1.13-23. Shuttle pressure equalization valve

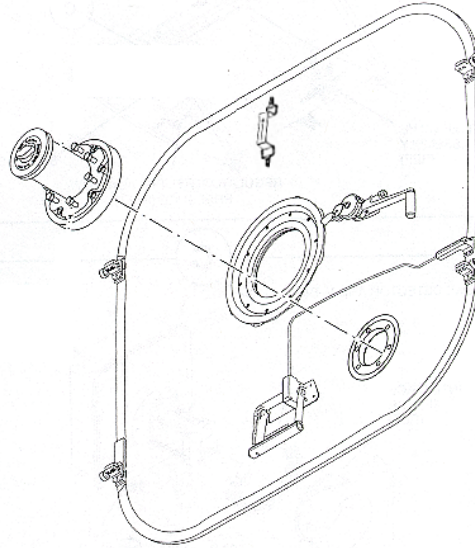


Figure 1.13-24. SPEV location on IV hatch

1.13.2.7 Valve Performance

Repress

The IV hatch equalization valve is a shuttle valve and used for repress. Below are some tables detailing the performance of SPEVs. These tables are from the EECOM console handbook and SODF. *Table 1.13-2* details the flow rates of the SPEV in the NORM and EMER positions at various pressures.

Table 1.13-2. SPEV Flow Rates

Airlock component flow rates (approximate)									
Valve Position		Hole	Eff.	Cd	Approx. Flow Rates (lb/hr)				
		Size	Area		Orbiter/Airlock Press (psi)				
		(in. dia)	(in ²)		5	8	10.2	12	14.7
Hatch	Cap Hole	0.18*	--		7.5	12	15	18	22
EQL VLV	NORM	0.451	0.159	0.59	83	132	169	199	243
	EMER	1.230	1.188		440	705	899	1058	1295

This is shuttle data, so the numbers may be slightly inaccurate. But the numbers are on the conservative side. ISS has a larger volume of cabin pressure, which would increase the repress rate. Also, the Crewlock volume is 188 ft³, slightly smaller than the airlock volume in *Table 1.13-3*. This would also increase the repress rate of the SPEV as compared to the table rates.

Table 1.13-3. SPEV Repress Rates

Total A/L Vol - 208 ft ³						
EQL VLV (position)	14.7 psi cabin			10.2 psi cabin		
	Flow (lb/hr)	dP/dT airlock (psi/min)		Flow (lb/hr)	dP/dT airlock (psi/min)	
1 - NORM	243	+3.82		169	+2.66	
1 - EMER	1295	+0.34		899	+0.24	
		psi/sec			psi/sec	
1 Cap Hole	22	+0.35		15	+0.24	

Figure 1.13-25 shows actual flight data on the repress of the Crewlock during EVA1 of the 8A mission. This profile shows a nominal repress of the Crewlock using the NORM position of the SPEV.

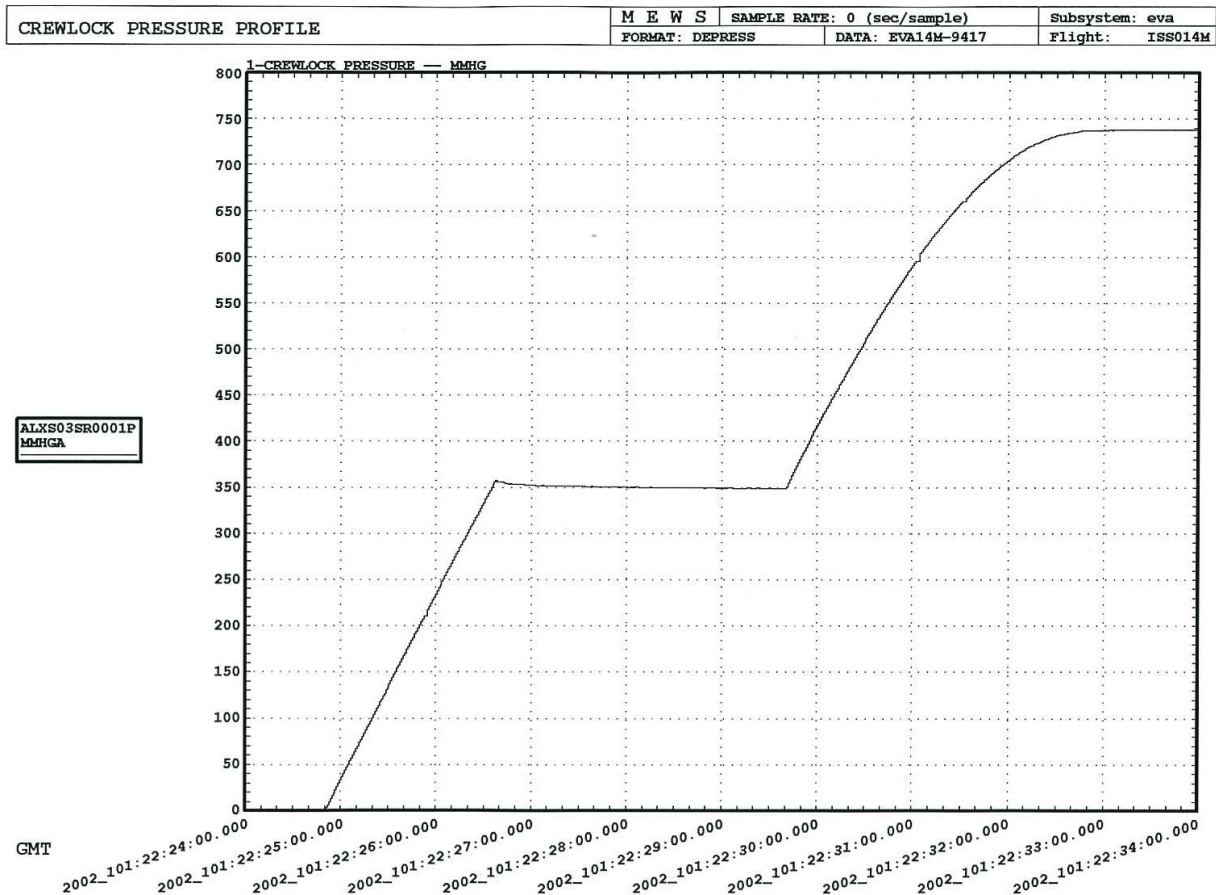


Figure 1.13-25. Flight 8A EVA1 Crewlock repress

Depress

As mentioned earlier, the AMPEV by itself takes about 40 minutes to depress from 5 psi to 0.5 psi. This was too slow, so the depress is helped by using the VAJ connection between the Emergency MPEV and the airlock PCA VRA VAP. The depress time in this new configuration takes about 15 minutes to go from 5 psi to 0.5 psi.

Figure 1.13-26 shows the 8A EVA1 flight data of the depress using the AMPEV and VAJ. Figure 1.13-26 also shows the time to depress from 14.5 psi (750 mmHg) to 5 psi (260 mmHg) to be about 9 minutes. This is through the usual channel of the depress pump and the depress pump manual isolation valve.

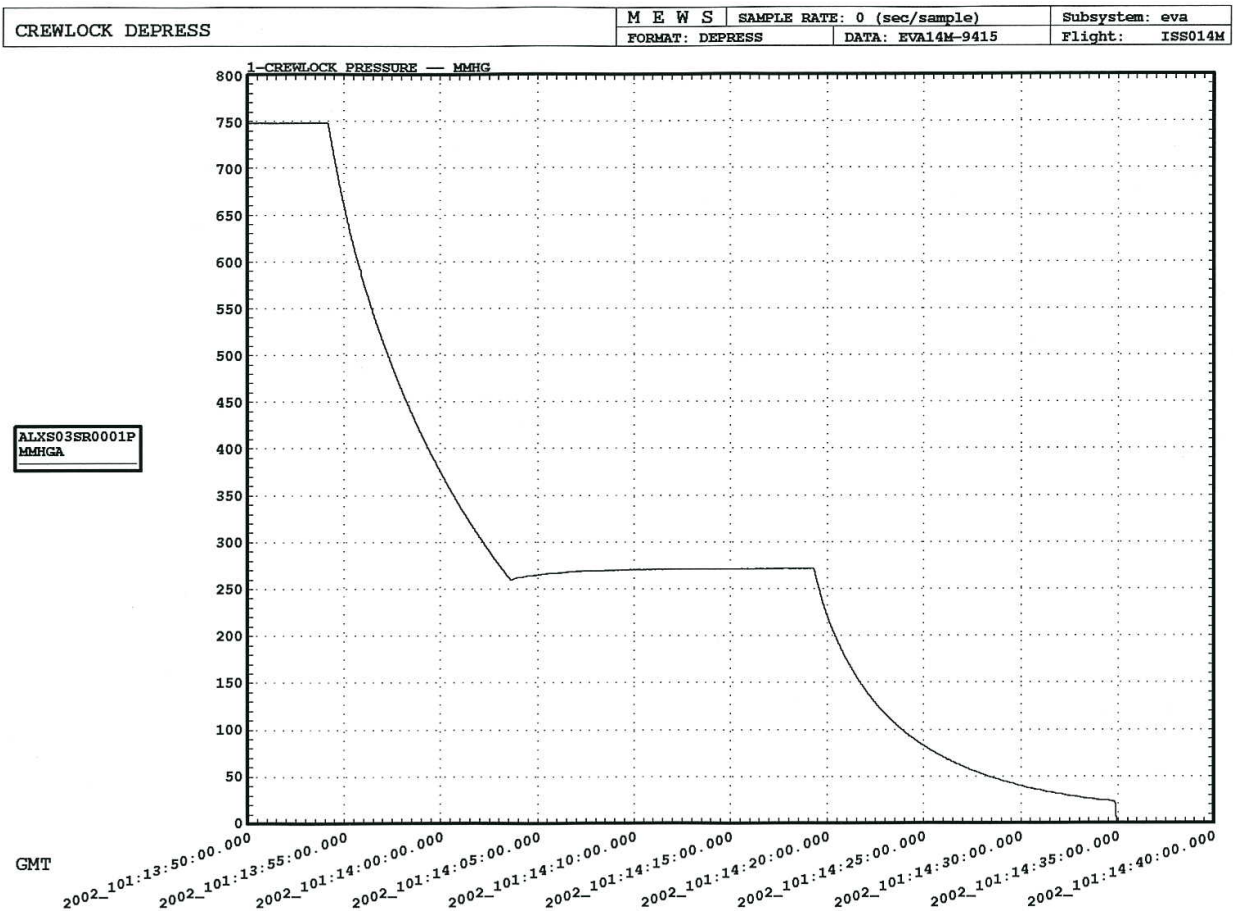


Figure 1.13-26. 8A EVA1 Crewlock Depress with AMPEV and VAJ

1.13.3 Related Documentation References

Data Processing System - Systems Brief, Volume 1 – Hardware, Rev. Basic, Section 11.14, J. Jason

Environmental Systems Console Handbook, Volume5 – Airlock / EVA, Rev. C, Section 1.2.1.2, & 1.5, S.C. Doering

ECLSS Systems Briefs, 3.4 Manual Pressure Equalization Valve, J. Garr.

EVA Systems Brief, 6.0 Joint Airlock Equalization Valves System Brief, D. Miller

International Space Station (Crewlock) – EV Hatch Design Overview, T. Cooks

USOS Standard Hatch System Brief, OSO, Mike Campion

ISS Joint Airlock Systems Brief, OSO

2.1 EVA TELEMETRY

EVA telemetry consists of EMU telemetry and Servicing and Performance Checkout Equipment (SPCE) telemetry. They have two different paths to get to the S-Band antennas, which is discussed in this section. For more detailed information on this subject, reference SSP-41154, Software Interface Control Document Part 1 United States On-Orbit Segment to United States Ground Segment Command and Telemetry. Sections 3.3.2.1 to 3.3.2.5 discuss the S-Band Packets.

2.1.1 EMU Radio IDs

Refer to Section 2.3, Appendix C for a listing of all the EMU radio IDs that the Command and Control (C&C) Multiplexer/Demultiplexer (MDM) recognizes. This listing is given to the C&C MDM in the form of a Pre-Positioned Load (PPL), which is nothing more than a software patch. If the radio ID of the EMU is not in the PPL, the data will not get to the ground. The C&C MDM only routes the data if it recognizes the radio. The radio ID will not show up in the upper left corner of the ISS EMU Data Page 1 if it is not in the PPL. There are four PUIs associated with the radio IDs, which are LACU03FC1000U, LACU03FC2000U, LACU03FC3000U, and LACU03FC4000U. These PUIs are owned by Communications and Tracking Officer (CATO). The ISS supports the telemetry downlink of four EMUs radios.

2.1.2 EMU Telemetry

EMU telemetry is routed directly from the Ultrahigh Frequency (UHF) radios (Space-to-Space EMU Radio (SSER) to Space to Space Station Radio (SSSR)) to the C&C MDM. The C&C MDM then routes it to the S-Band format by preempting Housekeeping One (HK1) with EMU data and biomed (*Figure 2.1-1*). The Command and Control Software (CCS) preempts HK1 with EMU data when the SSSR RT I/O (remote terminal input/output) is enabled and a non-zero radio ID less than 256 is received from the SSSR. The SSSR RT I/O is how the C&C MDM and the SSSR communicate with each other. The C&C MDM uses two kinds of RAM (SRAM and DRAM) to receive the EMU radio IDs. The SRAM first receives the radio ID from the SSSR through the 1553 bus. SRAM is used for receiving data through the 1553 buses. This is where the CCS looks to find a non-zero radio ID less than 256 to determine if EMU data is available for preemption of HK1. Once the SSSR RT I/O is enabled and the SRAM has a non-zero radio ID less than 256, the EMU telemetry flag is set to true, and preemption of HK1 is active. When the SSER is turned off, the SRAM in the C&C MDM will read a zero, and the criteria are no longer met for EMU telemetry flag to be true. However, the CCS does not recognize if the criteria is no longer met, and will continue with the EMU telemetry flag set to true, and preempt HK1. To turn off EMU telemetry, the SSSR RT I/O must be disabled. Disabling or enabling the SSSR RT I/O will initialize the EMU telemetry flag to false. The C&C MDM copies non-zero values from the SRAM to the current value table (CVT), which is in DRAM. The value in the CVT is the value sent to the ground as radio ID. The CVT can only be initialized to zero when the SSSR RT I/O is enabled, so even if the SRAM is reading zero from the SSSR, the CVT will retain its last non-zero value. The CVT can only be updated with non-zero values. That is why the ground continues to receive a radio ID even if the SSER is turned off.

When the Extended Data Dump (EDD) is configured, the CCS rejects the EMU preemption command. EMU data preempts HK1 on the odd numbered frames. The Russian Contingency telemetry will also preempt HK1 data, but on the even numbered frames. When EMU data and Russian Contingency telemetry are both configured, then HK1 is preempted completely and no ISS HK1 data is will be downlinked.

During STS-115 (12A) an anomaly was observed when the SSSR was powered up and the RT I/O was enabled for a Shuttle rendezvous. The anomaly was that HK1 was getting preempted by EMU data when no SSERs were even powered up that day. This anomaly can be explained using the information in this section, and the fact that the SSSR will continue to update the SRAM with the radio ID 5 minutes after the SSER is turned off. This 5 minutes is to protect for comm dropouts. So normally, the EVA team will power off the SSER, and then call CATO to tell them they can power off the SSSR. When CATO powers off the SSSR less than 5 minutes after the SSER is powered off, the C&C MDM SRAM will still contain the radio ID. The SSSR never had a chance to send a zero to the SRAM. So the SRAM will carry the same radio ID until the next time the SSSR can update it. This is where the anomaly can occur. When the SSSR is powered on next, and then the RT I/O enabled, there is a fifty-fifty chance that the stale data in the SRAM will be read and processed before the SSSR updates the SRAM. If the SSSR RT I/O is enabled on an even frame, then the SSSR can update the SRAM with a zero radio ID (the CVT is initialized to zero when RT I/O is enabled). Then the next frame, the CCS sees that the SRAM radio ID is zero and the criteria for setting the EMU telemetry flag is false. No problems. However, if the SSR RT I/O is enabled on an odd frame, then the CCS will take the stale SRAM data and process it before getting an update from the SSSR in the next frame. If this happens then the CVT is initialized to zero from the RT I/O enable, but then the SRAM will just overwrite it back to the stale radio ID. At the same time the CCS recognizes that the SSSR RT I/O is enabled and a non-zero radio ID of less than 256 exists in SRAM. This satisfies the criteria for setting the EMU telemetry flag to true. Once the criteria is satisfied for EMU telemetry, the only way to disable EMU telemetry is to disable (or enable, but it is enabled already) the SSSR RT I/O. In order to avoid this anomaly, flight controllers should have CATO wait over 5 minutes after SSERs powerdown before powering off the SSSR. That is also the recommendation of SPN 35272. If this anomaly does occur again, or if the SSSR is needed after the SSERs are powered off, simply disable the SSSR RT I/O and enable it after the SSSR has cleared the radio IDs from memory (wait 5 minutes). *Table 2.1-1* shows the sequences of events during the day of the anomaly.

Table 2.1-1. Sequence of events leading to the 12A EMU preemption anomaly

Event	Radio ID in SRAM	Radio ID in CVT	Emu_telemetry
SSSR powered off too early previously	73	73	
SSSR powered on	73	73	
SSSR RT I/O Enabled	73	0 (initialized to 0 when RT I/O enabled)	False (set to false when RT I/O enabled)
Code evaluates SSSR data (prior to updated transmission from SSSR)	73	73 (overwritten with new SRAM contents)	True (because SRAM radio ID is not 0 and < 256)
Code evaluates SSSR data (after being updated from SSSR)	0	73 (CVT is not updated. It is only updated when the radio ID is not 0.)	True (When the radio ID is non-zero and < 256, emu_telemetry = true. But, when criteria are not met, emu_telemetry is not set to false.)
SSSR FDIR Enabled	0	73	True
SSSR FDIR Inhibited	0	73	True
SSSR RT I/O Disabled	0	73	False (set to false when RT I/O disabled)
SSSR powered OFF	0	73	False
SSSR RT I/O Enabled	0	0 (initialized to 0 when RT I/O enabled)	False (set to false when RT I/O disabled)
SSSR FDIR Enabled	0	0	False

Figure 2.1-1 shows a typical frame of the normal high data rate S-Band format. Essential telemetry and Normal Data Dump (NDD) sections of that frame do not get preempted.

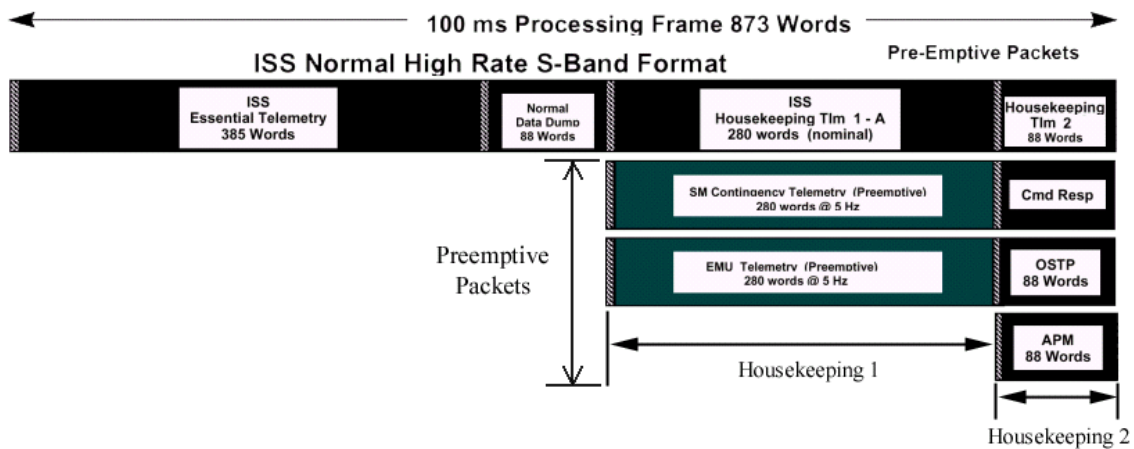


Figure 2.1-1. S-band format with preemptive packets

The ISS can transition to Low Rate S-band telemetry, in which case the CCS disables the Data Dump, HK1, HK2, and any preemptive packets such as the EMU telemetry. However, during this low data rate, any and all of those disabled functions can be commanded on, so that EMU telemetry can be recovered if the CCS HK1 was commanded back on.

2.1.2.1 Preemption

Preemption of a packet means that the preempted packet is replaced every other frame by another desired data frame. Therefore, when preempting is selected the packet transmission is delayed by half since the bandwidth is shared with another user.

HK 1 can only be preempted by Russian Segment Contingency Telemetry or EMU telemetry, as shown in Figure 2.1-1. If both the Russian and EMU telemetry are preempting HK1 data there will not be any HK1 data.

Housekeeping 2 (HK2) can be preempted by Command Response, Onboard Short Term Plan (OSTP) (post-Flight12A CCSR3), or APM (Attached Pressurized Module) as shown in Figure 2.1-1. They are beyond the scope of this document.

2.1.2.2 Replace

The EDD replaces the HK1 and NDD (See Figure 2.1-2), which means that no HK1 or NDD data is sent to the ground. It is completely replaced with the EDD. With no HK1, there is no preemption of HK1, so that EMU data is not possible during EDD ops. HK2 is still active with all its preemptive packets as shown in Figure 2.1-2. Periodic Data Dumps are performed, as needed, that last about 30 minutes.

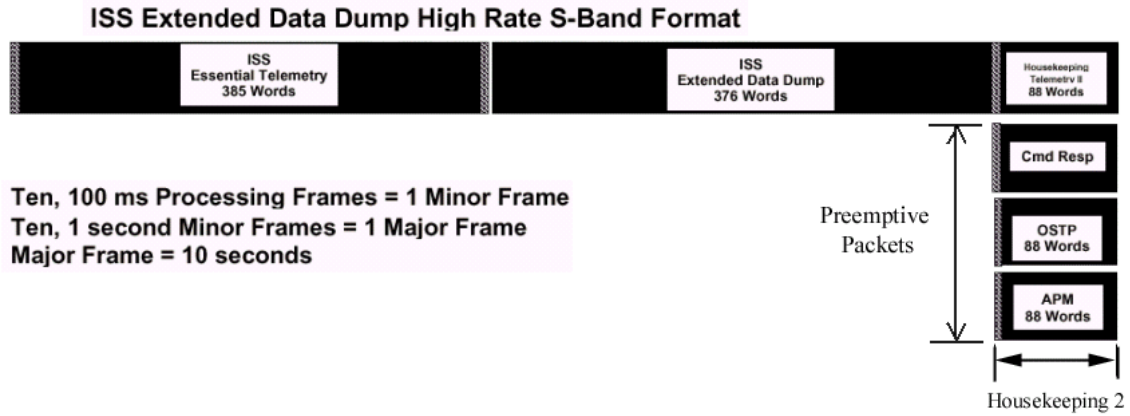


Figure 2.1-2. Extended data dump in S-band format

2.2 SPCE TELEMETRY AND PACKET SWAPPING

The Servicing, Performance, and Checkout Equipment telemetry is supplied from the PSA, UIA, and BCA. All the SPCE signal PUIs and their downlink rates are listed in Section 2.3, Appendix A. Section 2.3, Appendix D shows the breakdown of the BCA Serial Data. In summary, all signal PUIs measuring the power draw of the suits (EMU or Orlan) from the UIA and PSA are sent down at 1 Hz, or once every second. The remaining signal PUIs (BCA analog and serial data, PSA IRU, PSA LCD, etc.) are sent down at 0.1 Hz, or once every 10 seconds. BCA serial data is sent every 10 seconds, but what is sent is only what is known by the Airlock MDM. The Airlock MDM has to poll the BCAs to get the serial data (the hour glass seen on the BCA displays). This process takes additional time, so BCA serial data is actually older than 10 seconds when seen.

All the SPCE data is downlinked in House Keeping 1 (HK1) packet. The upgrade to CCS R6 (following Flight 13A), introduces packet swapping. This concept is similar to the Telemetry Format Loads (TFLs) in Shuttle. There will be three telemetry format versions for S-Band. They are JSC, KSC, and LSC. The format names are xSC, where the "x" is a sequence identifier. "SC" indicates S-Band Content. Therefore, any format with "SC" identifies S-Band telemetry. *Table 2.2-1* below shows the format name, the MDM and PCS versions, and the approximate transition timeframe. Again, all SPCE data are still in the HK1 format.

There is one format that does not have the BCA Serial Channel, Type, Task, Status, or BCA Serial Data Status info in it, but it does have everything else. This format is LSC HK1.

Table 2.2-1. ISS S-band telemetry formats and their effective flights

ISS Software versions	Formats and Packet	Content
CCS R6 (~after 13A) MSS R3**** NCS R2** (Packet swapping)	JSC HK1	All EVA, Airlock and Orlan Telemetry Families 1, 2, 3, 4, 5, 6, 7, 8*
	KSC HK1	All EVA, Airlock and Orlan Telemetry Families 1, 2, 3, 4, 5, 6, 7, 8*
	LSC HK1	All, except BCA Serial Data Health, and BCA Channel, Type, Task, and Status Families 1, 2, 5, 6, 7, 8*
CCS R6 MSS R5**** (~TBD) NCS R2** (Packet swapping)	PSC HK1	All EVA, Airlock and Orlan Telemetry Families 1, 2, 3, 4, 5, 6, 7, 8*
	QSC HK1	All EVA, Airlock and Orlan Telemetry Families 1, 2, 3, 4, 5, 6, 7, 8*
	RSC HK1	All EVA, Airlock and Orlan Telemetry Families 1, 2, 3, 4, 5, 6, 7, 8*
CCS R7 MSS R5.1**** (~TBD) NCS R3** (Packet swapping)	VSC HK1	All EVA, Airlock and Orlan Telemetry Families 1, 2, 3, 4, 5, 6, 7, 8*
	WSC HK1	All EVA, Airlock and Orlan Telemetry Families 1, 2, 3, 4, 5, 6, 7, 8*
	XSC HK1	All EVA, Airlock and Orlan Telemetry Families 1, 2, 3, 4, 5, 6, 7, 8*
CCS R7 MSS R6**** (~TBD) NCS R3** (Packet swapping)	761SC HK1	All EVA, Airlock except Dep Pump, Orlan CW Families 1, 2, 3, 4, 5, 7*
	762SC HK1	All EVA, Airlock and Orlan Telemetry Families 1, 2, 3, 4, 5, 6, 7, 8*
	763SC HK1	Only Orlan C&W Family 5*
	764SC HK1	Only Orlan C&W Family 5*

* More information on the families can be found in Section 2.2.5.1 Families

**Node Control Software

****Mobile Servicing Software

2.2.1 Command and Control Software (CCS)

CCS describes the software version that the ISS is running. As Table 2.2-1 shows, telemetry formats are tied with CCS releases. In the format identifier, CCS Rx, the “x” indicates the release version or revision number. New versions are required to accommodate improvements and corrections in the software. The release schedule allows time for software certification and testing prior to implementation. Changing from one telemetry format to another requires a Pre-Positioned Load (PPL). The Communications and Tracking Officer (CATO) is in charge of changing the PPLs. As reflected in *Figure 2.2-1*, CATO has a Comm Sentry display to indicate which packet is currently active. It takes less than 5 minutes to swap packets.

2.2.2 Packet Swapping

The reason for packet swapping is limited bandwidth. As the ISS increases in size and complexity, the amount of data also increases, and it is projected that by assembly

complete, the ISS will need to downlink twice as much data as it has bandwidth. The solution is to timeshare the bandwidth (e.g., packet swapping).

Packet swapping is required to share the limited bandwidth coming from ISS. The packet swapping concept is similar to the shuttle's telemetry system as it switches TFLs, depending on what telemetry is needed. The idea is that not all data is needed all the time. There are many special operations that only require data during those operations, such as EVA. There are no EVA operations that require constant data downlink for more than a few days. There is no packet swapping of the Essential telemetry formats. The data in those formats are critical to the ISS functions and crew health.

Figure 2.2-1 is the Comm Sentry display, which has a bottom row that indicates the currently active packets. This display is much easier to use than trying to decipher the PPL packets because the deciphering is done automatically. The Essential packet never changes in CCSR6, MSSR3 and will always be JSC. The HK1 and HK2 packets can change from JSC to KSC to LSC. The OIU format is not important to EVA; it is used to send data down the Orbiter Interface when the Shuttle is docked. The CATO group built the Comm Sentry display. To call it up, simply find the CATO group in the DNAV; the Comm Sentry is right on top. The Joint Airlock display will also have the active packets displayed.

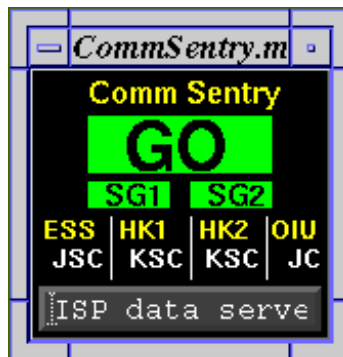


Figure 2.2-1. Comm Sentry display

The telemetry format LSC contains all the BCA Serial data. It does not contain the Channel, Type, Task, and Status parameters from the BCA serial data. It also does not contain any of the BCA Serial Data Status parameters (the health flags of the serial data, i.e., NORMAL vs. NO DATA). Looking in Section 2.3, Appendix A, the data not contained in LSC are from the families called **A/L EVA SPCE - Supporting_BCA Serial_Data Status** and **A/L EVA SPCE - BCA_Serial_Data_Status**. The only BCA serial data that LSC does have are Volts, Amps, and Time.

2.2.2.1 Families

A family is a group of related PUIs that always go together. The family names are used to select PUIs into the packets. The family system makes it much easier to organize the thousands of PUIs when deciding what telemetry goes in which packet. The ISS

Command Telemetry Team (ICATT) attempts to select the families logically into the packets.

EVA has six families of interest:

1. A/L EVA PSA&UIA – EMU&ORLAN_Power
2. A/L EVA SPCE – Volts&Amps&Ser_Data
3. A/L EVA SPCE – Supporting_BCA_Serial_Data
4. A/L EVA SPCE – BCA_Serial_Data_Status
5. MULTI – Russian ECW_A
6. SM EVA Orlan – Suit Telemetry

The following two families are owned by other disciplines but are of interest to EVA:

1. MULTI C&T UHF – SP OPS 0.1_HZ
2. A/L ECLSS – Depress Pump HK-A

See Section 2.3, Appendix A for a list of PUIs that are in each family. All the PUIs with a rate of 1 Hz are in the family A/L EVA PSA&UIA – EMU&ORLAN_Power. The rest of the PUIs in the remaining families are sent at 0.1 Hz.

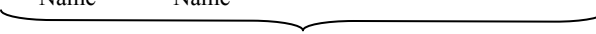
Quick summary of each family:

1. A/L EVA PSA&UIA – EMU&ORLAN_Power: Contains PSA and UIA volts and amps for EMU and Orlan. This data is sent down to the ground at 1 Hz or once every second.
2. A/L EVA SPCE – Volts&Amps&Ser_Data: Contains BCA serial data for volts, amps, and time. Also contains BCA analog volts and amps. PSA IRU and LCD volts and amps are in this family as well. The LCD is really the sixth channel in the PSA and runs the signal conditioning board for the PSA as well as powering on the display.
3. A/L EVA SPCE – Supporting_BCA_Serial_Data: Contains the rest of the BCA serial data, the Channel, Type, Task, and Status.
4. A/L EVA SPCE – BCA_Serial_Data_Status: Contains the Airlock MDM telemetry on the health of the BCA serial data. This family includes the Serial Data Status parameter, the parameter we use to tell if the BCA is powered on, i.e., NO DATA or NORMAL.
5. MULTI – Russian ECW_A: Contains Orlan C&W indications of Low O2, Low Suit P, or Emergency O2 activated.

6. SM EVA Orlan – Suit Telemetry: Contains Orlan suit parameters.
7. MULTI C&T UHF – SP OPS 0.1 HZ: Contains the EMU Radio IDs
8. A/L ECLSS – Depress Pump HK-A: Contains all the Depress Pump data except the RPC data.

The first four families (1 - 4) are part of a super family called SSRMS_EVA_Prox_Ops_UHF. A super family is a grouping of families that most likely will be used together. This superfamily includes SSSR telemetry, SSRMS telemetry and EVA airlock telemetry, which is everything needed for an EVA requiring arm ops. The families in the superfamily are not stuck there; they can still be individually selected for another packet. The superfamily is just a convenient way of organizing families. Packet LSC is a case in point. Not all of the superfamily SSRMS_EVA_Prox_Ops_UHF is selected in it. Only some select families. Each family is given a priority level of importance prior to selection. After the most important data has been selected into packets, any empty space is filled in with the families of lesser importance. Having to assign priority levels for the data is why there are multiple families for battery charging data.

The family names are in the following format.

ISS Element Name	ISS System Name	ISS Subsystem Name	Subsystem Name	Component Name	Subcomponent Name	Function
						
				Optional		

2.2.3 Zone of Exclusion (ZOE) Recorder

The C&C MDM has a ZOE recorder that records all the S-Band Telemetry during ZOE. The ground can command the C&C to playback the recorder through either Ku-Band or S-Band systems. The preference is Ku-band due to the higher bandwidth. The data on the ground is stored and can be accessed using the Operational Data Reduction Complex (ODRC). If the data is not in the format, the ZOE recorder will not be able to record the data either. A timely request to ODIN/CATO must be made within 30 - 50 minutes of the event to download or the data will be lost.

2.2.4 Known issue with Packet Swapping

There is a known issue with packet swapping that affects EVA RTPLOTS. For some reason, packet swapping causes all EVA RTPLOTS to draw a straight line from the current GMT to a GMT far into the future. After everything settles out from the packet swapping, the RTPLOTS continue to plot data points, but now the plot does not autoscale to show the latest GMT. It just sits at the future date as though it is showing the latest information. So far, the only workarounds are to

- A. Clear all plots, which erases the data (so this choice is undesirable).
- B. Rescale the plots manually.

C. If possible, disable all plots before the packet swap occurs; after the packet swap, reenable the plots. Be sure to wait until everything settles out before reenabling.

2.2.5 Summary

EMU suit data is preempting HK1 and is, therefore, independent of packet swapping. No amount of packet swapping can cause EMU suit data to not get downlinked. One thing to note is that when the Russian Contingency Telemetry (which also preempts HK1) is active at the same time, no HK1 packet data reaches ground. The EMU data and the Russian data will take turns coming down HK1. All SPCE data and BCA Serial Data are in HK1. When ISS transitions to CCSR6, all SPCE data, BCA Serial Data, and Orlan data are in HK1, except for LSC HK1, which does not have some BCA serial data (see *Table 2.2-2*). After the MSS software is updated to R5, the packets will be called PSC, QSC, and RSC. All SPCE data, BCA Serial data, and Orlan data are in each HK1 packet P, Q, and R. As of now, CCSR7, MSSSR5.1 will have packets called VSC, WSC, and XSC. All SPCE data, BCA Serial data, and Orlan data are in each HK1 packet of V, W, and X as well. CCSR7, MSSSR6 will have packets 761SC, 762SC, 763SC, and 764SC. As of 7/12/2007, those packet contents are preliminary, but only 761SC and 762SC have EVA data. Section 2.3, Appendix B shows that almost all the airlock parameters are in all the packets, since they are needed during nominal operations and will always be available no matter what packet is active. The Depress pump data, however, is in its own family and is only selected for packet 762SC. The EMU radio IDs are also only selected for 761SC and 762SC.

Table 2.2-2 details which telemetry is in which packet. An ALL designation means all EVA related data is within the packet (i.e., all families mentioned above). Section 2.3, Appendix A lists the PUIs and the families. If not all telemetry is available in the packet, then there is a listing of what family(ies) of telemetry is available. Cross referencing the families in Appendix A will give the detail of which PUI is available.

Table 2.2-2. EVA and Related Telemetry in ISS S-band Telemetry Formats

FORMATS and PACKETS	CONTENT of interest to EVA
JSC	ALL
KSC	ALL
LSC	A/L EVA PSA&UIA – EMU&ORLAN_Power A/L EVA SPCE – Volts&Amps&Ser_Data MULTI – Russian ECW_A SM EVA Orlan – Suit Telemetry MULTI C&T UHF – SP OPS 0.1_HZ A/L ECLSS – Depress Pump HK-A

PSC	ALL
-----	-----

Table 2.2-2. EVA and Related Telemetry in ISS S-band Telemetry Formats (concluded)

FORMATS and PACKETS	CONTENT of interest to EVA
QSC	ALL
RSC	ALL
VSC	ALL
WSC	ALL
XSC	ALL
761SC	A/L EVA PSA&UIA – EMU&ORLAN_Power A/L EVA SPCE – Volts&Amps&Ser_Data A/L EVA SPCE – Supporting_BCA_Serial_Data A/L EVA SPCE – BCA_Serial_Data_Status MULTI – Russian ECW_A MULTI C&T UHF – SP OPS 0.1_HZ
762SC	A/L EVA PSA&UIA – EMU&ORLAN_Power A/L EVA SPCE – Volts&Amps&Ser_Data A/L EVA SPCE – Supporting_BCA_Serial_Data A/L EVA SPCE – BCA_Serial_Data_Status MULTI – Russian ECW_A SM EVA Orlan – Suit Telemetry MULTI C&T UHF – SP OPS 0.1_HZ A/L ECLSS – Depress Pump HK-A
763SC	MULTI – Russian ECW_A
764SC	MULTI – Russian ECW_A

2.3 EVA TELEMETRY APPENDIXES

APPENDIX A

SPUI	OPS_Name	ENG_Title	Super Family	Family Name
LADP01MDAYNRU	EVA_Buffer_Update_Counter_1	CCI EVA CVT EVA buffer update counters 1		A/L EVA - - - Unassigned
LADP01MDAYNSU	EVA_Buffer_Update_Counter_2	CCI EVA CVT EVA buffer update counters 2		A/L EVA - - - Unassigned
LADP01MDAYNTU	EVA_Buffer_Update_Counter_3	CCI EVA CVT EVA buffer update counters 3		A/L EVA - - - Unassigned
LADP01MDAYNUU	EVA_Buffer_Update_Counter_4	CCI EVA CVT EVA buffer update counters 4		A/L EVA - - - Unassigned
LADP01MDCWYZU	EMU_TLM_CTRL_SPARE	CCT telemetry control extra-vehicular maneuvering mobility unit spare		A/L EVA - - - Unassigned
ALXS03PW0001V	UIA_EV_1_VOLTS	EVAS AL EMU1 Voltage Monitor	SSRMS_EVA_Prox_Ops_UHF	A/L EVA PSA&UIA - - EMU&ORLAN_Power
ALXS03PW0002C	UIA_EV_1_AMPS	EVAS AL EMU1 Current Monitor	SSRMS_EVA_Prox_Ops_UHF	A/L EVA PSA&UIA - - EMU&ORLAN_Power
ALXS03PW0101V	UIA_EV_2_VOLTS	EVAS AL EMU2 Voltage Monitor	SSRMS_EVA_Prox_Ops_UHF	A/L EVA PSA&UIA - - EMU&ORLAN_Power
ALXS03PW0102C	UIA_EV_2_AMPS	EVAS AL EMU2 Current Monitor	SSRMS_EVA_Prox_Ops_UHF	A/L EVA PSA&UIA - - EMU&ORLAN_Power
ALXS03PW0201V	UIA_ORL1_VOLTS	EVAS AL ORL1 Voltage Monitor	SSRMS_EVA_Prox_Ops_UHF	A/L EVA PSA&UIA - - EMU&ORLAN_Power
ALXS03PW0202C	UIA_ORL1_AMPS	EVAS AL ORL1 Current Monitor	SSRMS_EVA_Prox_Ops_UHF	A/L EVA PSA&UIA - - EMU&ORLAN_Power
ALXS03PW0301V	UIA_ORL2_VOLTS	EVAS AL ORL2 Voltage Monitor	SSRMS_EVA_Prox_Ops_UHF	A/L EVA PSA&UIA - - EMU&ORLAN_Power
ALXS03PW0302C	UIA_ORL2_AMPS	EVAS AL ORL2 Current Monitor	SSRMS_EVA_Prox_Ops_UHF	A/L EVA PSA&UIA - - EMU&ORLAN_Power
ALXS02PW0001V	PSA_EMU1_VOLTS	EVAS AL AA Rack PS #1 Voltage	SSRMS_EVA_Prox_Ops_UHF	A/L EVA PSA&UIA - - EMU&ORLAN_Power
ALXS02PW0002C	PSA_EMU1_AMPS	EVAS AL AA Rack PS #1	SSRMS_EVA_Prox_Ops_UHF	A/L EVA PSA&UIA - - EMU&ORLAN_Power

SPUI	OPS_Name	ENG_Title	Super Family	Family Name
		Current		
ALXS02PW0101V	PSA_EMU2_VOLTS	EVAS AL AA Rack PS #2 Voltage	SSRMS_EVA_Prox_Ops_UHF	A/L EVA PSA&UIA - - EMU&ORLAN_Power
ALXS02PW0102C	PSA_EMU2_AMPS	EVAS AL AA Rack PS #2 Current	SSRMS_EVA_Prox_Ops_UHF	A/L EVA PSA&UIA - - EMU&ORLAN_Power
ALXS02PW0201V	PSA_ORL1_VOLTS	EVAS AL AA Rack PS #3 Voltage	SSRMS_EVA_Prox_Ops_UHF	A/L EVA PSA&UIA - - EMU&ORLAN_Power
ALXS02PW0202C	PSA_ORL1_AMPS	EVAS AL AA Rack PS #3 Current	SSRMS_EVA_Prox_Ops_UHF	A/L EVA PSA&UIA - - EMU&ORLAN_Power
ALXS02PW0301V	PSA_ORL2_VOLTS	EVAS AL AA Rack PS #4 Voltage	SSRMS_EVA_Prox_Ops_UHF	A/L EVA PSA&UIA - - EMU&ORLAN_Power
ALXS02PW0302C	PSA_ORL2_AMPS	EVAS AL AA Rack PS #4 Current	SSRMS_EVA_Prox_Ops_UHF	A/L EVA PSA&UIA - - EMU&ORLAN_Power
LADP01MDCWYYJ	EMU_TLM_ENABLED	CCT extravehicular maneuvering mobility unit telemetry enabled	SSRMS_EVA_Prox_Ops_UHF	A/L EVA PSA&UIA - - EMU&ORLAN_Power
ALDS15MD0000C	BCA1_Ch1_Serial_Amps	BCA 1 Channel 1 Amps	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0000V	BCA1_Ch1_Serial_Volts	BCA 1 Channel 1 Volts	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0001C	BCA1_Ch2_Serial_Amps	BCA 1 Channel 2 Amps	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0001V	BCA1_Ch2_Serial_Volts	BCA 1 Channel 2 Volts	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0002C	BCA1_Ch3_Serial_Amps	BCA 1 Channel 3 Amps	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0002V	BCA1_Ch3_Serial_Volts	BCA 1 Channel 3 Volts	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0003C	BCA1_Ch4_Serial_Amps	BCA 1 Channel 4 Amps	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0003V	BCA1_Ch4_Serial_Volts	BCA 1 Channel 4 Volts	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0004C	BCA1_Ch5_Serial_Amps	BCA 1 Channel 5 Amps	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0004V	BCA1_Ch5_Serial_Volts	BCA 1 Channel 5 Volts	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0005C	BCA1_Ch6_Serial_Amps	BCA 1 Channel 6 Amps	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0005V	BCA1_Ch6_Serial_Volts	BCA 1 Channel 6 Volts	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0006C	BCA2_Ch1_Serial_Amps	BCA 2 Channel 1 Amps	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0006V	BCA2_Ch1_Serial_Volts	BCA 2 Channel 1 Volts	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0007C	BCA2_Ch2_Serial_Amps	BCA 2 Channel 2 Amps	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0007V	BCA2_Ch2_Serial_Volts	BCA 2 Channel 2 Volts	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0008C	BCA2_Ch3_Serial_Amps	BCA 2 Channel 3 Amps	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data

SPII	OPS_Name	ENG_Title	Super Family	Family Name
ALDS15MD0008V	BCA2_Ch3_Serial_Volts	BCA 2 Channel 3 Volts	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0009C	BCA2_Ch4_Serial_Amps	BCA 2 Channel 4 Amps	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0009V	BCA2_Ch4_Serial_Volts	BCA 2 Channel 4 Volts	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0010C	BCA2_Ch5_Serial_Amps	BCA 2 Channel 5 Amps	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0010V	BCA2_Ch5_Serial_Volts	BCA 2 Channel 5 Volts	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0010W	BCA1_Ch1_Serial_Time	BCA 1 Channel 1 Time	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0011C	BCA2_Ch6_Serial_Amps	BCA 2 Channel 6 Amps	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0011V	BCA2_Ch6_Serial_Volts	BCA 2 Channel 6 Volts	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0011W	BCA1_Ch2_Serial_Time	BCA 1 Channel 2 Time	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0012C	BCA3_Ch1_Serial_Amps	BCA 3 Channel 1 Amps	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0012V	BCA3_Ch1_Serial_Volts	BCA 3 Channel 1 Volts	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0012W	BCA1_Ch3_Serial_Time	BCA 1 Channel 3 Time	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0013C	BCA3_Ch2_Serial_Amps	BCA 3 Channel 2 Amps	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0013V	BCA3_Ch2_Serial_Volts	BCA 3 Channel 2 Volts	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0013W	BCA1_Ch4_Serial_Time	BCA 1 Channel 4 Time	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0014C	BCA3_Ch3_Serial_Amps	BCA 3 Channel 3 Amps	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0014V	BCA3_Ch3_Serial_Volts	BCA 3 Channel 3 Volts	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0014W	BCA1_Ch5_Serial_Time	BCA 1 Channel 5 Time	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0015C	BCA3_Ch4_Serial_Amps	BCA 3 Channel 4 Amps	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0015V	BCA3_Ch4_Serial_Volts	BCA 3 Channel 4 Volts	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0015W	BCA1_Ch6_Serial_Time	BCA 1 Channel 6 Time	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0016C	BCA3_Ch5_Serial_Amps	BCA 3 Channel 5 Amps	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0016V	BCA3_Ch5_Serial_Volts	BCA 3 Channel 5 Volts	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0016W	BCA2_Ch1_Serial_Time	BCA 2 Channel 1 Time	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0017C	BCA3_Ch6_Serial_Amps	BCA 3 Channel 6 Amps	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0017V	BCA3_Ch6_Serial_Volts	BCA 3 Channel 6 Volts	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0017W	BCA2_Ch2_Serial_Time	BCA 2 Channel 2 Time	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0018C	BCA4_Ch1_Serial_Amps	BCA 4 Channel 1 Amps	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0018V	BCA4_Ch1_Serial_Volts	BCA 4 Channel 1 Volts	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0018W	BCA2_Ch3_Serial_Time	BCA 2 Channel 3 Time	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0019C	BCA4_Ch2_Serial_Amps	BCA 4 Channel 2 Amps	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data

SPII	OPS_Name	ENG_Title	Super Family	Family Name
ALDS15MD0019V	BCA4_Ch2_Serial_Volts	BCA 4 Channel 2 Volts	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0019W	BCA2_Ch4_Serial_Time	BCA 2 Channel 4 Time	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0020C	BCA4_Ch3_Serial_Amps	BCA 4 Channel 3 Amps	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0020V	BCA4_Ch3_Serial_Volts	BCA 4 Channel 3 Volts	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0020W	BCA2_Ch5_Serial_Time	BCA 2 Channel 5 Time	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0021C	BCA4_Ch4_Serial_Amps	BCA 4 Channel 4 Amps	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0021V	BCA4_Ch4_Serial_Volts	BCA 4 Channel 4 Volts	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0021W	BCA2_Ch6_Serial_Time	BCA 2 Channel 6 Time	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0022C	BCA4_Ch5_Serial_Amps	BCA 4 Channel 5 Amps	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0022V	BCA4_Ch5_Serial_Volts	BCA 4 Channel 5 Volts	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0022W	BCA3_Ch1_Serial_Time	BCA 3 Channel 1 Time	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0023C	BCA4_Ch6_Serial_Amps	BCA 4 Channel 6 Amps	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0023V	BCA4_Ch6_Serial_Volts	BCA 4 Channel 6 Volts	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0023W	BCA3_Ch2_Serial_Time	BCA 3 Channel 2 Time	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0024W	BCA3_Ch3_Serial_Time	BCA 3 Channel 3 Time	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0025W	BCA3_Ch4_Serial_Time	BCA 3 Channel 4 Time	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0026W	BCA3_Ch5_Serial_Time	BCA 3 Channel 5 Time	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0027W	BCA3_Ch6_Serial_Time	BCA 3 Channel 6 Time	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0028W	BCA4_Ch1_Serial_Time	BCA 4 Channel 1 Time	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0029W	BCA4_Ch2_Serial_Time	BCA 4 Channel 2 Time	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0030W	BCA4_Ch3_Serial_Time	BCA 4 Channel 3 Time	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0031W	BCA4_Ch4_Serial_Time	BCA 4 Channel 4 Time	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0032W	BCA4_Ch5_Serial_Time	BCA 4 Channel 5 Time	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD0033W	BCA4_Ch6_Serial_Time	BCA 4 Channel 6 Time	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALXS01BT0302V	BCA3_Analog_VOLTS	EVAS AL AA Rack BC #3 Voltage Monitor	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALXS01BT0303C	BCA3_Analog_AMPS	EVAS AL AA Rack BC #3 Current Monitor	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALXS01BT0402V	BCA4_Analog_VOLTS	EVAS AL AA Rack BC #4 Voltage Monitor	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALXS01BT0403C	BCA4_Analog_AMPS	EVAS AL AA Rack BC #4 Current Monitor	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data

SPII	OPS_Name	ENG_Title	Super Family	Family Name
ALXS02PW0401V	PSA_IRU_Utility_VOLTS	EVAS AL AA Rack PS #5 Voltage	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALXS02PW0402C	PSA_IRU_Utility_AMPS	EVAS AL AA Rack PS #5 Current	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALXS02PW0501V	PSA_LCD_VOLTS	EVAS AL AA Rack PS #6 Voltage	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALXS02PW0502C	PSA_LCD_AMPS	EVAS AL AA Rack PS #6 Current	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALXS01BT0102V	BCA1_Analog_VOLTS	EVAS AL AA Rack BC #1 Voltage Monitor	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALXS01BT0103C	BCA1_Analog_AMPS	EVAS AL AA Rack BC #1 Current Monitor	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALXS01BT0202V	BCA2_Analog_VOLTS	EVAS AL AA Rack BC #2 Voltage Monitor	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALXS01BT0203C	BCA2_Analog_AMPS	EVAS AL AA Rack BC #2 Current Monitor	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - - Volts&Amps&Ser_Data
ALDS15MD5301J	BCA1_Serial_Data_Status	BCA 1 Serial Data Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5302J	BCA1_Sequence	BCA 1 Sequence	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5303J	BCA1_Invalid_Channel_State	BCA 1 Invalid Channel State	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5304J	BCA1_Invalid_Channel_Status	BCA 1 Invalid Channel Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5305J	BCA1_Invalid_Condition_Code	BCA 1 Invalid Condition Code	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5306J	BCA1_SPD1553_Operational	BCA 1 SPD1553 Operational	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5307J	BCA1_Charger_ID	BCA 1 Charger ID	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5333J	BCA2_Serial_Data_Status	BCA 2 Serial Data Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5334J	BCA2_Sequence	BCA 2 Sequence	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5335J	BCA2_Invalid_Channel_State	BCA 2 Invalid Channel State	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5336J	BCA2_Invalid_Channel_Status	BCA 2 Invalid Channel Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5337J	BCA2_Invalid_Condition_Code	BCA 2 Invalid Condition Code	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5338J	BCA2_SPD1553_Operational	BCA 2 SPD1553 Operational	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5339J	BCA2_Charger_ID	BCA 2 Charger ID	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5365J	BCA3_Serial_Data_Status	BCA 3 Serial Data Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5366J	BCA3_Sequence	BCA 3 Sequence	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5367J	BCA3_Invalid_Channel_State	BCA 3 Invalid Channel State	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status

SPII	OPS_Name	ENG_Title	Super Family	Family Name
ALDS15MD5368J	BCA3_Invalid_Channel_Status	BCA 3 Invalid Channel Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5369J	BCA3_Invalid_Condition_Code	BCA 3 Invalid Condition Code	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5370J	BCA3_SPD1553_Operational	BCA 3 SPD1553 Operational	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5371J	BCA3_Charger_ID	BCA 3 Charger ID	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5397J	BCA4_Serial_Data_Status	BCA 4 Serial Data Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5398J	BCA4_Sequence	BCA 4 Sequence	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5399J	BCA4_Invalid_Channel_State	BCA 4 Invalid Channel State	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5400J	BCA4_Invalid_Channel_Status	BCA 4 Invalid Channel Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5401J	BCA4_Invalid_Condition_Code	BCA 4 Invalid Condition Code	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5402J	BCA4_SPD1553_Operational	BCA 4 SPD1553 Operational	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5403J	BCA4_Charger_ID	BCA 4 Charger ID	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5312J	BCA1_Data_Integrity	BCA 1 Data Integrity Coding	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5344J	BCA2_Data_Integrity	BCA 2 Data Integrity Coding	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5376J	BCA3_Data_Integrity	BCA 3 Data Integrity Coding	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5408J	BCA4_Data_Integrity	BCA 4 Data Integrity Coding	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - BCA_Serial_Data_Status
ALDS15MD5308J	BCA1_Ch1_Channel	BCA 1 Channel 1 Channel	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5313J	BCA1_Ch2_Channel	BCA 1 Channel 2 Channel	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5317J	BCA1_Ch3_Channel	BCA 1 Channel 3 Channel	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5321J	BCA1_Ch4_Channel	BCA 1 Channel 4 Channel	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5325J	BCA1_Ch5_Channel	BCA 1 Channel 5 Channel	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5329J	BCA1_Ch6_Channel	BCA 1 Channel 6 Channel	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5309J	BCA1_Ch1_Type	BCA 1 Channel 1 Type	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5314J	BCA1_Ch2_Type	BCA 1 Channel 2 Type	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5318J	BCA1_Ch3_Type	BCA 1 Channel 3 Type	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status

SPII	OPS_Name	ENG_Title	Super Family	Family Name
ALDS15MD5322J	BCA1_Ch4_Type	BCA 1 Channel 4 Type	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5326J	BCA1_Ch5_Type	BCA 1 Channel 5 Type	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5330J	BCA1_Ch6_Type	BCA 1 Channel 6 Type	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5310J	BCA1_Ch1_Task	BCA 1 Channel 1 Task	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5315J	BCA1_Ch2_Task	BCA 1 Channel 2 Task	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5319J	BCA1_Ch3_Task	BCA 1 Channel 3 Task	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5323J	BCA1_Ch4_Task	BCA 1 Channel 4 Task	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5327J	BCA1_Ch5_Task	BCA 1 Channel 5 Task	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5331J	BCA1_Ch6_Task	BCA 1 Channel 6 Task	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5311J	BCA1_Ch1_Status	BCA 1 Channel 1 Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5316J	BCA1_Ch2_Status	BCA 1 Channel 2 Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5320J	BCA1_Ch3_Status	BCA 1 Channel 3 Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5324J	BCA1_Ch4_Status	BCA 1 Channel 4 Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5328J	BCA1_Ch5_Status	BCA 1 Channel 5 Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5332J	BCA1_Ch6_Status	BCA 1 Channel 6 Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5340J	BCA2_Ch1_Channel	BCA 2 Channel 1 Channel	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5345J	BCA2_Ch2_Channel	BCA 2 Channel 2 Channel	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status

SPII	OPS_Name	ENG_Title	Super Family	Family Name
ALDS15MD5349J	BCA2_Ch3_Channel	BCA 2 Channel 3 Channel	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5353J	BCA2_Ch4_Channel	BCA 2 Channel 4 Channel	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5357J	BCA2_Ch5_Channel	BCA 2 Channel 5 Channel	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5361J	BCA2_Ch6_Channel	BCA 2 Channel 6 Channel	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5341J	BCA2_Ch1_Type	BCA 2 Channel 1 Type	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5346J	BCA2_Ch2_Type	BCA 2 Channel 2 Type	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5350J	BCA2_Ch3_Type	BCA 2 Channel 3 Type	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5354J	BCA2_Ch4_Type	BCA 2 Channel 4 Type	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5358J	BCA2_Ch5_Type	BCA 2 Channel 5 Type	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5362J	BCA2_Ch6_Type	BCA 2 Channel 6 Type	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5342J	BCA2_Ch1_Task	BCA 2 Channel 1 Task	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5347J	BCA2_Ch2_Task	BCA 2 Channel 2 Task	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5351J	BCA2_Ch3_Task	BCA 2 Channel 3 Task	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5355J	BCA2_Ch4_Task	BCA 2 Channel 4 Task	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5359J	BCA2_Ch5_Task	BCA 2 Channel 5 Task	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5363J	BCA2_Ch6_Task	BCA 2 Channel 6 Task	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5343J	BCA2_Ch1_Status	BCA 2 Channel 1 Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status

SPII	OPS_Name	ENG_Title	Super Family	Family Name
ALDS15MD5348J	BCA2_Ch2_Status	BCA 2 Channel 2 Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5352J	BCA2_Ch3_Status	BCA 2 Channel 3 Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5356J	BCA2_Ch4_Status	BCA 2 Channel 4 Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5360J	BCA2_Ch5_Status	BCA 2 Channel 5 Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5364J	BCA2_Ch6_Status	BCA 2 Channel 6 Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5372J	BCA3_Ch1_Channel	BCA 3 Channel 1 Channel	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5377J	BCA3_Ch2_Channel	BCA 3 Channel 2 Channel	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5381J	BCA3_Ch3_Channel	BCA 3 Channel 3 Channel	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5385J	BCA3_Ch4_Channel	BCA 3 Channel 4 Channel	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5389J	BCA3_Ch5_Channel	BCA 3 Channel 5 Channel	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5393J	BCA3_Ch6_Channel	BCA 3 Channel 6 Channel	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5373J	BCA3_Ch1_Type	BCA 3 Channel 1 Type	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5378J	BCA3_Ch2_Type	BCA 3 Channel 2 Type	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5382J	BCA3_Ch3_Type	BCA 3 Channel 3 Type	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5386J	BCA3_Ch4_Type	BCA 3 Channel 4 Type	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5390J	BCA3_Ch5_Type	BCA 3 Channel 5 Type	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5394J	BCA3_Ch6_Type	BCA 3 Channel 6 Type	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status

SPII	OPS_Name	ENG_Title	Super Family	Family Name
ALDS15MD5374J	BCA3_Ch1_Task	BCA 3 Channel 1 Task	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5379J	BCA3_Ch2_Task	BCA 3 Channel 2 Task	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5383J	BCA3_Ch3_Task	BCA 3 Channel 3 Task	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5387J	BCA3_Ch4_Task	BCA 3 Channel 4 Task	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5391J	BCA3_Ch5_Task	BCA 3 Channel 5 Task	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5395J	BCA3_Ch6_Task	BCA 3 Channel 6 Task	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5375J	BCA3_Ch1_Status	BCA 3 Channel 1 Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5380J	BCA3_Ch2_Status	BCA 3 Channel 2 Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5384J	BCA3_Ch3_Status	BCA 3 Channel 3 Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5388J	BCA3_Ch4_Status	BCA 3 Channel 4 Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5392J	BCA3_Ch5_Status	BCA 3 Channel 5 Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5396J	BCA3_Ch6_Status	BCA 3 Channel 6 Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5404J	BCA4_Ch1_Channel	BCA 4 Channel 1 Channel	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5409J	BCA4_Ch2_Channel	BCA 4 Channel 2 Channel	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5413J	BCA4_CH3_CHANNEL	BCA 4 Channel 3 Channel	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5417J	BCA4_CH4_CHANNEL	BCA 4 Channel 4 Channel	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5421J	BCA4_CH5_CHANNEL	BCA 4 Channel 5 Channel	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status

SPII	OPS_Name	ENG_Title	Super Family	Family Name
ALDS15MD5425J	BCA4_CH6_CHANNEL	BCA 4 Channel 6 Channel	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5405J	BCA4_Ch1_Type	BCA 4 Channel 1 Type	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5410J	BCA4_Ch2_Type	BCA 4 Channel 2 Type	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5414J	BCA4_CH3_TYPE	BCA 4 Channel 3 Type	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5418J	BCA4_CH4_TYPE	BCA 4 Channel 4 Type	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5422J	BCA4_CH5_TYPE	BCA 4 Channel 5 Type	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5426J	BCA4_CH6_TYPE	BCA 4 Channel 6 Type	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5406J	BCA4_Ch1_Task	BCA 4 Channel 1 Task	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5411J	BCA4_Ch2_Task	BCA 4 Channel 2 Task	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5415J	BCA4_CH3_TASK	BCA 4 Channel 3 Task	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5419J	BCA4_CH4_TASK	BCA 4 Channel 4 Task	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5423J	BCA4_CH5_TASK	BCA 4 Channel 5 Task	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5427J	BCA4_CH6_TASK	BCA 4 Channel 6 Task	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5407J	BCA4_Ch1_Status	BCA 4 Channel 1 Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5412J	BCA4_Ch2_Status	BCA 4 Channel 2 Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5416J	BCA4_CH3_STATUS	BCA 4 Channel 3 Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5420J	BCA4_CH4_STATUS	BCA 4 Channel 4 Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA Serial_Data Status
ALDS15MD5424J	BCA4_CH5_STATUS	BCA 4 Channel 5 Status	SSRMS_EVA_Prox_Ops_UHF	A/L EVA SPCE - Supporting_BCA

SPII	OPS_Name	ENG_Title	Super Family	Family Name
ALDS15MD5428J	BCA4_CH6_STATUS	BCA 4 Channel 6 Status	SSRMS_EVA_Prox_Ops_UHF	Serial_Data Status A/L EVA SPCE - Supporting_BCA Serial_Data Status
RREC00CT0051J	SM_ECW_Orlan_O2_P_in_Backpack_Tank_is_Low_1-RS	SM Orlan O2 P in Backpack Tank is Low 1-RS		MULTI - - - - Russian ECW_A
RREC00CT0052J	SM_ECW_Orlan_P_is_Low_1-RS	SM Orlan P is Low 1-RS		MULTI - - - - Russian ECW_A
RREC00CT0053J	SM_ECW_Orlan_O2_Emergency_Supply_Activation_1-RS	SM Orlan O2 Emergency Supply Activation 1-RS		MULTI - - - - Russian ECW_A
RREC00CT0054J	SM_ECW_Orlan_O2_P_in_Backpack_Tank_is_Low_2-RS	SM Orlan O2 P in Backpack Tank is Low 2-RS		MULTI - - - - Russian ECW_A
RREC00CT0055J	SM_ECW_Orlan_P_is_Low_2-RS	SM Orlan P is Low 2-RS		MULTI - - - - Russian ECW_A
RREC00CT0056J	SM_ECW_Orlan_O2_Emergency_Supply_Activation_2-RS	SM Orlan O2 Emergency Supply Activation 2-RS		MULTI - - - - Russian ECW_A
RREC00CT1001C	SM_Orlan_Battery_Current_1-RS	SM Orlan Battery Current 1-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1001E	SM_Orlan_Power_Consumption_1-RS	SM Orlan Power Consumption 1-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1001Q	SM_Orlan_CO2_Concentration_1-RS	SM Orlan CO2 Concentration 1-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1001T	SM_Orlan_Water_Temp_at_Sublimator_Outlet_1-RS	SM Orlan Water Temp at Sublimator Outlet 1-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1001V	SM_Orlan_Battery_Voltage_1-RS	SM Orlan Battery Voltage 1-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1002C	SM_Orlan_Battery_Current_2-RS	SM Orlan Battery Current 2-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1002E	SM_Orlan_Power_Consumption_2-RS	SM Orlan Power Consumption 2-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1002Q	SM_Orlan_CO2_Concentration_2-RS	SM Orlan CO2 Concentration 2-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1002R	SM_Orlan_Gas_Flow_1-RS	SM Orlan Gas Flow 1-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1002T	SM_Orlan_Water_Temp_at_Sublimator_Outlet_2-RS	SM Orlan Water Temp at Sublimator Outlet 2-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1002V	SM_Orlan_Battery_Voltage_2-RS	SM Orlan Battery Voltage 2-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1003R	SM_Orlan_Gas_Flow_2-RS	SM Orlan Gas Flow 2-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1003T	SM_Orlan_Water_Temp_Difference_at_LCG_Inlet-Outlet1-RS	SM Orlan Water Temp Difference at LCG Inlet-Outlet1-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1004R	SM_Orlan_CO2_Concentration_	SM Orlan CO2 Concentration		SM EVA Orlan - - Suit Telemetry

SPII	OPS_Name	ENG_Title	Super Family	Family Name
	Difference_1-RS	Difference 1-RS		
RREC00CT1004T	SM_Orlan_Water_Temp_Difference_at_LCG_Inlet-Outlet2-RS	SM Orlan Water Temp Difference at LCG Inlet-Outlet2-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1005R	SM_Orlan_CO2_Concentration_Difference_2-RS	SM Orlan CO2 Concentration Difference 2-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1007T	SM_Orlan_Gas_Temp_at_Sublimator_Outlet_1-RS	SM Orlan Gas Temp at Sublimator Outlet 1-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1008T	SM_Orlan_Gas_Temp_at_Sublimator_Outlet_2-RS	SM Orlan Gas Temp at Sublimator Outlet 2-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1019P	SM_Orlan_O2_P_in_Prime_Tank_of_Backpack_1-RS	SM Orlan O2 P in Prime Tank of Backpack 1-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1020P	SM_Orlan_O2_P_in_Prime_Tank_of_Backpack_2-RS	SM Orlan O2 P in Prime Tank of Backpack 2-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1021P	SM_Orlan_O2_P_in_Reserve_Tank_of_Backpack_1-RS	SM Orlan O2 P in Reserve Tank of Backpack 1-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1022P	SM_Orlan_O2_P_in_Reserve_Tank_of_Backpack_2-RS	SM Orlan O2 P in Reserve Tank of Backpack 2-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1023P	SM_Orlan_Gas_P_1-RS	SM Orlan Gas P 1-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1024P	SM_Orlan_Gas_P_2-RS	SM Orlan Gas P 2-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1051J	SM_Orlan_Reserve_O2_Tank_Activation_1-RS	SM Orlan Reserve O2 Tank Activation 1-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1052J	SM_Orlan_Injector_Activation_1-RS	SM Orlan Injector Activation 1-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1053J	SM_Orlan_Prime_Fan_Operation_1-RS	SM Orlan Prime Fan Operation 1-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1054J	SM_Orlan_Reserve_Fan_Operation_1-RS	SM Orlan Reserve Fan Operation 1-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1055J	SM_Orlan_Prime_Pump_Operation_1-RS	SM Orlan Prime Pump Operation 1-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1056J	SM_Orlan_Reserve_Pump_Operation_1-RS	SM Orlan Reserve Pump Operation 1-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1057J	SM_Orlan_Reserve_O2_Tank_Activation_2-RS	SM Orlan Reserve O2 Tank Activation 2-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1058J	SM_Orlan_Injector_Activation_2-RS	SM Orlan Injector Activation 2-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1059J	SM_Orlan_Prime_Fan_Operation_2-RS	SM Orlan Prime Fan Operation 2-RS		SM EVA Orlan - - Suit Telemetry

SPII	OPS_Name	ENG_Title	Super Family	Family Name
	2-RS			
RREC00CT1060J	SM_Orlan_Reserve_Fan_Operation_2-RS	SM Orlan Reserve Fan Operation 2-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1061J	SM_Orlan_Prime_Pump_Operation_2-RS	SM Orlan Prime Pump Operation 2-RS		SM EVA Orlan - - Suit Telemetry
RREC00CT1062J	SM_Orlan_Reserve_Pump_Operation_2-RS	SM Orlan Reserve Pump Operation 2-RS		SM EVA Orlan - - Suit Telemetry
ALXD01IU0003J	Airlock_Depress_Pump_Motor_Fail	EVAS AL EL DPA EU Motor Failure		A/L ECLSS - Depress Pump HK-A
ALXD01IU0004J	Airlock_Depress_Pump_EU_Fail	EVAS AL EL DPA EU Failure		A/L ECLSS - Depress Pump HK-A
ALXD01IU0005J	Airlock_Depress_Pump_Emergency_Off	EVAS AL EL DPA EU Emergency Off		A/L ECLSS - Depress Pump HK-A
ALXD01IU0006J	Airlock_Depress_Pump_Continuity_Check	EVAS AL EL DPA Continuity Check		A/L ECLSS - Depress Pump HK-A
ALXD02CN0001H	Airlock_Depress_Pump_Power_Switch	EVAS AL DP Switch Status		A/L ECLSS - Depress Pump HK-A
ALXD01IU0001V	Airlock_Depress_Pump_Speed	EVAS AL EL DPA EU RPM		A/L ECLSS - Depress Pump HK-A
ALXD01IU0002V	Airlock_Depress_Pump_Current	EVAS AL EL DPA EU Current		A/L ECLSS - Depress Pump HK-A
ALDS15MD0024J	Airlock_Depress_Pump_Status	EVAS AL DP Status		A/L ECLSS - Depress Pump HK-A
LACU03FC1000U	UHF_EMU_1_RADIO_ID_SA_1	SSSR_EMU1_Radio_ID	SSRMS_EVA_Prox_Ops_UHF	MULTI C&T UHF - - SP OPS 0.1_HZ
LACU03FC2000U	UHF_EMU_2_RADIO_ID_SA_3	SSSR_EMU2_Radio_ID	SSRMS_EVA_Prox_Ops_UHF	MULTI C&T UHF - - SP OPS 0.1_HZ
LACU03FC3000U	UHF_EMU_3_RADIO_ID_SA_5	SSSR_EMU3_Radio_ID	SSRMS_EVA_Prox_Ops_UHF	MULTI C&T UHF - - SP OPS 0.1_HZ
LACU03FC4000U	UHF_EMU_4_RADIO_ID_SA_7	SSSR_EMU4_Radio_ID	SSRMS_EVA_Prox_Ops_UHF	MULTI C&T UHF - - SP OPS 0.1_HZ

Appendix B

Telemetry of interest to EVA

All telemetry designated as RNOM are in all packets. Telemetry designated as SpOps (highlight in yellow below) are not in all packets. They are only in the packets designated in Section 2.2, Table 2.2-2. EVA and Related Telemetry in ISS S-band Telemetry Formats. SpOps stands for Special Operations.

Depress Pump Assembly	PUI	Type	Family
Enable Light	ALPR68FC1016J	RNOM	A/L EPS RPCM ESS_C
Power Switch	ALXD02CN0001H	SpOps	A/L ECLSS - Depress Pump HK-A
Current (amps)	ALXD01IU0002V	SpOps	A/L ECLSS - Depress Pump HK-A
Speed (rpm)	ALXD01IU0001V	SpOps	A/L ECLSS - Depress Pump HK-A
Fault Light On/Off	ALDS15MD0024J	SpOps	A/L ECLSS - Depress Pump HK-A
'X' Motor Fail Electronics Unit Emerg Off Continuity Check	ALXD01IU00xxJ xx = 03 xx = 04 xx = 05 xx = 06	SpOps	A/L ECLSS - Depress Pump HK-A

EMU Radio IDs	PUI	Type	Family
CH1	LACU03FC1000U	SpOps	MULTI C&T UHF - - SP OPS 0.1_HZ
CH2	LACU03FC2000U	SpOps	MULTI C&T UHF - - SP OPS 0.1_HZ
CH3	LACU03FC3000U	SpOps	MULTI C&T UHF - - SP OPS 0.1_HZ
CH4	LACU03FC4000U	SpOps	MULTI C&T UHF - - SP OPS 0.1_HZ

Airlock N2	PUI	Type	Family
TK P (supply press)	ALEA34SR0001P	RNOM	A/L ECLSS - O2N2 System ESS-A 1.0
Supply Valve Position (L007)	ALDS15MD0046J	RNOM	A/L ECLSS - O2N2 System ESS-A 1.0
Supply Valve Status	ALDS15MD0049J	RNOM	A/L ECLSS - O2N2 System HK-B

Airlock O2	PUI	Type	Family
Tank			
Low P Tk1 P (supply p)	ALEA33SR0001P	RNOM	A/L ECLSS - O2N2 System ESS-A 1.0
High P Tk2 P (supply p)	ALEA32SR0001P	RNOM	A/L ECLSS - O2N2 System ESS-A 1.0
Line Temperature			
O2 High P Line T	ALEA78SR0001T	RNOM	A/L ECLSS - O2N2 System ESS-A 1.0
O2 Low P Line T	ALEA77SR0001T	RNOM	A/L ECLSS - O2N2 System ESS-A 1.0
Supply Valve			
High P Sply Vlv Pos (L002)	ALDS15MD0044J	RNOM	A/L ECLSS - O2N2 System ESS-A 1.0
High P Sply Vlv Status	ALDS15MD0047J	RNOM	A/L ECLSS - O2N2 System HK-B
Low P Sply Vlv Pos (L003)	ALDS15MD0045J	RNOM	A/L ECLSS - O2N2 System ESS-A 1.0
Low P Sply Vlv Status	ALDS15MD0048J	RNOM	A/L ECLSS - O2N2 System HK-B
UIA			
UIA O2 Sply P	ALEA31SR0001P	RNOM	A/L ECLSS - O2N2 System ESS-A 1.0

Airlock ACS	PUI	Type	Family
ACS Campout Status	LADP08MD2382J	RNOM	MULTI ECLSS - PCA & VRA ESS-C
ACS State	LADP08MD2505J	RNOM	MULTI ECLSS - PCA & VRA ESS-A 1.0
PCA			
Primary PCA	LADP08MD2383J	RNOM	MULTI ECLSS - PCA & VRA ESS-B
VRIV Vent Pos	ALEA22FC0016J	RNOM	MULTI ECLSS - PCA & VRA ESS-A 1.0
PCA O2 Valve Pos	ALEA22FC0014J	RNOM	MULTI ECLSS - PCA & VRA ESS-A 1.0
PCA O2 Sply P	ALEA22FC0003P	RNOM	MULTI ECLSS - PCA & VRA ESS-A 1.0
PCA N2 Valve Pos	ALEA22FC0015J	RNOM	MULTI ECLSS - PCA & VRA ESS-A 1.0
PCA State	ALEA22FC0001J	RNOM	MULTI ECLSS - PCA & VRA ESS-A 1.0
PCS Status (Failure)	ALEA22FC0011J	RNOM	MULTI ECLSS - PCA & VRA ESS-C

Lab MCA	PUI	Type	Family
Sample Location	LADP08MDE071J	RNOM	MULTI ECLSS - MCA & SDS ESS-B
Sample Time	Comp	RNOM	
Sample Status	Comp	RNOM	
ppO2	LAER12FC0972P	RNOM	MULTI ECLSS - MCA & SDS ESS-A 1.0
ppN2	LAER12FC0956P	RNOM	MULTI ECLSS - MCA & SDS ESS-A 1.0
ppCO2	LAER12FC0537P	RNOM	MULTI ECLSS - MCA & SDS ESS-A 1.0
ppCH4	LAER12FC0521P	RNOM	MULTI ECLSS - MCA & SDS ESS-A 1.0
ppH2	LAER12FC0765P	RNOM	MULTI ECLSS - MCA & SDS ESS-A 1.0

Cabin Pressure	PUI	Type	Family
Crew Lk	ALXS03SR0001P	RNOM	MULTI ECLSS - PCA & VRA ESS-A 1.0
Equip Lk	ALEA22FC0001P	RNOM	MULTI ECLSS - PCA & VRA ESS-A 1.0
Equip Lk Dp/Dt	ALEA22FC0018J	RNOM	MULTI ECLSS - Emergency ESS-A 1.0
Node 1	N1ER35SR0001P	RNOM	MULTI ECLSS - PCA & VRA ESS-A 1.0
Lab	LAEA21FC0001P	RNOM	MULTI ECLSS - PCA & VRA ESS-A 1.0
Lab Dp/Dt	LAEA21FC0018J	RNOM	MULTI ECLSS - Emergency ESS-A 1.0

Node 1 IMV	PUI	Type	Family
Stbd Aft Vlv Pos	LADP08MD2786J	RNOM	MULTI ECLSS - Cabin Fan & IMV ESS-A
Stbd Fwd Vlv Pos	LADP08MD2787J	RNOM	MULTI ECLSS - Cabin Fan & IMV ESS-A
Stbd Aft Fan Stat	LADP08MD2656J	RNOM	MULTI ECLSS - Cabin Fan & IMV ESS-C
Stbd Aft Fan Spd	N1EI37FA0002R	RNOM	MULTI ECLSS - Cabin Fan & IMV ESS-A

Smoke Detection System	PUI	Type	Family
Monitor Cabin	ALDS15MD0065J	RNOM	MULTI ECLSS - FDS ESS-B
Duct	ALDS15MD0021J	RNOM	MULTI ECLSS - FDS ESS-B
Status Cabin	ALDS15MD0062J	RNOM	MULTI ECLSS - FDS ESS-A
Duct	ALDS15MD0019J	RNOM	MULTI ECLSS - FDS ESS-A

Airlock CCAA	PUI	Type	Family
Inlet T1	ALET24SR0201T	RNOM	MULTI ECLSS - CCAA ESS-A 0.1
Inlet T2	ALET24SR0301T	RNOM	MULTI ECLSS - CCAA ESS-A 0.1
Fan Speed (rpm)	ALET19FA0003R	RNOM	MULTI ECLSS - CCAA ESS-A 1.0
Fan Dp	ALET19SR0201P	RNOM	MULTI ECLSS - CCAA ESS-A 1.0
TCCV Posn (°angle)	ALET14VL0003H	RNOM	MULTI ECLSS - CCAA ESS-A 1.0
H2O Sep LS	ALET04IU0006Q	RNOM	MULTI ECLSS - CCAA ESS-A 1.0
H2O Sep P	ALET09SR0001P	RNOM	MULTI ECLSS - CCAA ESS-A 1.0
H2O Sep Spd (rpm)	ALET09WS0002R	RNOM	MULTI ECLSS - CCAA ESS-A 1.0
Outlet T1	ALET14SR0201T	RNOM	MULTI ECLSS - CCAA ESS-A 0.1
Outlet T2	ALET14SR0301T	RNOM	MULTI ECLSS - CCAA ESS-A 0.1
Outlet Hx LS	ALET04IU0007J	RNOM	MULTI ECLSS - CCAA ESS-A 1.0
EIB Fail	ALDS15MD0011J	RNOM	MULTI ECLSS - CCAA ESS-C

TCS	PUI	Type	Family
Lab LTL TWMV Set Pt	LADS19MD7554T	RNOM	MULTI ITCS HK_B Low Rate
Lab LTL TWMV Out T	LATM01SR0001T	RNOM	MULTI ITCS ESS_A Low Rate
Lab MTL TWMV Out T	LATM02SR0001T	RNOM	MULTI ITCS ESS_A Low Rate
LTL Airlock Return	ALTT52SR0001T	RNOM	MULTI ITCS ESS_C Low Rate
MTL Airlock Return	ALTT51SR0001T	RNOM	MULTI ITCS ESS_C Low Rate

LAB Condensate Storage Tank	PUI	Type	Family
Status	LADP08MD2390J	RNOM	MULTI ECLSS - WRM ESS-C
Tk Qty 1	LAEW07SR0001Q	RNOM	MULTI ECLSS - WRM ESS-A 1.0
Tk Qty 2	LAEW08SR0001Q	RNOM	MULTI ECLSS - WRM ESS-A 1.0
Water Vent System Status	LADP08MD2778J	RNOM	MULTI ECLSS - WRM ESS-C

EPS	PUI	Type	Family
LAB LA1A4A F RPC03			
Status	LAPR37FC1018J	RNOM	LAB EPS 1A4A RPCM ESS_C
Power		RNOM	
LAB LA2A3B D RPC03			
Status	LAPR28FC1018J	RNOM	LAB EPS 2A3B RPCM ESS_C
Power		RNOM	
AL1A4A A			
AL1A4A A amps	ALPR68FC1000C	RNOM	A/L EPS RPCM ESS_C
DPA Trip Stat	ALPR68FC0396J	RNOM	A/L EPS RPCM HK_B
DPA On/Off Stat	ALPR68FC1016J	RNOM	A/L EPS RPCM ESS_C
AI1A4A B			
AL1A4A B amps	ALPR65FC1000C	RNOM	A/L EPS RPCM ESS_C
BC1 On/Off (RPC 03)	ALPR65FC1018J	RNOM	A/L EPS RPCM ESS_C
BC1 Trip Stat	ALPR65FC0400J	RNOM	A/L EPS RPCM HK_B
BC2 On/Off (RPC 04)	ALPR65FC1019J	RNOM	A/L EPS RPCM ESS_C
BC2 Trip Stat	ALPR65FC0401J	RNOM	A/L EPS RPCM HK_B

AI1A4A B (concluded)			
BC3 On/Off (RPC 05)	ALPR65FC1020J	RNOM	A/L EPS RPCM ESS_C
BC3 Trip Stat	ALPR65FC0402J	RNOM	A/L EPS RPCM HK_B
BC4 On/Off (RPC 06)	ALPR65FC1021J	RNOM	A/L EPS RPCM ESS_C
BC4 Trip Stat	ALPR65FC0403J	RNOM	A/L EPS RPCM HK_B
METOX On/Off (RPC 17)	ALPR65FC1032J	RNOM	A/L EPS RPCM ESS_C
METOX Trip Stat	ALPR65FC1003J	RNOM	A/L EPS RPCM ESS_C
A/L Htrs 1	ALPR65FC1022J	RNOM	A/L EPS RPCM ESS_C
2	ALPR65FC1023J		
3	ALPR65FC1024J		
4	ALPR65FC1025J		
5	ALPR65FC1026J		
AL2A3B A			
AL2A3B A amps	ALPR67FC1000C	RNOM	A/L EPS RPCM ESS_C
ATU AL1 On/Off (RPC 01)	ALPR67FC1016J	RNOM	A/L EPS RPCM ESS_C
AL MDM On/Off (RPC 02)	ALPR67FC1017J	RNOM	A/L EPS RPCM ESS_C
PCA PCP On/Off (RPC 07)	ALPR67FC1022J	RNOM	A/L EPS RPCM ESS_C
ATU EMU1 On/Off (rpc 14)	ALPR67FC1029J	RNOM	A/L EPS RPCM ESS_C
AL UOP On/Off (RPC 17)	ALPR67FC1032J	RNOM	A/L EPS RPCM ESS_C
AL2A3B B			
AL2A3B B amps	ALPR66FC1000C	RNOM	A/L EPS RPCM ESS_C
ATU EMU2 On/Off (rpc 01)	ALPR66FC1016J	RNOM	A/L EPS RPCM ESS_C
EACP On/Off (RPC 02)	ALPR66FC1017J	RNOM	A/L EPS RPCM ESS_C
EACP Trip Stat	ALPR66FC0398J	RNOM	A/L EPS RPCM HK_B
O2 LP Vlv On/Off (RPC 10)	ALPR66FC1025J	RNOM	A/L EPS RPCM ESS_C
O2 HP Vlv On/Off (RPC 11)	ALPR66FC1026J	RNOM	A/L EPS RPCM ESS_C
PSA On/Off (RPC 18)	ALPR66FC1033J	RNOM	A/L EPS RPCM ESS_C
PSA Trip Stat	ALPR66FC1004J	RNOM	A/L EPS RPCM ESS_C

Airlock MDM (AL1)	PUI	Type	Family
Processing State	ALDS15MD4984J	RNOM	MULTI CDH ALL_MDM Processing_State
Frame Count	ALDS15MD4353J	RNOM	MULTI CDH ALL_MDM FMT_Status Frame_Count -
Sync Status	ALDS15MD4263J	RNOM	MULTI CDH - - - Unassigned

COMM	PUI	Type	Family
Active UHF	LADP01MDB07TJ	RNOM	MULTI C&T UHF - - Nominal_B_1.0_HZ
RPCM			
LAD52B A RPC08 (UHF1)	LAPR57FC1023J	RNOM	LAB EPS RPCM ESS_B
UHF2 Rack Power	LAPE13SU0001J	RNOM	EPS_C_and_C ESS_C
LA1B H RPC04 (UHF2)	LAPR04FC1019J	RNOM	LAB EPS 1B RPCM ESS_C
Mode	LACU03FC0015J	RNOM	MULTI C&T UHF - - Nominal_B_0.1_HZ
Frequency	LACU03FC0013J	RNOM	MULTI C&T UHF - - Nominal_B_0.1_HZ
RF Pwr Output	LACU03FC0010E	RNOM	MULTI C&T UHF - - Nominal_B_1.0_HZ
Pwr Supply	LACU03FC0009C	RNOM	MULTI C&T UHF - - Nominal_B_1.0_HZ
Frame Sync	LACU03FC0019J	RNOM	MULTI C&T UHF - - Nominal_B_1.0_HZ
DSP Status	LACU03FC0018J	RNOM	MULTI C&T UHF - - Nominal_B_1.0_HZ
Frame Count	LACU03FC0028U	RNOM	MULTI C&T UHF - - Nominal_B_1.0_HZ

Appendix C

EMU radio IDs PPL version 2002, used in CCSR2

Name: cci_emu_radio_ids

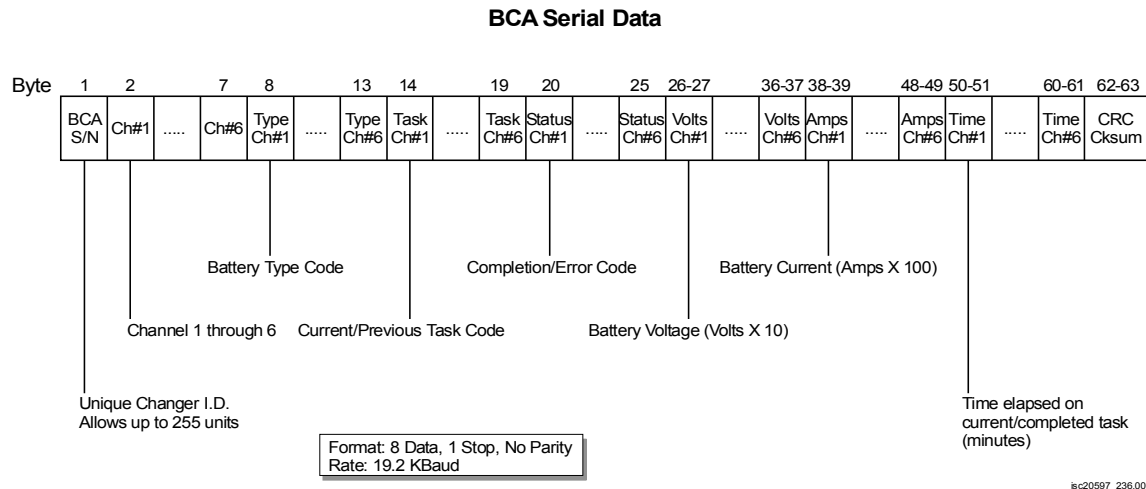
Version: 2002

Modem Ids (hex)	Engineering Units	Engineering Name	Ada Name
16#A9#	N/A	Suit 1 Primary Radio ID	radio_id (1,1)
16#6C#	N/A	Suit 1 Secondary Radio ID	radio_id (1,2)
16#68#	N/A	Suit 2 Primary Radio ID	radio_id (2,1)
16#93#	N/A	Suit 2 Secondary Radio ID	radio_id (2,2)
16#34#	N/A	Suit 3 Primary Radio ID	radio_id (3,1)
16#B8#	N/A	Suit 3 Secondary Radio ID	radio_id (3,2)
16#70#	N/A	Suit 4 Primary Radio ID	radio_id (4,1)
16#F8#	N/A	Suit 4 Secondary Radio ID	radio_id (4,2)
16#1B#	N/A	Suit 5 Primary Radio ID	radio_id (5,1)
16#D4#	N/A	Suit 5 Secondary Radio ID	radio_id (5,2)
16#35#	N/A	Suit 6 Primary Radio ID	radio_id (6,1)
16#89#	N/A	Suit 6 Secondary Radio ID	radio_id (6,2)
16#3D#	N/A	Suit 7 Primary Radio ID	radio_id (7,1)
16#E4#	N/A	Suit 7 Secondary Radio ID	radio_id (7,2)
16#31#	N/A	Suit 8 Primary Radio ID	radio_id (8,1)
16#D7#	N/A	Suit 8 Secondary Radio ID	radio_id (8,2)
16#3C#	N/A	Suit 9 Primary Radio ID	radio_id (9,1)
16#A7#	N/A	Suit 9 Secondary Radio ID	radio_id (9,2)
16#7D#	N/A	Suit 10 Primary Radio ID	radio_id (10,1)
16#EF#	N/A	Suit 10 Secondary Radio ID	radio_id (10,2)
16#73#	N/A	Suit 11 Primary Radio ID	radio_id (11,1)
16#F4#	N/A	Suit 11 Secondary Radio ID	radio_id (11,2)
16#79#	N/A	Suit 12 Primary Radio ID	radio_id (12,1)
16#A6#	N/A	Suit 12 Secondary Radio ID	radio_id (12,2)
16#66#	N/A	Suit 13 Primary Radio ID	radio_id (13,1)
16#DD#	N/A	Suit 13 Secondary Radio ID	radio_id (13,2)
16#4B#	N/A	Suit 14 Primary Radio ID	radio_id (14,1)
16#FA#	N/A	Suit 14 Secondary Radio ID	radio_id (14,2)
16#4C#	N/A	Suit 15 Primary Radio ID	radio_id (15,1)
16#B5#	N/A	Suit 15 Secondary Radio ID	radio_id (15,2)
16#49#	N/A	Suit 16 Primary Radio ID	radio_id (16,1)
16#AE#	N/A	Suit 16 Secondary Radio ID	radio_id (16,2)
16#33#	N/A	Suit 17 Primary Radio ID	radio_id (17,1)
16#A3#	N/A	Suit 17 Secondary Radio ID	radio_id (17,2)
16#4F#	N/A	Suit 18 Primary Radio ID	radio_id (18,1)
16#BA#	N/A	Suit 18 Secondary Radio ID	radio_id (18,2)
16#37#	N/A	Suit 19 Primary Radio ID	radio_id (19,1)
16#F6#	N/A	Suit 19 Secondary Radio ID	radio_id (19,2)
16#26#	N/A	Suit 20 Primary Radio ID	radio_id (20,1)
16#E6#	N/A	Suit 20 Secondary Radio ID	radio_id (20,2)

16#65#	N/A	Suit 21 Primary Radio ID	radio_id (21,1)
16#90#	N/A	Suit 21 Secondary Radio ID	radio_id (21,2)
0	N/A	Suit 22 Primary Radio ID	radio_id (22,1)
0	N/A	Suit 22 Secondary Radio ID	radio_id (22,2)
0	N/A	Suit 23 Primary Radio ID	radio_id (23,1)
0	N/A	Suit 23 Secondary Radio ID	radio_id (23,2)
0	N/A	Suit 24 Primary Radio ID	radio_id (24,1)
0	N/A	Suit 24 Secondary Radio ID	radio_id (24,2)
0	N/A	Suit 25 Primary Radio ID	radio_id (25,1)
0	N/A	Suit 25 Secondary Radio ID	radio_id (25,2)
0	N/A	Suit 26 Primary Radio ID	radio_id (26,1)
0	N/A	Suit 26 Secondary Radio ID	radio_id (26,2)
0	N/A	Suit 27 Primary Radio ID	radio_id (27,1)
0	N/A	Suit 27 Secondary Radio ID	radio_id (27,2)
0	N/A	Suit 28 Primary Radio ID	radio_id (28,1)
0	N/A	Suit 28 Secondary Radio ID	radio_id (28,2)
0	N/A	Suit 29 Primary Radio ID	radio_id (29,1)
0	N/A	Suit 29 Secondary Radio ID	radio_id (29,2)

Appendix D

BCA Serial Data



The above figure shows one cycle of 63-byte serial data from one Battery Charger.

The Channel and BCA S/N are one-byte data words that only send an ID number.

The Type, Task, and Status are also one-byte words that send a number code (enumerated state) that gets translated into a word phrase on the ground.

Type

Code	Type	ID Res.	Battery Type Table
0	Unknown	N/A	N/A
1	EMU BSA	4.22K	Table 103
2	EMU Suit	6.81K	Table 110
3	HL-A	4.87K	Table 105
4	HL-B	19.1K	Table 126
5	REBA-10	12.1K	Table 119
6	PGT	10K	Table 116
7	HL-B	10.7K	Table 117
8	REBA-30	15.6K	Table 123
9	PGT	20.5K	Table 127
10	HL-B Empty	23.7K	Table 129
11	HL-B Empty	13.7K	Table 121

Task

Code	Task
0	No History
1	Constant Current Charge
2	Reflex Charge
3	PCS Mode
4	Download Mode
5	ALT Charge

Status

Code	Status
0	No History
1	Presently charging
2	Task completed Ok
3	Stop switch toggled
4	Batt circuit open
5	Wrong batt or Hi-imp
6	Batt over-temp error
7	Amp-hour tested Ok
8	Amp-hour test error
9	Low-slope error
10	Power error
11	Reverse polarity error
12	Short-circuit error
13	Time-out error
14	External-temp error

The volts are two-byte words sent in counts ranging from 0 to 600. Each count represents 0.1 volts.

The amps are two-byte words sent in counts ranging from 0 to 300. Each count represents 0.01 amps.

The time is two-byte words sent in counts from 0 to 3600. Each count represents 1 minute.

2.3.1 Related Document References

C&T TM C 21109 ISS Communication and Tracking Manual

SSP41154 Software Interface Control Document Part 1 United States On-Orbit
Segment to United States Ground Segment Command and Telemetry Rev H

SSP-50462 International Space Station Telemetry Format Definition Document Rev B

3.1 ISS ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEMS

3.1.1 Description

TBD

3.2 ISS THERMAL CONTROL SYSTEMS

3.2.1 Description

TBD

3.3 ISS ELECTRICAL POWER SYSTEMS

3.3.1 Description

TBD

3.4 ISS ATTITUDE DETERMINATION AND CONTROL

3.4.1 Description

TBD

3.5 ISS COMMAND AND DATA HANDLING

3.5.1 Description

TBD

3.5.2 ISS Caution and Warning

3.5.2.1 Description

TBD

3.6 EVA CONTAMINATION

3.6.1 Purpose

This section provides background information on ammonia, oxidizer, and hydrazine contamination, and describes detection devices and methods for IV atmospheric cleanup. This section does not address contamination concerns from Fuel Oxidizer Reaction Products (FORP).

3.6.2 Description

3.6.2.1 Ammonia (NH₃)

Ammonia is the active cooling fluid used on the US External Thermal Control System on ISS. Crew exposure can cause eye and throat irritation, inflammation of the respiratory tract, or death. Table 4.6.1 describes the Spacecraft Maximum Allowable Concentration (SMAC) and Emergency Guidance Concentration (EGC).

Table 3.6-1. Maximum ammonia concentration

	Concentration (ppm)
1 Hour SMAC	30
1 Day SMAC	20
7 Day SMAC	10
EGC	100
Odor Threshold	5-50

EVA procedures are written conservatively to prevent crew exposure above the 7-day SMAC regardless of duration.

In vapor form, ammonia is invisible and will not stick to the EMU and, therefore, does not pose a contamination concern. In liquid form, ammonia is clear and rapidly freezes upon exposure to vacuum. Direct liquid contamination may occur in the immediate vicinity of a pressurized leak if the EMU is exposed to the stream prior to its phase transition. This liquid will freeze and stick to the EMU orthofabric. Solid ammonia is most likely to deflect off the EMU unless it is trapped in Thermal Micrometeoroid Garment (TMG) folds. However, when liquid ammonia freezes, an outer shell of ice will insulate a liquid core. Upon impact with the EMU, the ice could break and allow the liquid to freeze and stick to the EMU. Frozen ammonia is very difficult to distinguish

from white orthofabric. The main visual indication is a change in texture. Visual inspections are most effective when performed at oblique viewing angles with dark or shaded ambient light with the EMU spot lights turned on. Crewmembers should look for unusual contours and a loss of TMG thread pattern.

3.6.2.2 EVA Removal

Ammonia ice is ductile and forms a strong bond with EMU TMG. Therefore, mechanical removal is ineffective. Bending TMG will not generate a crack. Scraping with tools does not remove significant amounts of material. The hydrazine brush will not remove any ammonia from the suit. Conductive and radiative heat transfers are the most efficient methods of removal.

Conductive heat transfer is accomplished by touching the ice with warm, metal objects with a high thermal mass. The EVA prybar, PGT battery housing, and ISS structure are all examples of effective heat sinks for removal. In addition, use of metal objects such as these will aid in visual inspection because a distinct ice boundary may become apparent.

Radiative heat transfer, or bakeout, is accomplished by facing the cold ammonia ice towards a warmer surface. The rate of removal is dependent upon the temperature differential as well as the view factor. The view factor is defined as the fraction of the radiation leaving one surface that is intercepted by a second surface. In other words, while in the Crewlock, 100 percent of the heat transfer is happening between the EMU and the airlock walls (which are warm). Outside a fraction of heat is exchanged from the sun to the EMU, but the EMU also gives up a lot of heat to deep space and colder surfaces. Although exposure to the Sun establishes a high temperature differential, the view factor is small. Therefore, the heat flux inside the Crewlock is higher because it has a 100 percent view factor. In order to determine the required duration of bakeout, it is first necessary to assume an initial ice layer thickness. Tests at White Sands Test Facility (WSTF) evaluated the ice layer thickness required for visual detection on the EMU under various lighting conditions. These tests determined that an ice layer of 0.016 inches could be seen. EVA crewmembers will perform visual inspections during the EVA and continue to implement conductive removal until the time when ammonia is not seen. At this time, the ice layer is assumed to be 0.016 inches thick. Then MCC must track the durations spent at different locations and the associated environment temperatures. By using the Ammonia Bakeout Time Calculator, MCC can determine if the bakeout time has been sufficient to remove the remaining contamination.

3.6.2.3 Ammonia Bakeout Calculator Use

This application is used for planning and real-time evaluation of ammonia bakeout. It requires the operator to have a complete Thermal Data Package presented at Certificate of Flight Readiness (CoFR)². Note that the CoFR² presentation is sometimes abbreviated. If wet ammonia QD operations are expected during an EVA, the full thermal package can be requested that specifies EMU Orthofabric Sink Temperatures at all ISS locations during day, night, and average.

3.6.2.4 Initial Inputs

The worksheet in Figure 3.6-1 is used to determine the bingo times for completion of high risk QD operations. This ensures that if the EMU is contaminated, sufficient EMU consumables will remain to complete the required cleanup procedures.

Preferred Bakeout Location Information	
Group # and Location	Inside Crewlock
EMU Orthofabric Average Sink Temp (F)	70
Sublimation Rate	0.030189476
Translation Time from Leak Location to Preferred Bakeout Location (h:mm)	0:15
Translation Time from Preferred Bakeout Location to SCU	0:00
Metox BTUs Remaining	7200
Bingo Time to finish QD Ops (h:mm from now)	5:55

Figure 3.6-1. Example initial inputs page

Group # and Location: This field is optional and is only used for MCC reference. The preferred bakeout group number and location is determined on a flight-specific basis, depending upon thermal data delivered during CoFR2. This location should provide maximum radiative heat transfer. It is also beneficial to choose a location near the airlock. Therefore, inside the Crewlock is generally the chosen location.

EMU Orthofabric Average Sink Temp (F): If the Crewlock is chosen as the preferred bakeout location, 70 should be used. If an alternate location is chosen, the sink temperature is listed in the CoFR2 Thermal Data Package. See Figure 3.6-2.

Sublimation Rate: This field is automatically calculated based on the EMU Orthofabric Average Sink Temp (F). This specifies the rate at which ammonia ice sublimates in the preferred bakeout location.

Translation Time From Leak Location to Preferred Bakeout Location (h:mm): This field can be estimated based on the QD location.

Translation Time From Preferred Bakeout Location to SCU: This field should be 0:00 if the SCU can be connected at the preferred bakeout location.

Metox BTUs Remaining: This field is used to determine Contaminant Control Cartridge (CCC) capacity remaining. During an EVA this data must be updated from the consumables tracking spreadsheet. For EVA timeline planning purposes it may be

necessary to determine how late in an EVA QD tasks can be scheduled. If being used for planning purposes, enter 7200.

Bingo Time to Finish QD Ops (h:mm from now): This field is automatically calculated based on the other values on this sheet. It will specify the time remaining until QD ops must be complete in order to protect for decontamination activities. This assumes 1000 BTUs/hr for the remainder of the EVA.

3.6.2.5 Updates

This sheet is used to track the EVA thermal environment during EVA after a contamination event. The output of this page will determine when a bakeout has been sufficient to remove residual ammonia once a visual inspection could not detect suit contamination.

Location Group #	EMU Orthofabric Sink Temp (F)	Time in Location (h:mm)	NH3 Ice Sublimation Rate (in/hr)	NH3 Ice Sublimated (in)	Total NH3 Sublimated (in)	NH3 Ice Remaining on EMU (in)	Additional Bakeout Required at this Location (h:mm)	Additional Bakeout Required at Preferred Location (h:mm)
23-Day	8	0:35	0.018016019	0.010509	0.010509	0.005491	0:18	0:10
78-Night	-90	0:20	0.006589578	0.002197	0.012706	0.003294	0:30	0:06
82-Night	-30	0:10	0.012605563	0.002101	0.014807	0.001193	0:05	0:02
82-Day	-6	0:15	0.015858912	0.003965	0.018772	-0.002772	#####	#####
5-Day	-51	0:25	0.010181212	0.004242	0.023014	-0.007014	#####	#####
			0.016759	0.000000	0.023014	-0.007014	#####	#####
			0.016759	0.000000	0.023014	-0.007014	#####	#####
			0.016759	0.000000	0.023014	-0.007014	#####	#####

Figure 3.6-2. Example updates sheet

Location Group #: This field does not effect the application calculations. It is only used for MCC reference. The group number corresponds to an external location on ISS and is found in the CoFR2 Thermal Data Package (see Figure 3.6-3). Note that the sink temperature changes depending upon orbit night and day. Therefore, it is necessary to start a new line at sunrise and sunset even if the location does not change.

EMU Orthofabric Sink Temp (F): This field is obtained from the CoFR2 Thermal Data Package. The value should be obtained from the Day or Night column depending upon the location in the orbit cycle. It is necessary to start a new line at sunrise and sunset even if the location does not change.

Time in Location (h:mm): This field is used to track the time spent in a particular thermal environment. It will be necessary to start a new line at sunrise and sunset even if the location does not change. Note, an entry of 0:00 is not valid for this field. If interested in determining the total time required at a particular location to sublimate all the remaining ammonia, enter a value of 0:01. Then, look at the field “Additional Bakeout Required at this Location (h:mm)” and add 1 minute from this time.

Sublimation Rate (in/hr): Automatically calculated by application based on the following equation: $\text{Rate} = 6.8701\text{E-}10(\text{sink Temp})^3 + 5.0668\text{E-}07(\text{sink Temp})^2 + 1.5303\text{E-}04(\text{sink Temp}) + 1.6759\text{E-}02$. Note that this equation is derived from analysis, not test. In addition, this rate is independent of the surface area of the contamination and is only dependent upon the ice layer thickness.

NH3 Ice Sublimated (in): This field is automatically calculated and determines the thickness of an ice layer that is sublimated during the time spent at this particular location.

Total NH3 Sublimated (in): This field is automatically calculated and is simply the summation of all the ice that has been sublimated since tracking began.

NH3 Ice Remaining on EMU (in): This field assumes an initial ice thickness of 0.016 inches and subtracts the total NH3 sublimated. Recall that 0.016 inches was determined by WSTF testing as the ice thickness that is visually detectable. Therefore, bakeout time tracking assumes that a visual inspection could not detect any remaining ammonia ice on the TMG.

Additional Bakeout at This Location (h:mm): This field is automatically calculated and determines how much additional time must be spent in the current thermal environment to remove all the remaining ammonia. See the comment under "Time in Location (h:mm)" to understand how this field can be used to predict required times in future locations.

Additional Bakeout Required at Preferred Location (h:mm): This field specifies how much bakeout time would be required if the EV crewmember completed the remainder of bakeout at the preferred location that is specified on the Initial Inputs sheet. This field may be useful for determining when useful EVA tasks at non-ideal bakeout locations must be terminated in order to complete a sufficient bakeout with the remaining EMU consumables.

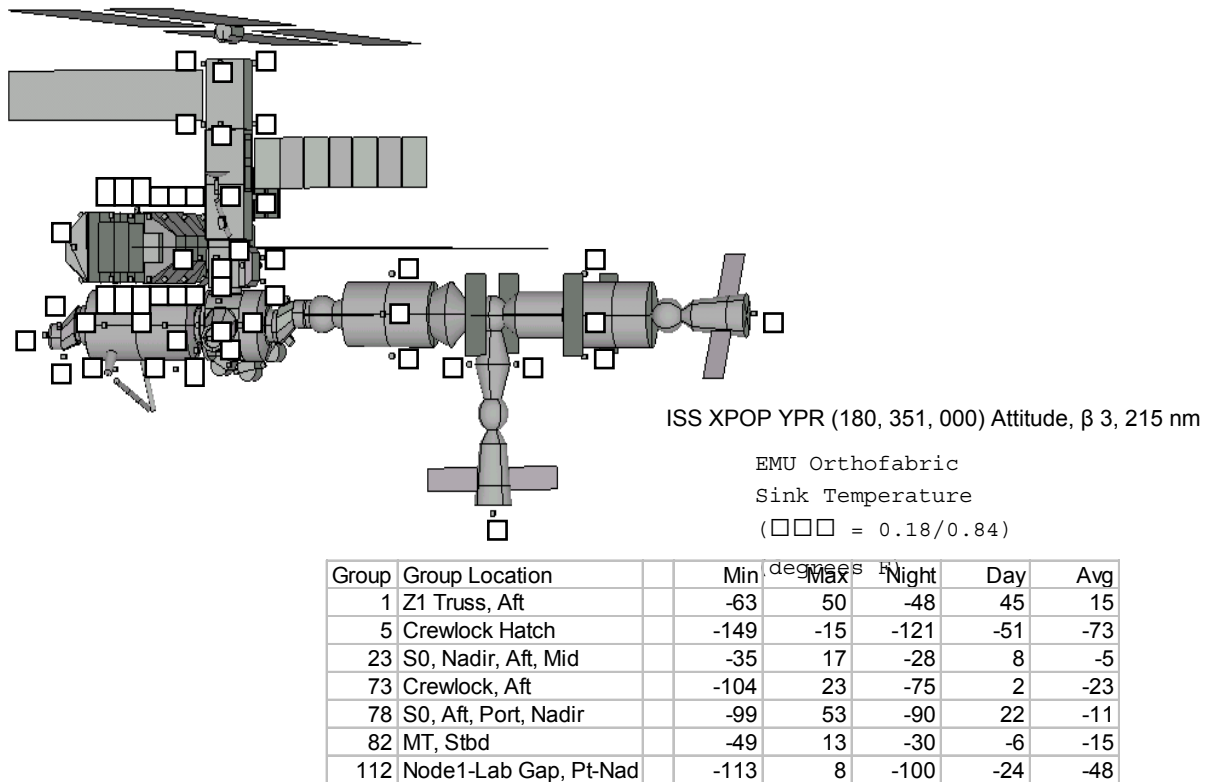


Figure 3.6-3. Example of CoFR2 thermal data package

3.6.2.6 EVA Ammonia Contamination Testing

The Contamination Detection Kit (CDK) includes hardware capable of detecting ammonia. The Commercial Off The Shelf (COTS) ammonia Draeger tube 2/a is enclosed in an encapsulation device (see Figure 3.6-4). The tube is sensitive to ammonia in the range of 5 to 90 parts per million (ppm). The encapsulation device serves several functions. First, it allows the glass tips to be pre-broken on the ground and then seals the tube to prevent atmospheric exposure. It provides flow limiting to achieve the desired flow rate through the tube during testing. It provides a safe method for EVA handling without exposure to glass.

The ammonia detector can be used in the Crewlock or orbiter external airlock. In the Crewlock, the ISS Contamination Sampler sits on the inlet muffler of the Airlock Manual Pressure Equalization Valve (AMPEV.) In the external airlock, the STS Contamination Sampler screws onto the inlet of the depress valve. During stowage, the ammonia detector encapsulation device is sealed to prevent premature exposure. To enable a flow path through the Draeger tube, an equipment hook is used to break off two tether points. The tether points should remain on the equipment hook to prevent Foreign Object Debris (FOD). The ammonia detector is then installed into the Contamination Sampler appropriate for the airlock in use. When the valve is opened, airlock gas flows through the Draeger tube before going overboard. The flow time is critical as the test

accuracy is dependent upon the total mass flow through the tube. If ammonia is present in the gas, the Ammonia Detector changes from yellow to blue. The color change is very distinct and easy to see. The length of the color reaction is proportional to the ammonia concentration. Because a flow restrictor is installed in the detector, and the test is performed at 5 psi, the numbers on the Draeger tube scale do not accurately indicate the sampled concentration. Rather, the testing procedure includes a table to correlate the indicated value to the actual concentration. Due to the flow restrictor in the detector, the Crewlock pressure is not expected to drop significantly during the test. If it does, this would be indicative of gas bypassing the flow restrictor and the Draeger tube. In this situation the test should be repeated as the results are not reliable.

The assumed concentration values listed in the Contamination Test procedure include a factor of safety of 2. This was chosen to add conservatism to the safety critical test. In addition, it helps protect for sampler leaks or frozen ammonia ice particle that are not mixed in the Crewlock air prior to test. It should be noted that trace amounts of ammonia nominally exist on ISS. Non-zero readings are not necessarily indicative of EVA contamination.

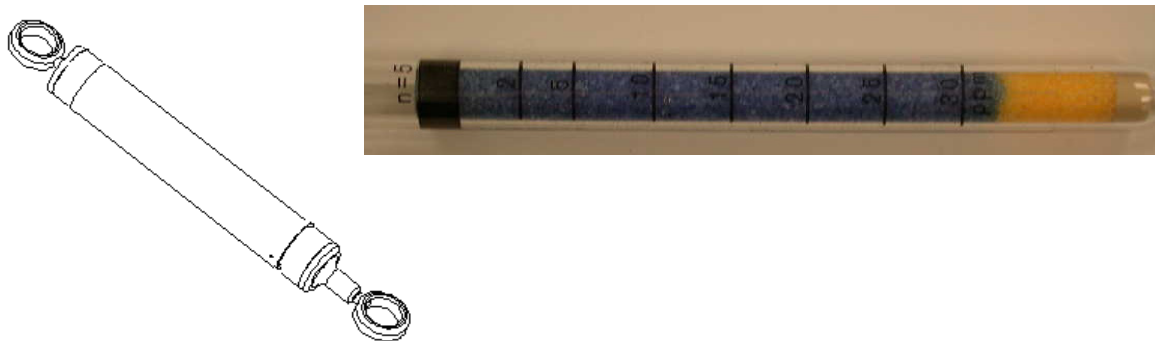


Figure 3.6-4. Draeger encapsulation device and reacted Draeger tube (encapsulation device removed)

3.6.2.7 IV Ammonia Detection and Countermeasures

An IV ammonia detection kit exists on shuttle and ISS (see Figure 3.6-5). This kit includes a Draeger Accuro hand pump, husker tool for breaking the pre-scored glass tips, and Ammonia 2/a and 5/a Draeger tubes. The 2/a and 5/a refer to the Draeger model number. The 2/a is more sensitive to lower concentrations than the 5/a. With the exception of a few minor modifications, the IV kit is very similar to the COTS configuration. This kit is used after an EVA that involved ammonia contamination as a secondary verification of atmosphere cleanliness prior to crew exposure.

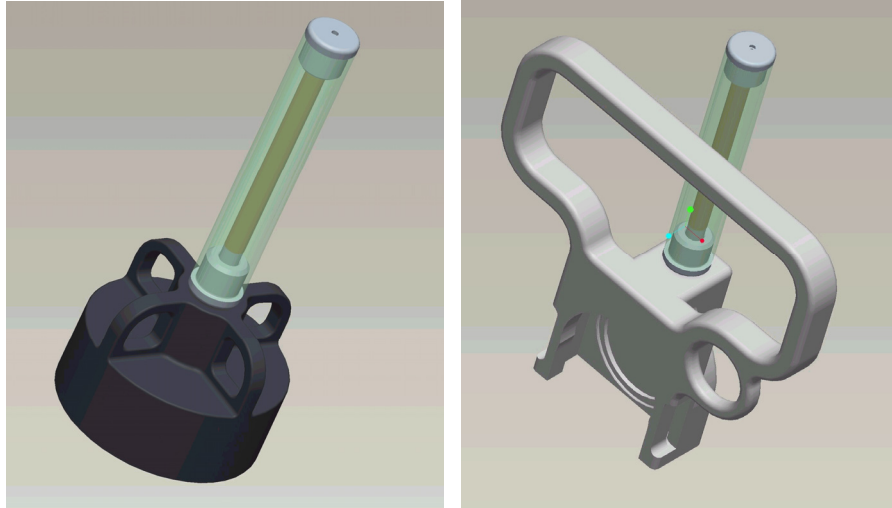


Figure 3.6-5. Draeger detector in STS and ISS contamination samplers

There are several effective ways to reduce ammonia concentration in the atmosphere. Mixing with uncontaminated air will dilute the concentration until an equilibrium concentration is achieved. For example, Crewlock repress from 5 psia to 14.7 psia reduces the concentration by a factor of three. Ammonia has a strong affinity for liquid water. Due to its solubility, exposure to water will trap ammonia vapor. During the cleanup response this is utilized by wiping EMUs and Crewlock walls with wet towels and then sealing the towels in ziplock bags. Additionally, if condensation exists on the CCAA heat exchangers, this will remove ammonia from the atmosphere. Finally, charcoal filters with a phosphoric acid coating will remove ammonia. On ISS, the Trace Contaminate Control System (TCCS), Russian БМП (Micropurification Unit), and ФВП (Harmful Contaminate Filter) include such a filter. Additionally, the Waste Collection System (WCS) on the orbiter is also effective in removing ammonia. The Ambient Temperature Catalytic Oxidizer (ATCO) and LiOH canisters are not effective at ammonia removal.

3.6.2.8 Hydrazine (MMH, UDMH)

Hydrazine is used in three different forms on ISS and shuttle. Monomethyl Hydrazine (MMH) is used as fuel on orbiter hypergolic propulsion systems. Unsymmetrical Dimethyl Hydrazine (UDMH) is used as fuel on ISS propulsion systems. Hydrazine (N_2H_4) is used to power orbiter Auxiliary Power Units (APUs). If N_2H_4 were to leak, it would be contained in the aft compartment and, therefore, does not pose an EVA contamination concern. Subsequent references to hydrazine in this document refer to either MMH or UDMH. Hydrazine has been identified as a substance that could threaten the health and safety of any IV or EV crewmember. Should liquid hydrazine come in contact with an EMU in extremely large quantities, the helmet visor and certain layers of the protective TMG may be damaged by chemical reaction. Such damage increases the likelihood of suit leaks and loss of suit pressure integrity. For UDMH,

realistic exposure quantities do not cause any concern for EMU reusability or degradation (reference EMUM 0086 Acceptability of EMU Use after Exposure to Unsymmetrical Dimethyl Hydrazine (UDMH) During ISS EVAs.) If hydrazine vapor reaches the orbiter cabin from a contaminated EMU, the eyes, lungs, and skin of unprotected IV crewmembers are susceptible to injury following direct absorption.

The procedures currently used to ensure crew safety include detecting hydrazine, cleaning up contaminated articles, and scrubbing cabin air. Contamination is detected visually or by indications from the two separate detection systems discussed later in this section. Cleanup is primarily performed by exposing the EMU to radiative heat to allow sublimation of hydrazine to space. While it is not effective at ammonia removal, the hydrazine brush can be used to sweep off frozen hydrazine crystals during an EVA. Hydrazine is soluble in liquid water. After ingressing and repressurizing the airlock to cabin pressure, wet towels will be passed into the airlock to clean up hydrazine. Activated charcoal filters are effective at removing hydrazine. Efficiency is improved if the filter contains a platinum bed. TCCS, Russian БМП, ФБП, and the ATCO filters are all effective at removal. The condensing heat exchangers also provide hydrazine removal capability. Because it is possible to activate the Portable Fan Assembly (PFA) with an ATCO canister, the EV crewmember will remain isolated in the Equipment Lock until this filter has sufficiently reduced the concentration. Filtration is more efficient prior to dilution into the large ISS volume.

EMU Hydrazine Susceptibility

Hydrazine susceptibility tests were performed on the EMU for the STS 41-G Orbital Refueling System (ORS) mission. Tests were performed that exposed representative EMU material to contamination levels ranging from 0.72 to 2.88 cc that were applied over wide and narrow spray areas. Worst case results occurred with the narrow concentration spray pattern at 2.88 cc. A summary of results is given in Table 3.6-2.

The results shown in Table 3.6-2 may occur when the airlock is repressurized because any frozen hydrazine will liquefy. However, analysis has shown that if the bakeout period sublimated all contamination from the outer TMG, there should be no internal contamination left to liquefy during repress.

Table 3.6-2. Results of hydrazine susceptibility tests

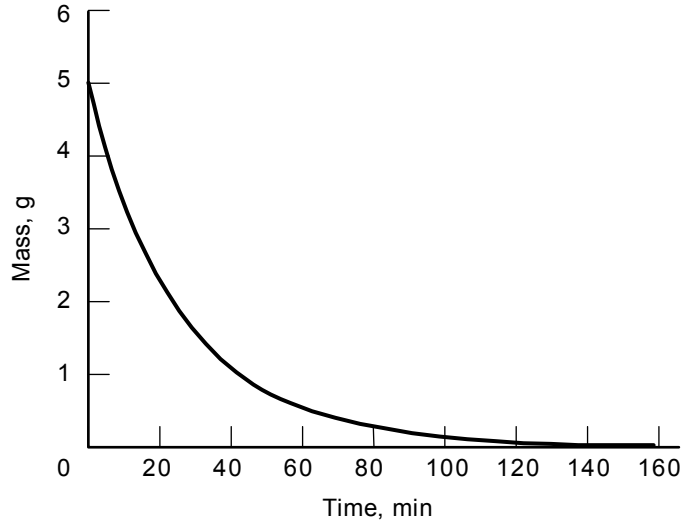
Item	Effects after exposure
Polysulfone Sun visor	<ul style="list-style-type: none"> • Unaffected
Lexan polycarbonate helmet visor	<ul style="list-style-type: none"> • Chemical dissolution produced a gummy substance at the exposed surface • Immediately formed a pattern of small cracks (crazing) • A decision was made not to modify the outer visor since it is only an impact shield and not a pressure vessel
Ortho fabric (outer layer of TMG)	<ul style="list-style-type: none"> • Light brown staining from liquid hydrazine • No apparent loss of structural integrity • Readily permitted soaking of inner suit layers
Aluminized Mylar insulation	<ul style="list-style-type: none"> • Aluminum coating of outer layers degraded enough to pass light • Not considered a hazard because three to five layers were not degraded throughout the EMU
Pressure bladder	<ul style="list-style-type: none"> • Unaffected
Chemglaze thermal paint	<ul style="list-style-type: none"> • Stained
RTV-630	<ul style="list-style-type: none"> • Stained

Hydrazine contamination also may be detected visually during EVA periods by the appearance of

- White flakes of frozen hydrazine on the outer TMG
- A patch or mound of white ice on the outer TMG

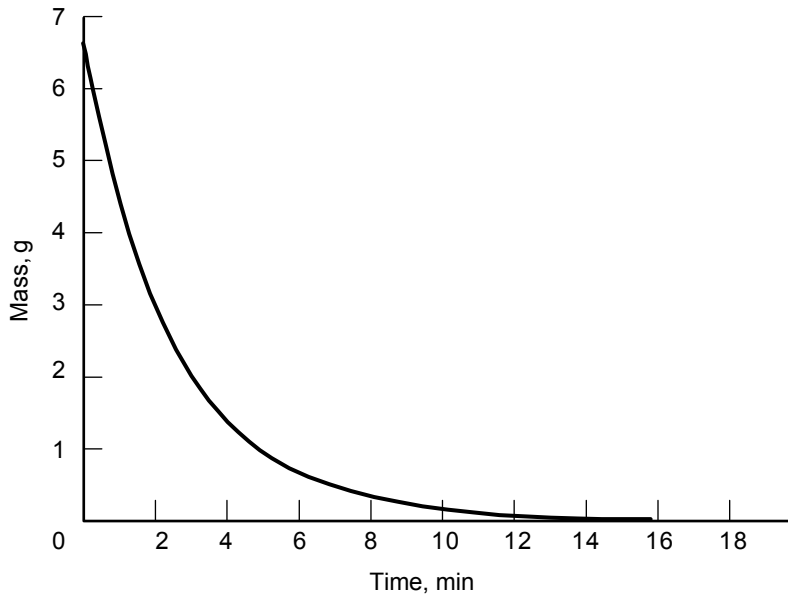
Bakeout Background

The WSTF conducted tests to determine hydrazine sublimation rates in a deep vacuum environment with incident solar flux. Under the test conditions, best and worst case sublimation behaviors were identified. The results indicate that under the worst case conditions (Figure 3.6-6) of no solar flux and a narrow stream application of 5.07 g, complete sublimation will not occur in less than 140 min. Best case conditions of direct Sun and a diffuse spray of 6.73 g permit total sublimation in 15 min (Figure 4.6-5). However, because the Crewlock is a warmer environment, that location will be most effective at removal. A bakeout calculator similar to the one used for ammonia is in development. Until it is available, 30 minutes of dedicated bakeout should be used.



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Figure 3.6-6. Representative narrow spray without solar energy



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Figure 3.6-7. Representative wide spray with solar energy

To model the response of an even larger spill, data using hydrazine volumes of 5 and 10 cc have been compiled. For the STS 41-G ORS mission, a maximum leak of 166 cc was analytically determined. The model predicted that with direct Sun and a narrow spray of 166 cc, full sublimation should occur in 70 minutes. Fifteen minutes should be sufficient for full sublimation under the same conditions, except with a diffuse spray

pattern (Figure 3.6-8). These results are only approximate and do not account for the actual amount of contamination that would stick to the EMU if the hydrazine brush was used.

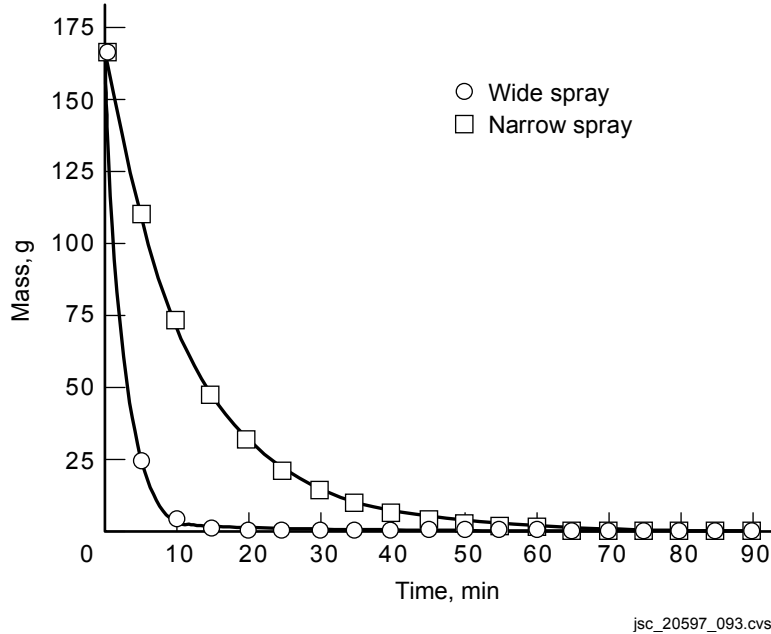


Figure 3.6-8. 166-cc spill with solar energy

Physiology

Hydrazine is commonly used as a fuel for liquid rocket motors and is highly toxic at extremely low exposure levels. Contamination of an unprotected person most likely will occur through direct absorption. The MMH SMAC is 2 parts per billion (ppb) regardless of duration. Although UDMH is understood to be less toxic than MMH, a SMAC has not been agreed to. Therefore, UDMH must be treated to the same concentration levels as MMH.

The physiological impacts of hydrazine contamination are summarized in Table 3.6-3.

Table 3.6-3. Physiological impacts of hydrazine

Body system	Reaction
Eyes	Irritation, inflammation, temporary blindness
Skin	Burns
Respiratory system	Bronchial irritation, pulmonary edema
Liver and kidney	Severe chronic exposure concerns
Central nervous system	Seizures, vomiting, instability
Blood	Hemolysis (dissolution of red blood cells)

Treatment of hydrazine exposure calls for flushing contact areas with water and covering exposed areas to limit additional contact. Further injury can be prevented by scrubbing the cabin atmosphere to prescribed safe levels, using the special hydrazine removal canisters.

Hydrazine Detection (Gold Salt) System Description

A Gold Salt Hydrazine detector was developed by WSTF to detect the presence of MMH and UDMH in the airlock at 5 psia. The same detector is used for MMH as UDMH. To perform a test, the detector is removed from two levels of packaging and installed into the ISS or STS Contamination Sampler depending upon which airlock is used. When the valve is opened, the degree of color change on the sample pad will be proportional to the hydrazine concentration. A color comparison chart is used to compare the reaction color to a standard color scale. A different color scale is used for MMH and UDMH. Because human perception of color varies between individuals the color matching process is not precise. Because of this a 2x factor of safety is applied to the perceived reading. The texture of the sample pad also generates micro-shadows on the surface that makes the exposure appear darker. As this adds conservatism, the crewmembers should vary the incident light angle and use the darkest perceived color.

ATCO Canister Description

The orbiter Air Revitalization System (ARS) nominally scrubs CO₂ out of the cabin air through two LiOH canisters installed in the middeck floor. Although the LiOH canisters will eventually remove hydrazine from the cabin, the ATCO canister removes hydrazine at a rate that is two to three times faster (Figure 3.6-9). The LiOH and hydrazine removal canisters (ATCO) are externally identical, except for the color of the canister tops.

If the Orbiter cabin is determined to be contaminated, a LiOH canister should be replaced with an ATCO canister. The chemical equation for this process is $3\text{N}_2\text{H}_4 + 4\text{KMnO}_4 \rightarrow 4\text{KOH} + 4\text{MnO}_2 + 4\text{H}_2\text{O} + 3\text{N}_2$.

Technical Specification

Weight - 6.72 lb

Part number - MC621-0008-0060

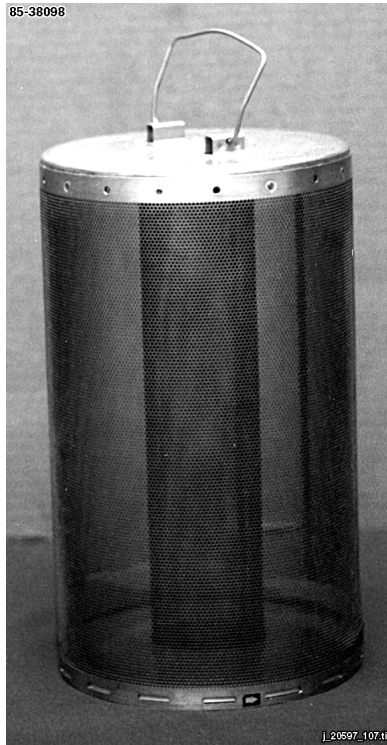


Figure 3.6-9. Hydrazine removal (ATCO) canister

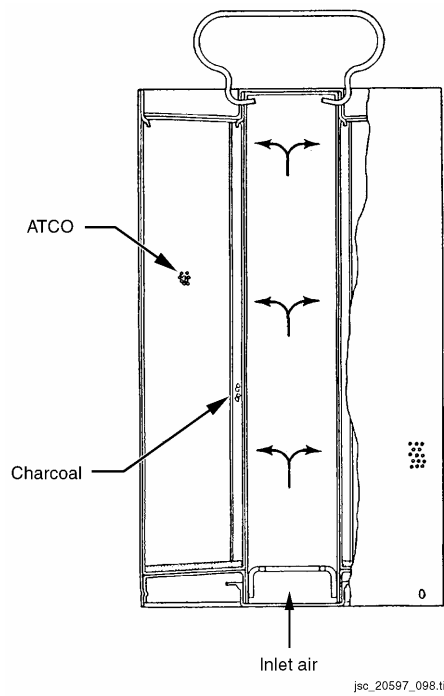


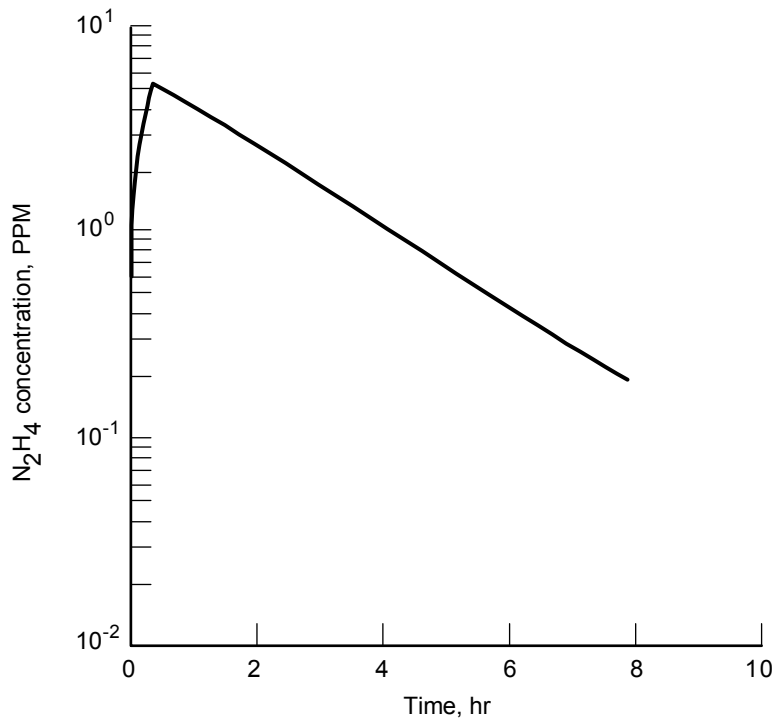
Figure 3.6-10. Hydrazine removal canister (inside view)

Operational Performance Data

Plots of hydrazine-decay profiles in a contaminated cabin (STS 41-G specific) were developed during testing at WSTF. The curves (Figure 3.6-11 to Figure 3.6-15) consider various initial contamination masses and whether one or two hydrazine canisters are used. They do not account for supplemental elimination agents, such as metal oxidizing surfaces and the condensing heat exchanger. The results are summarized in Table 3.6-4.

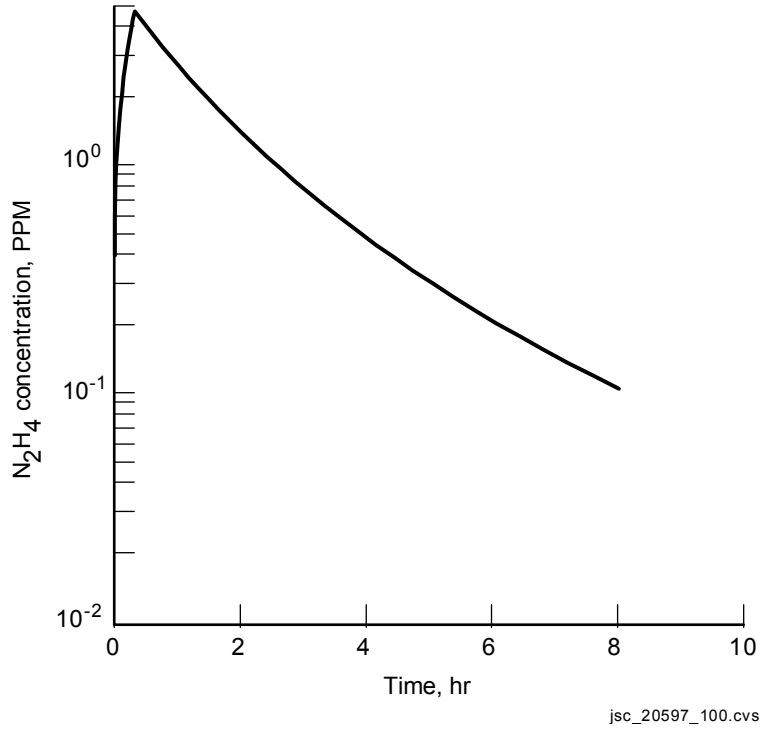
Table 3.6-4. Hydrazine decay profile

Hydrazine contamination (grams)	Decay time to 0.1 ppm (hours)	
	One hydrazine removal canister	Two hydrazine removal canisters
1.0	9.25	7.75
0.5	7.6	6.5
0.25	6.5	5.5

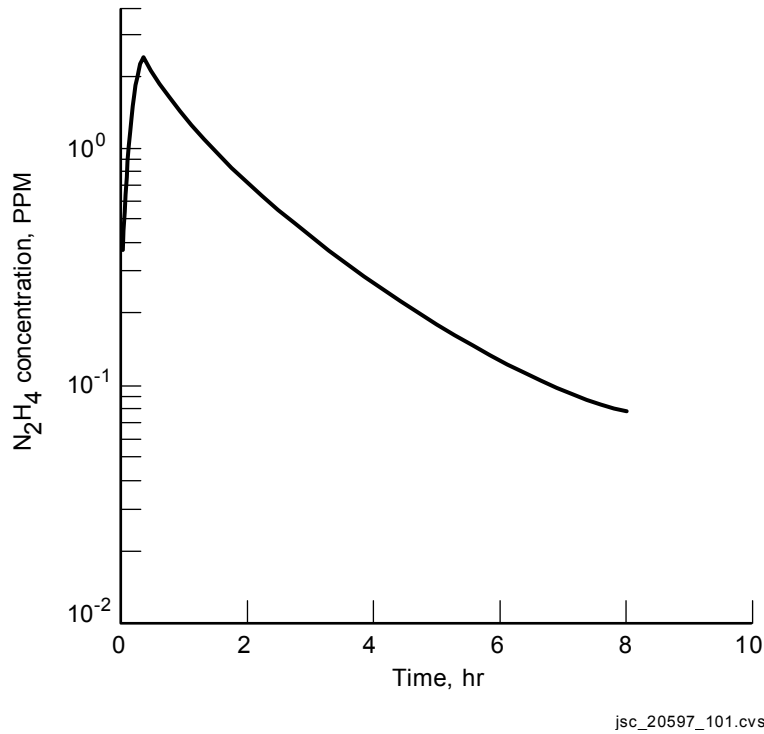


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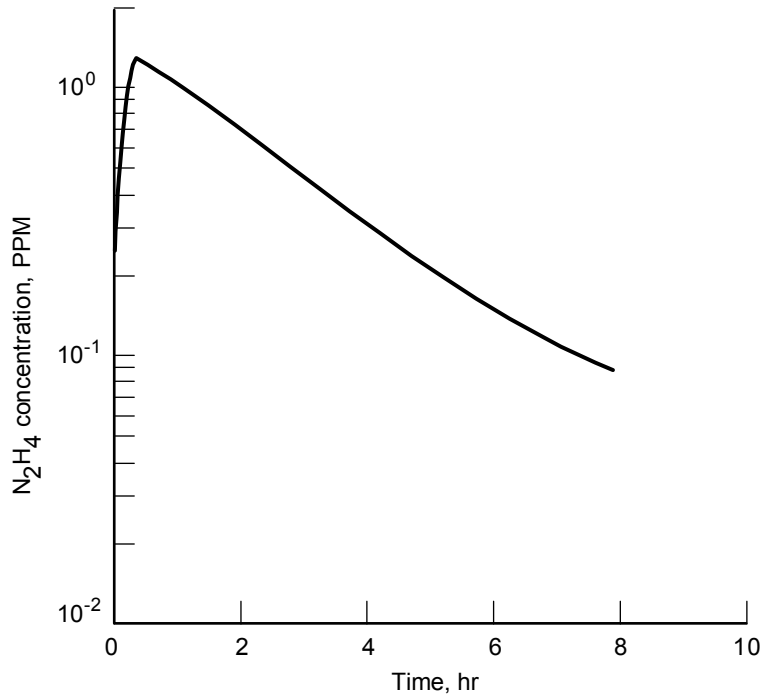
Figure 3.6-11. 1.0 gram hydrazine brought into cabin (One hydrazine removal canister)



**Figure 3.6-12. 1.0 gram hydrazine brought into cabin
(Two hydrazine removal canisters)**

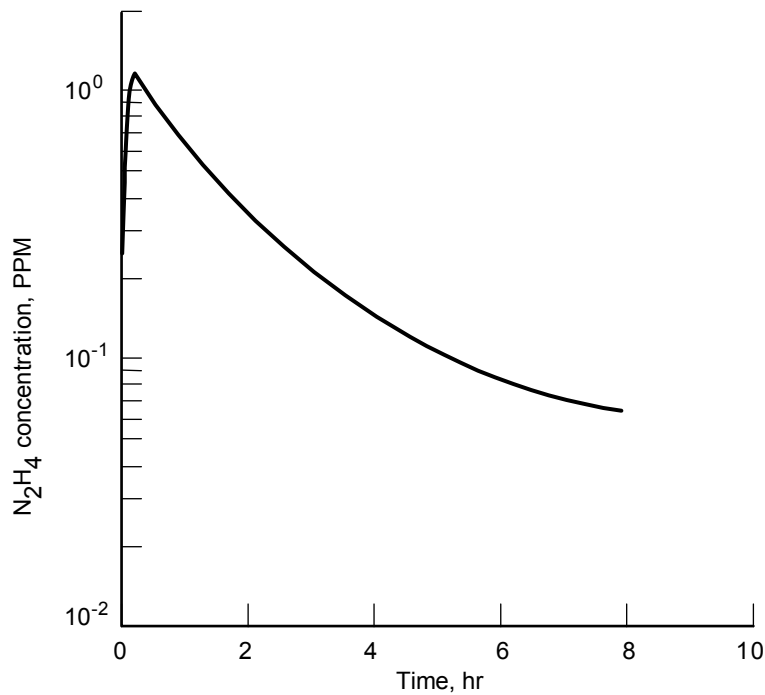


**Figure 3.6-13. 0.5 gram hydrazine brought into cabin
(Two hydrazine removal canisters)**



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**Figure 3.6-14. 0.25 gram hydrazine brought into cabin
(One hydrazine removal canister)**



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**Figure 3.6-15. 0.25 gram hydrazine brought into cabin
(Two hydrazine removal canisters)**

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