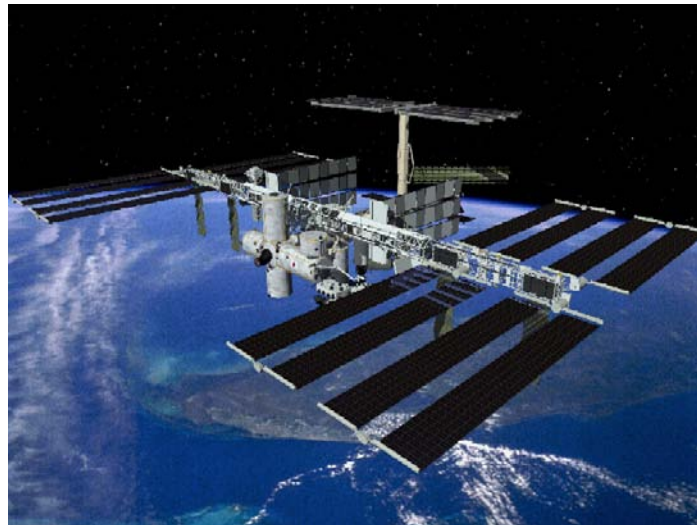




**International Space Station**

# **CHeCS**

**Medical Hardware Catalog**



**March 2011**

**Version 10.0**

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## ISS CHeCS Hardware Catalog – Preface

The purpose of this catalog is to provide a detailed description of each piece of hardware in the Crew Health Care System (CHeCS), including subpacks associated with the hardware, and to briefly describe the interfaces between the hardware and the ISS. The primary user of this document is the Space Medicine/Medical Operations ISS Biomedical Flight Controllers (ISS BMEs).

**IMPORTANT:** This reference is not an official NASA document. The information on each piece of hardware was assimilated by each of the Medical Operations-Operations Team Leads from various sources including the Government Certification Acceptance Request (GCAR) database.

Each section is formatted in the following manner:\*

- **X.X.1 Hardware Description** – Brief description of what the hardware is and its primary function.
- **X.X.2 Hardware Contents/Components List and Description** – List of main contents/components of the hardware, a table listing general specifications of the hardware (dimensions, mass, power, parameters, etc.), any hardware specific parameters and a description of the contents/components (may break down into subsections if necessary).
- **X.X.3 Hardware Interfaces with Vehicle** – Power connections, Velcro, seat tracks, etc.
- **X.X.4 Resupply Schedule** – Identifies the type and frequency of scheduled resupply.
- **X.X.5 Data/Commanding Capabilities**– Defines the data available from the hardware and/or activity related to the hardware, and the commanding capabilities of the hardware (whether it involves the ground or the crew to command).
- **X.X.6 Hazard Concerns** – A list of hazards associated with the hardware or activity in which the hardware is used.

\* **Some sections may have additional subsections depending on the components or complexity of the hardware. The EHS section has several subsystems: Acoustics, Microbiology and Water Quality, Radiation and Toxicology; therefore, the subsections are identified by 4 digits (X.X.X.1, for instance).**

For a complete listing of all CHeCS hardware anomalies (malfunctions) as of Expedition 10, which have occurred during real-time operations on the ISS, refer to the ISS Medical Operations CHeCS Hardware Anomalies book. This book can be accessed on the Space Medicine and Health Care Systems website.

For a complete listing of Medical Operations procedures, refer to **SODF** for the **ISS Medical Operations Book** for crew procedures, and the **ISS Ground Handbook: Ground Support Systems** book for ground procedures.

For detailed schematics of each piece of CHeCS hardware (including some exploded views of the hardware), refer to the **ISS Systems Handbook (ISSSH)** or the **EDCC website**.

For more information on operations involving CHeCS hardware and Biomedical Engineer (BME) flight controller responsibilities for each activity using CHeCS hardware, refer to the appropriate section within the **ISS BME Console Handbook** (internal reference for Medical Operations personnel).

# **1. Crew Health Care System (CHeCS)**

- 1.1. CHeCS 1553 Data Network**
- 1.2. CHeCS As-Flown Manifest**
- 1.3. Failed/Obsolete Hardware (CHeCS Systems Integration)**

## 1.1. CHeCS 1553 Data Network

### 1.1.1. Command & Data Handling (CDH) Support

In order for CHeCS data to reach the ground, the information must either be generated on a device, which can communicate using the 1553 protocol or it must be transferred to the Medical Equipment Computer (MEC). The CHeCS devices designed to communicate directly over a 1553 bus are the Tissue Equivalent Proportional Counter (TEPC) and the Extravehicular Charged Particle Directional Spectrometer (EVCPS). Depending on the device, data can be sent to the ground in real-time or saved as a file for transfer through the Payload Command & Control MDMs.

There are four CHeCS 1553 buses which connect directly to the Payload MDMs; LB CHeCS-SM, LB CHeCS-JEM, LB CHeCS-COL, and LB CHeCS-HAB. These buses are accessed from receptacles in the Service Module, Japanese Experimental Module (JEM), U.S. Laboratory, European Columbus Laboratory (COL), and S0 Truss (for EVCPS).

In addition to using the 1553 bus architecture, the MEC is capable of using the Ops LAN for file transfer to the ground.

#### *Additional Information:*

CDH Training Manual (TD9703)

- *Section 2:1 Portable Computer System (PCS) and Station Support Computer (SSC)*
- *Section 2.3: MDM Software and Architecture*

ISS Systems Handbook (ISSH)

- Drawing 7.1: COMMAND AND DATA HANDLING OVERVIEW FUNCTIONAL SCHEMATIC
- Table 7.1: Connectivity of RPCMs as 1553B RTs

### 1.1.2. CHeCS 1553 Data Network Description

The CHeCS 1553 Data Network is comprised of power/1553 data connections throughout the vehicle. The crew interface to these connections is through the Portable Computer Receptacle (PCR). There are two PCRs located on the front of each Utility Outlet Panel (UOP).

While there are numerous PCRs located throughout ISS, only a few offer a direct connection to CHeCS 1553 data buses. See the diagram and chart below for the location of these PCRs.

All PCRs are "keyed" to accept either a 1553 power/data cable or an Ethernet power/data cable. CHeCS equipment requiring 1553 data support are only equipped with the 1553 power/data cable. Therefore, the few PCRs that accept the Ethernet power/data cable will not be accessible to any CHeCS components. All other non-CHeCS PCRs accept the 1553 power/data cable and can be used for a "power only" connection.

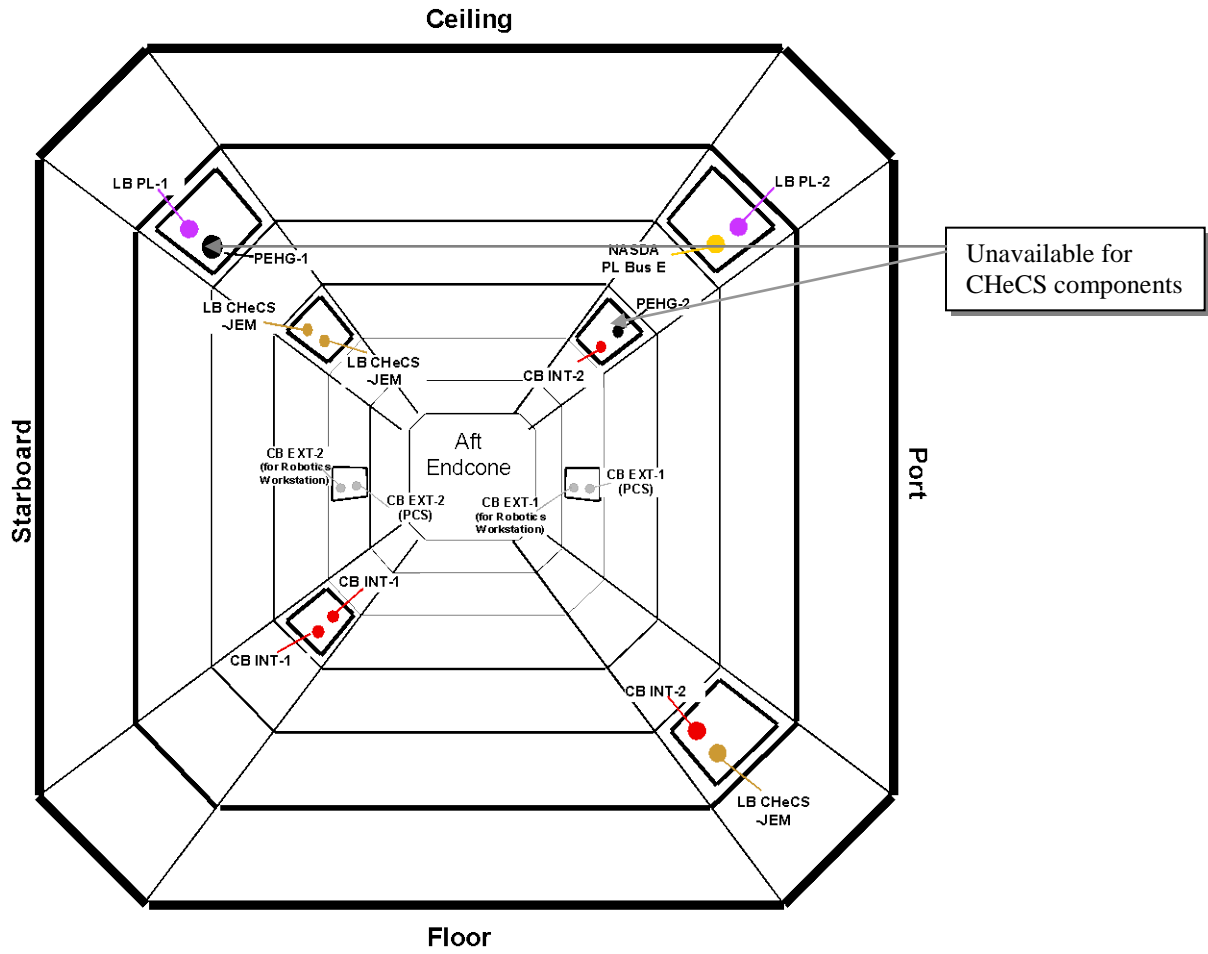


Figure 1. Lab PCR Locations

**Table 1.1.2 -1. CHeCS PCRs**

Location	Device	Power Supply	CHeCS 1553 Bus
LAB1PD2 J4	Utility Outlet Panel #5	USOS EPS Channel 2B DDCU LA2B RPCM LA2B H, RPC 18	LB CHeCS-JEM
LAB1OS4 J3	Utility Outlet Panel #2	USOS EPS Channel 1A	LB CHeCS-JEM
LAB1OS4 J4	Utility Outlet Panel #2	DDCU LAP3-1A RPCM LAP3-1A4A-C [Post-12A, additional redundancy added: USOS EPS Channel 4A DDCU LAP3-4A RPCM LAP3-1A4A-C]	LB CHeCS-JEM
S0 Truss	EV-CPDS #1	USOS EPS Channel 4B	LB CHeCS-COL
	EV-CPDS #2	DDCU LAP3-4A	LB CHeCS-COL
	EV-CPDS #3  (EVCPS External Heaters are powered from RPCM S0-2B_C, RPC 3)	SPDA S0-1A RPCM S0-1A-C (RPC 3) [Post 12A, change of power source to: USOS EPS Channel 1A DDCU S0-1A SPDA S0-1A RPCM S0-1A-C]	LB CHeCS-COL
SM above Panel #210 (Port, near the Central Command Post teleprinter)	CHeCS Receptacle #1	ROS EPS The exact power pathway for the ROS CHeCS receptacles is unknown at this time. It is likely that all ROS CHeCS receptacles are powered from the same source. There is a possibility that odd-numbered receptacles are powered from one bus (#3) and the even-numbered ones from a separate bus (#2). Each ROS CHeCS receptacle has a 5 amp fuse located on Power Supply Panel #22 located on SM Panel 308.	LB CHeCS-SM
SM above Panel #210 (Port, near the Central Command Post teleprinter)	CHeCS Receptacle #2		LB CHeCS-SM
SM Panel #431 (Starboard, above the galley table)	CHeCS Receptacle #3		LB CHeCS-SM
SM Panel #431 (Starboard, above the galley table)	CHeCS Receptacle #4		LB CHeCS-SM
SM Panel #450 (Starboard, near the crew cabin)	CHeCS Receptacle #5		LB CHeCS-SM
SM Panel #450 (Starboard, near the crew cabin)	CHeCS Receptacle #6		LB CHeCS-SM

**Table 1.1.2-2. EPS-Powered CHeCS Devices**

<b>CHeCS Device</b>	<b>Power Source</b>
Blood Pressure/Electrocardiogram	USOS 120 V DC ROS 28 V DC
Cycle Ergometer with Vibration Isolation System	USOS 120 V DC
Tissue Equivalent Proportional Counter	USOS 120 V DC ROS 28 V DC
Extravehicular-Charged Particle Directional Spectrometer	USOS 120 V DC
Treadmill with Vibration Isolation and Stabilization	ROS 28 V DC



## 1.2 As Flown Manifest

For a complete listing of all hardware that has been transferred to/from the ISS on specific flights, including part and/or serial numbers for each component, check the archived IDR, Annex 1: Flight Specific Manifests on the MIDAS database. Select “Integrated Manifest Report”, then choose a flight. The CHeCS To/From Lists on the SA Integration Sharepoint site ([https://meme-portal.jsc.nasa.gov/sites/groups/sa/projects/Crew\\_Health\\_Care\\_Systems/saintegration/ToFroms/Forms/AllItems.aspx](https://meme-portal.jsc.nasa.gov/sites/groups/sa/projects/Crew_Health_Care_Systems/saintegration/ToFroms/Forms/AllItems.aspx)) can also be referenced for transfer information by flight.

## 1.3. Failed/Obsolete Hardware

### 1.3.1. CHeCS Systems Integration

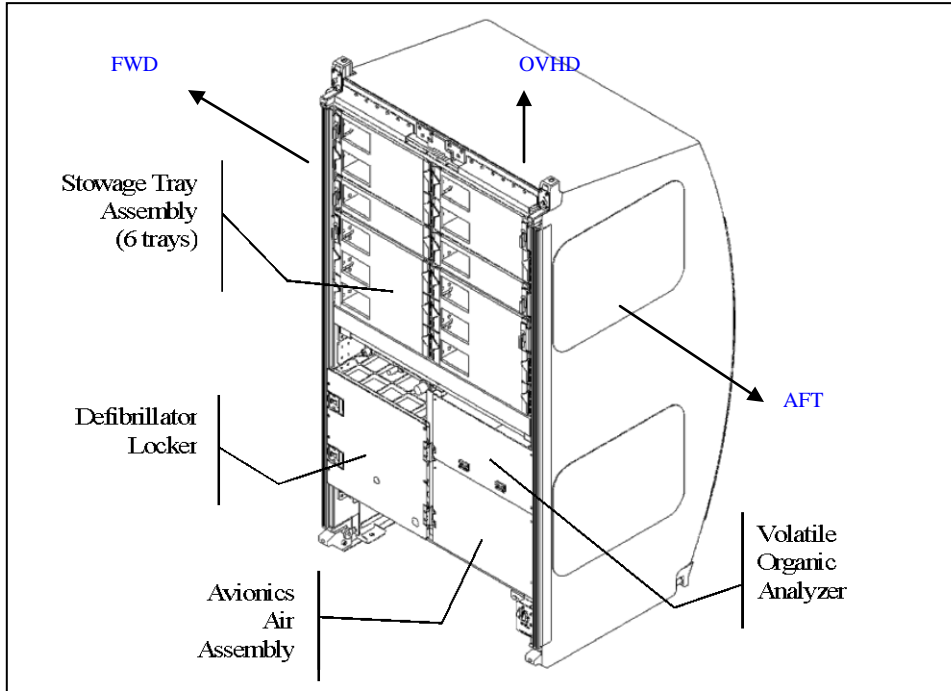
#### 1.3.1.1. CHeCS Rack #1 Description

The CHeCS rack is divided into two functional halves. The upper half of the rack provides stowage for a variety of CHeCS components. The upper half consists of locker compartments that are sealed and do not exchange air with the lower half of the rack. They are cooled by air that is circulated around the area behind the locker compartments. The locker doors have a total of ten 4”x 6” holes that also provide for air exchange with the cabin (the holes were originally designed to show tray labels; however trays are not being used in all of the lockers).

The lower half of the rack contains structural interfaces for the Volatile Organic Analyzer (VOA) and a utility panel for power/1553 data and nitrogen. The Avionics Air Assembly (AAA; a non-CHeCS component) also resides in the lower right portion of the rack. A Utility Interface Panel (UIP) is located at the base of the rack, and contains connections for rack power, thermal control, oxygen, nitrogen, and 1553 data. This lower portion of the rack has a gap, approximately 1 inch wide, just above the VOA and CHeCS Rack nitrogen, and power ports.

During Expedition 12, a procedure was performed to cover the gap in order to prevent excessive dust particles from getting into the AAA fan and degrading its performance. An activity was scheduled during Expedition 13 to install a filter originally designed for the Microscience Glove Box (MSG) (belonging to the European Space Agency (ESA)) over the AAA inlet duct to try and reduce the amount of dust that is being trapped in the heat exchanger of the AAA. Activities are scheduled as needed to clean the AAA filter to ensure that the fan will continue optimal operation. The Medical Operations Group has a Memorandum of Agreement with the Operations Support Officer (OSO) Group for the maintenance of the AAA, smoke detector, and the Remote Power Control Module (RPCM) for the CHeCS Rack.

Volume	One International Standard Payload Rack (ISPR)
Gas Sources	<ul style="list-style-type: none"> <li>Nitrogen: USOS ECLSS, ACS subsystem, Lab Nitrogen system</li> </ul>
Dimensions	One International Standard. Payload Rack (ISPR) – Approx. 203.2 cm x 105.4 cm x 96.5 cm (80”H x 41.5”W x 38”D)
Power Source	USOS EPS, Power Channels 2A and 3B, Remote Power Controller Module LA2A3B_G, RPC 2
Mass	The mass will vary for launch versus on-orbit.
Supplier	Boeing – Huntsville, Product Group (PG) 3
Location	U.S. Laboratory, starboard position 4 (LAB1S4)



**Figure 1. CHeCS Rack**

**1.3.1.2. Stowage Location Codes**

The CHeCS Rack is configured with compartments of various sizes:

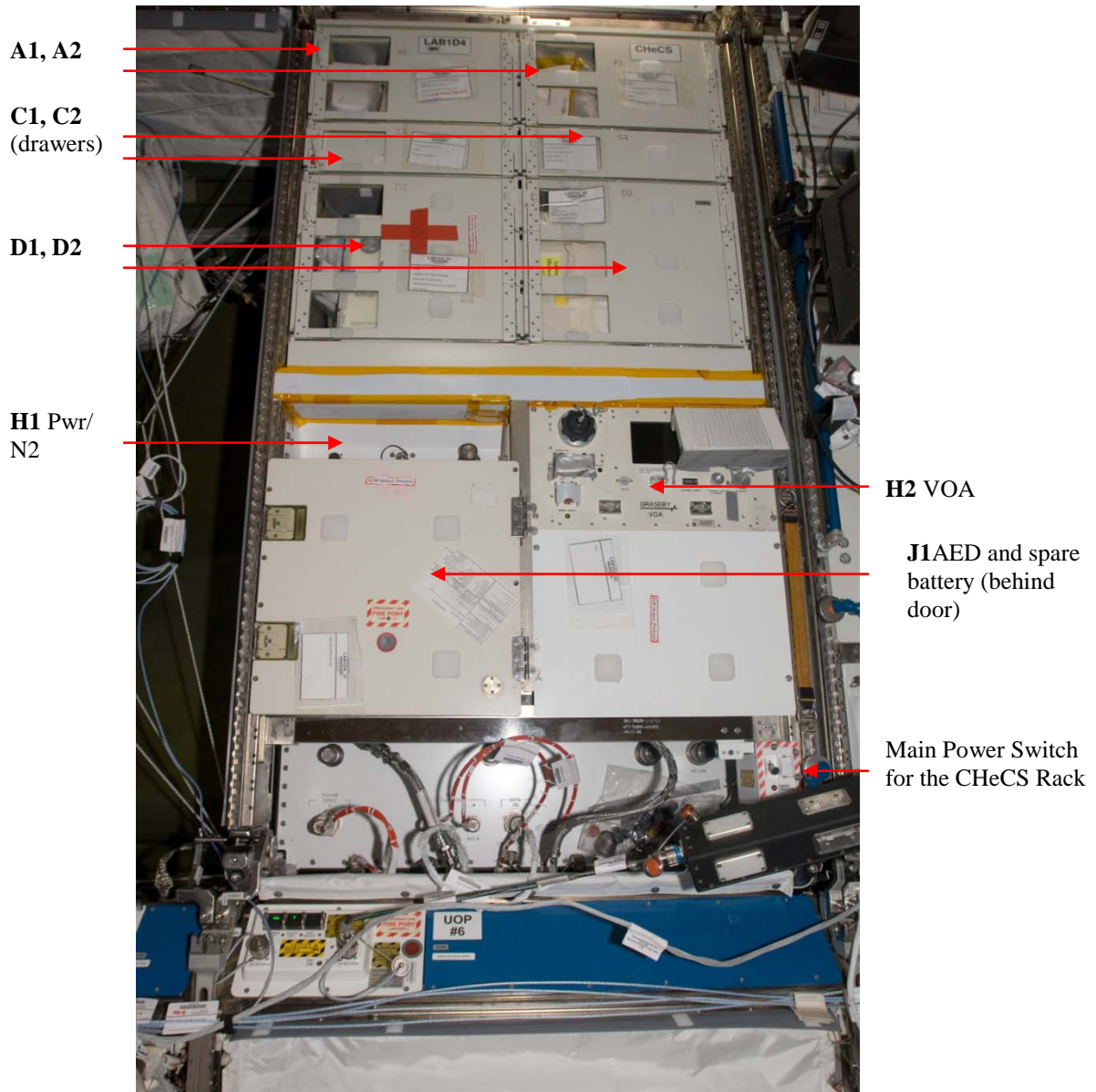
- **A1, A2** – Double Locker: (9.9”H x 16.75”W x 15.5”D)
- **C1, C2** – Single Locker (drawers): (4.65”H x 16.75”W x 28.52”D)
- **D1, D2** – Triple Locker: (14.75”H x 16.75”W x 32.5”D)
- **H1** – Custom Panel: Power and N<sub>2</sub> Ports
- **J1 (door)** – Custom Locker (tray) previously for Defibrillator: (8”H x 16.75”W x 21”D)
- **H2** – Custom Locker for VOA: (12”H x 16.75”W)
- **Power Distribution Box (door)**: (19”H x 16.75”W)
- **Avionics Air Assembly (door)**: (14.5”H x 16.75”W)

*(Dimensions were provided by Boeing as calculated from engineering drawings that were used to build the CHeCS Rack.)*

**CHeCS Rack (LAB1S4)\***

<p>A1</p> <p style="text-align: center;">CCPK HRM Resupply HRM Kit 0.5 CTB with Water/Micro Hardware</p>	<p>A2</p> <p style="text-align: center;">HASP CDMK PDK SSK VOA Repair Kit</p>
<p>C1</p> <p style="text-align: center;">GSC FMK CSA-O2 Resupply Kit</p>	<p>C2</p> <p style="text-align: center;">CSA-CP Resupply Kit</p>
<p>D1</p> <p style="text-align: center;">Intubation Kit/Airway Assy. ALSP Med Checklist RSP ACLS Flip Book CMRS (when stowed)</p>	<p>D2</p> <p style="text-align: center;">Ambulatory Medical Pack  Variable Oxygen System Kit WMK</p>
<p>H1 Pwr/N2 Ports</p>	<p>H2</p> <p style="text-align: center;">VOA</p>
<p>J1 (door)</p> <p style="text-align: center;">AED AED Spare Battery</p>	
<p style="text-align: center;">Power Distribution Box</p>	<p style="text-align: center;">Avionics Air Assembly</p>
<p style="text-align: center;">Utility Interface Panel</p>	

\* Stowage configuration as documented in the Inventory Management Search utility in October 2008.



**Figure 2. ISS On-Orbit CHeCS Rack  
(Photo taken during Expedition 17)**

### ***1.3.2. Stowage Item Interface to CHeCS Rack***

There is one stowage item that interfaces directly to the CHeCS rack, by a hard attach point and a power/data connection.

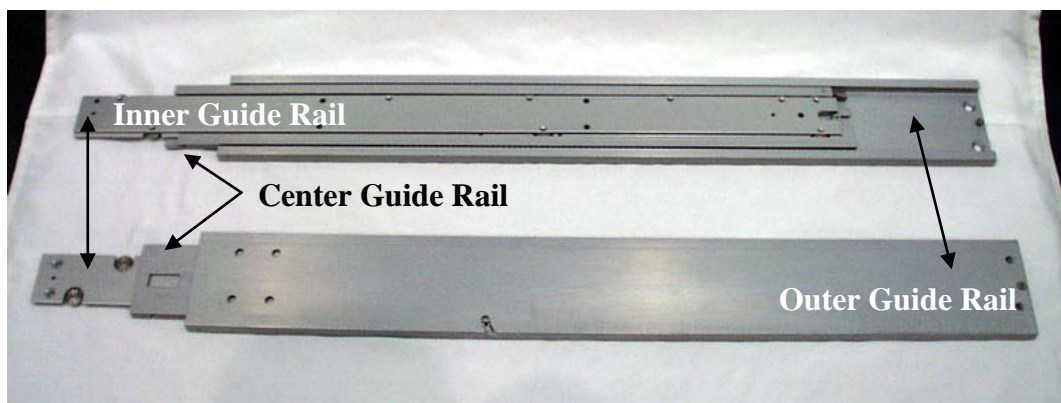
#### **1.3.2.1. Volatile Organic Analyzer Interface to the CHeCS Rack**

The VOA is secured in the rack by a series of four fasteners on the front panel in addition to slide guides mounted on both sides of the unit. Figure 3 illustrates the front panel attach points, and Figure 4 shows the slide guides.



**Figure 3. VOA Front Panel (CHeCS Rack attach points at corners)**

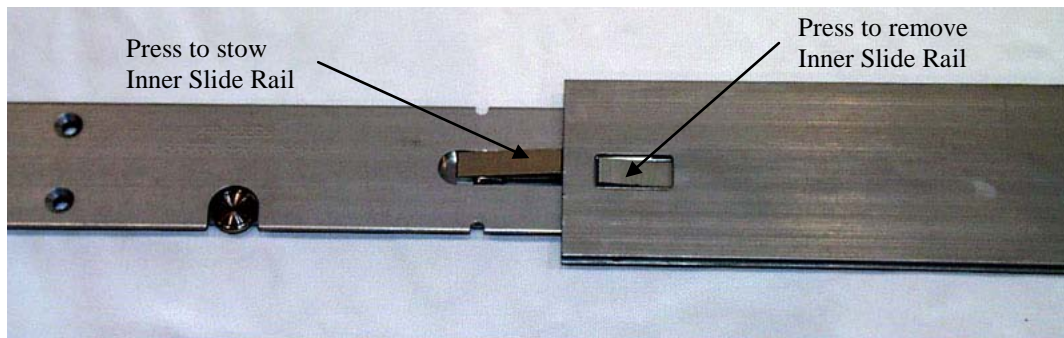
Each slide guide (left and right) is composed of three nested guide rails. The outer guide rails are the largest and are directly attached to the CHeCS rack internal structure. The center guide rails connect to both the inner and outer guide rails; however, they remain permanently attached to the outer guide rails. The inner guide rail is permanently attached to the VOA.



**Figure 4. VOA Slide Guide: Interior and Exterior View**

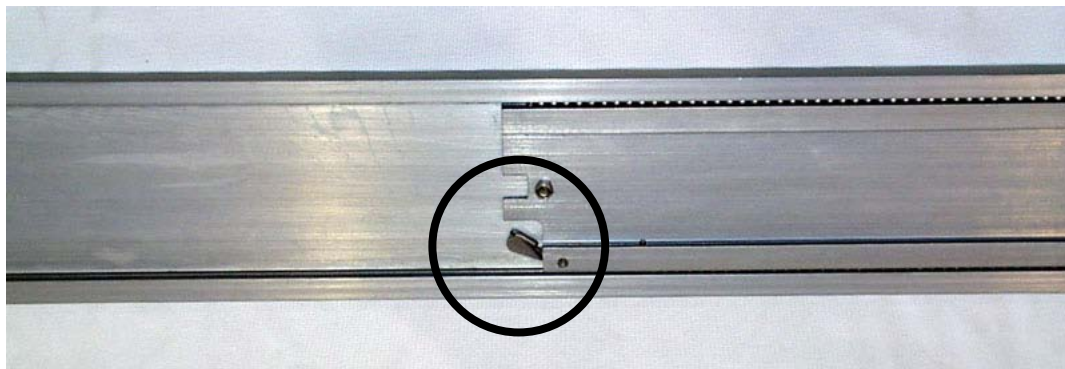
The VOA can be removed from the rack by releasing the front fasteners and drawing the VOA away from the rack until the slide guides are fully extended and latched. The VOA (attached to the inner guide rails) may then be disconnected from the center guide rails by pressing in on the spring-loaded latches on the inner guide rails as shown in Figure 5.





**Figure 5. VOA Slide Guide, Inner Guide Rail Release Latch (Exterior View)**

Note: In order to slide the center guide rail back into the rack, a small release latch on the lower rear corner of the center guide rail must be depressed, as shown in Figure 6. The center guide rail normally triggers this latch.



**Figure 6. Center Slide Guide Release Latch**

### ***1.3.3. ISS Systems Interface to CHeCS Rack Utility Interface Panel (UIP)***

The CHeCS rack interfaces with ISS systems through connections on the Utility Interface Panel (UIP) at the bottom of the rack, shown in Figure 8. During rack installation, short connectors are installed between the rack UIP and similar connectors on the LAB1SD4 standoff.

The CHeCS rack provides a source for power/1553 data and nitrogen to CHeCS hardware at the CHeCS Utility Panel (LAB1S4\_H1), shown in Figure 7. At this time, the VOA is the only CHeCS equipment that utilizes the nitrogen port on the CHeCS Utility Panel.

There is also a CHeCS Oxygen Port located on the LAB1PD4 Standoff. During contingency operations, the oxygen port is primarily used to supply the Respiratory Support Pack (RSP). The Quick Don Masks (QDMs) are also compatible with this oxygen port.



ISS017E015140

**Figure 7. LAB1S4\_H1: CHeCS Utility Panel With Non-Functional Oxygen Port Label**



**Figure 8. CHeCS Rack: Utility Interface Panel**



### 1.3.3.1. UIP Port Labels

The CHeCS rack connectors (Figure 8) are labeled as follows:

<b>Port</b>	<b>Label</b>	<b>Supplies&gt;Returns</b>
QP09	Nitrogen	Nitrogen Port, VOA
QP01	TCS Supply	To AAA Heat Exchanger, then RPDA Coldplate
QP02	TCS Return	From RPDA Coldplate
J1	Power – 120V DC	To RPDA, then distributed to VOA, AAA, Smoke Detector
J3	1553 Local/User Bus A	VOA Port
J4	1553 Local/User Bus B	VOA Port
J20	Remote Sensor Effector Data	Smoke Detector, AAA Sensors, RPDA, Maintenance Switch
No Identifier	Maintenance Switch Port	Maintenance Switch

### 1.3.3.2. Systems Interface Functional Schematic

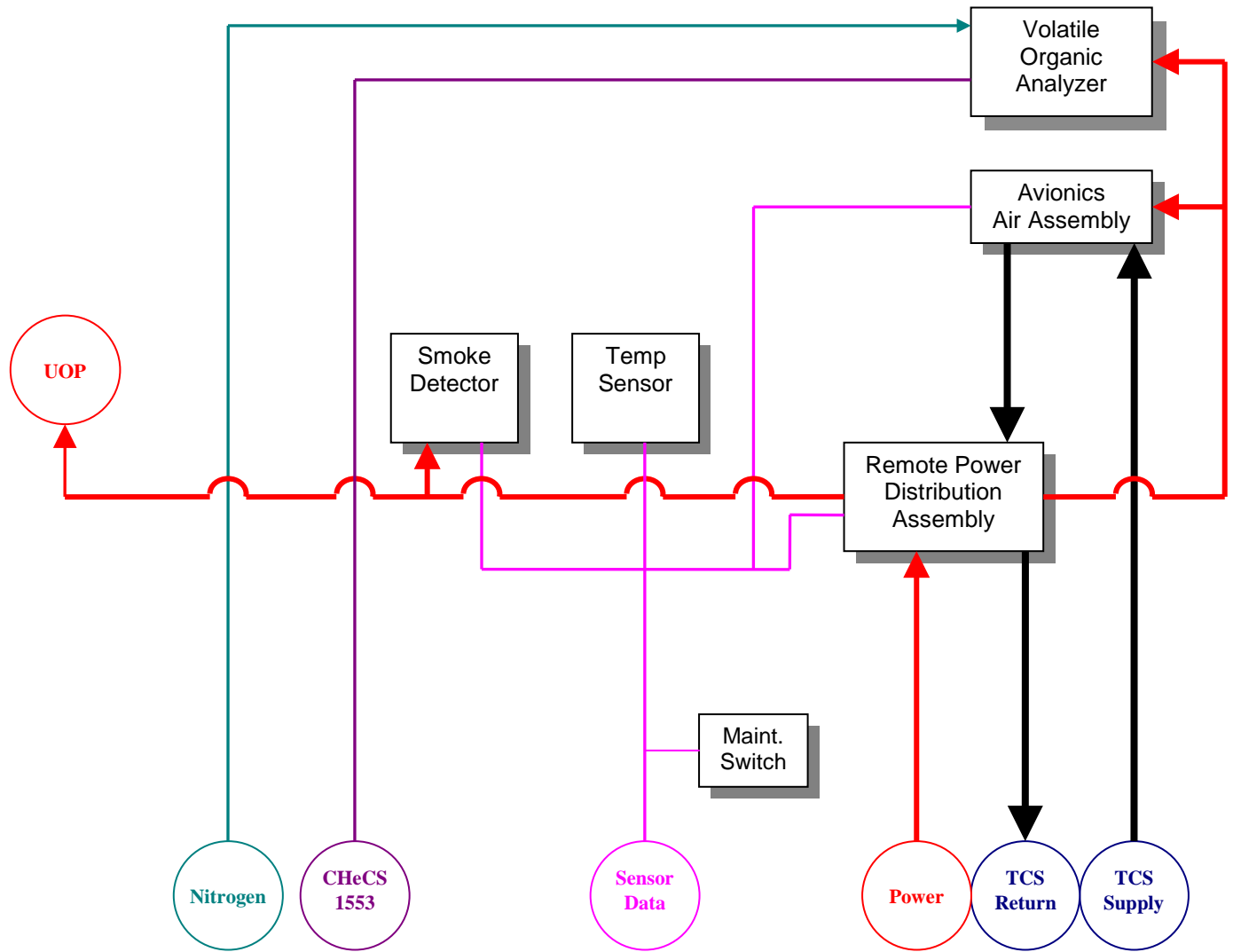


Figure 9. CHeCS Rack Utilities

### ***1.3.4. Environmental Control & Life Support Systems (ECLSS) Support***

#### **1.3.4.1. Gas/Vacuum**

The USOS Environmental Control and Life Support System (ECLSS) Atmosphere Control and Supply (ACS) subsystem provides gaseous nitrogen to the CHeCS rack. The supply tanks for the system are located on the exterior of the Joint Airlock and were delivered on flight 7A. The oxygen port to support the RSP is located on the LAB1PD4 standoff. An alternative (albeit short term) oxygen source is the Portable Breathing Apparatus (PBA) oxygen bottles located throughout the USOS.

The oxygen and nitrogen distribution systems deliver gas at a pressure of 100-120 psia (105 psia nominal) at a flow rate of 0-6 lbs/min. The primary response to isolating nitrogen gas leaks within the CHeCS rack is to disconnect the nitrogen Quick Disconnects (QD) at the Utility Interface Panel. The supply of gaseous nitrogen can also be controlled by computer commanding or manual override of the Payload Nitrogen Valve (located in the U.S. Lab forward endcone). Note that this action will terminate the nitrogen supply to all U.S. Lab payloads.

The CHeCS rack does not interface with the ISS Vacuum Exhaust/Resource System (VES/VRS).

#### *Additional Information:*

ECLSS Training Manual (TD9706)

- *Section 2.1: Atmosphere Control and Supply*
- *Section 2.4: Fire Detection and Suppression*

ISS Systems Handbook (ISSSH)

- Drawing 6.1: US ATMOSPHERE CONTROL AND SUPPLY OVERVIEW, sheet 2, coordinate L6

#### **1.3.4.2. Fire Detection**

Fire detection in the CHeCS rack is provided by a single smoke detector located inside the rack just above the Utility Interface Panel. It receives power from the CHeCS rack Remote Power Distribution Assembly (RPDA) and reports health & status data to the LA-3 MDM. The smoke detector is dependent on the AAA for air circulation past the detector and has a photoelectric sensor.

A small rack maintenance control panel is located at the base of the rack, just in front of the Utility Interface Panel. It contains a rack fire indicator LED and a rack maintenance power switch. The red LED (rack fire indicator) provides the crew with a cue of where a rack fire is located. It receives power from the LA-3 MDM and is driven by the LA-3 MDM based on detection of smoke in the rack.

The rack maintenance power switch is used in support of maintenance operations or fire suppression. When switched OFF, the switch sends a discrete signal to the INT SYS MDM (via the LA-3 MDM) to shutdown power loads in the rack and to open the RPC(s) that provide power to the rack.

The Medical Operations Group has a Memorandum of Agreement with the Operations Support Officer Group for the maintenance of the smoke detector within the CHeCS Rack.

*Additional Information:*

ECLSS Training Manual (TD9706)

- *Section 2.4: Fire Detection and Suppression*

ISS Systems Handbook (ISSSH)

- Drawing 6.63: LAB FIRE DETECTION SYSTEM, sheet 3, coordinate F3

### ***1.3.5. Avionics Air Assembly (AAA) Interface***

The Avionics Air Assembly (AAA) located in the lower right of the rack provides air circulation to the lower half of the CHeCS Rack and for the rack smoke detector. There is a physical separation between the AAA and the stowage drawers of the CHeCS Rack. The AAA is composed of a fan, motor controller, non-condensing heat exchanger, two inlet temperature sensors and mounting hardware. The AAA is an ECLSS Temperature and Humidity Control (THC) component, which provides telemetry from the two inlet temperature sensors, fan speed and an operational status. If reported temperatures from inlet sensors are significantly different (greater than a pre-set threshold), Caution & Warning messages will be triggered about the AAA's ability to monitor and control the heat load in the rack.

The Thermal Control System (TCS) Moderate Temperature Loop (MTL) connects to the AAA to provide cooling to the heat exchanger as warm air is returned from the rack.

Failures within the AAA or the TCS MTL have direct impacts on the rack-mounted CHeCS hardware. Loss of the AAA results in a loss of cooling for the VOA, as well as a loss of rack fire detection capability.

The Medical Operations Group has a Memorandum of Agreement (MOA) with the Operations Support Officer Group for the maintenance of the AAA fan within the CHeCS Rack. This MOA is documented in the ISS Flight Controller Operations Handbook.

*Additional Information:*

ECLSS Training Manual (TD9706)

- *Section 2.3: Temperature and Humidity Control*

TCS Training Manual (TD9708)

- *Section 2.3: Lab ITCS Functional Description*

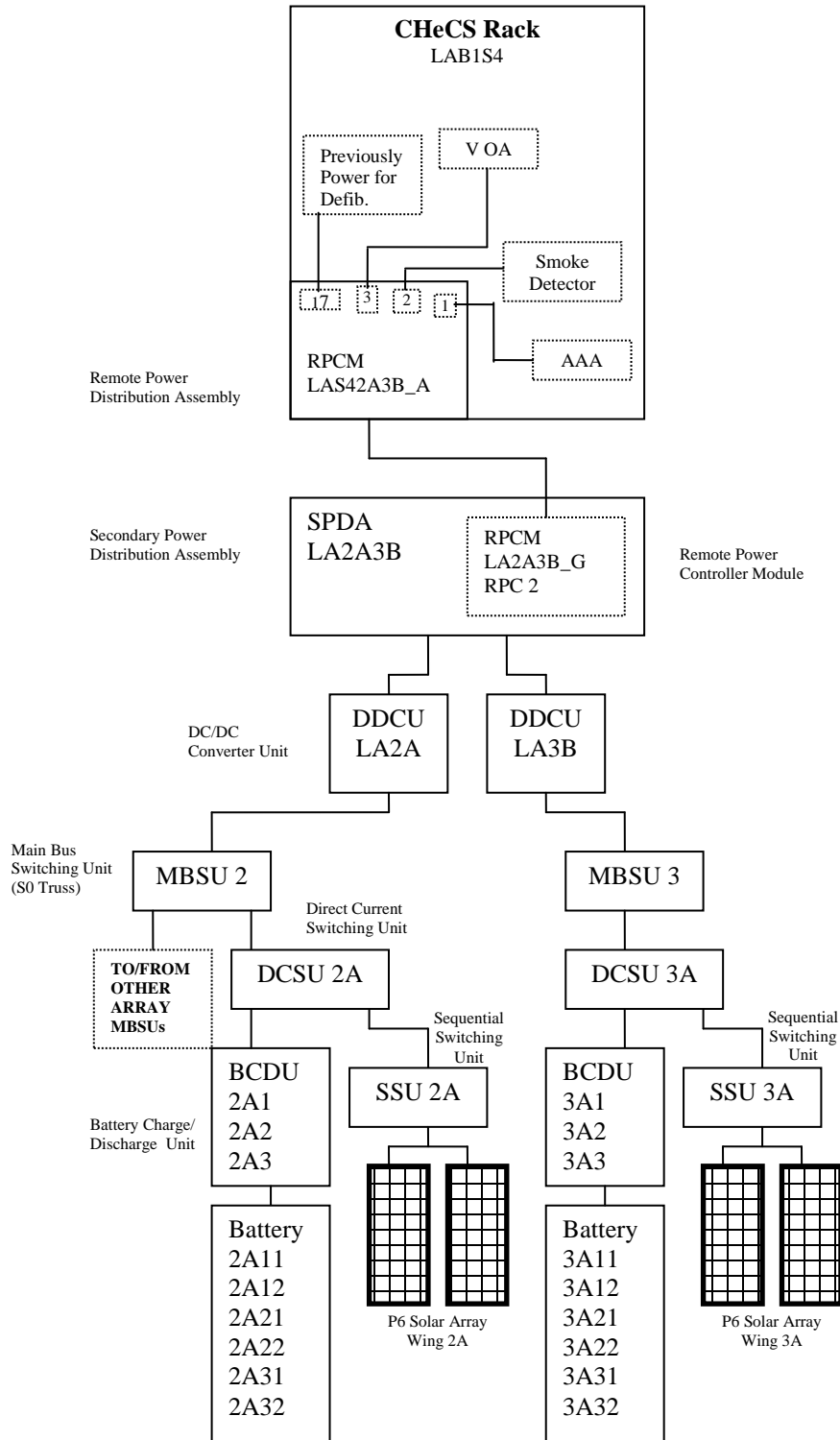
ISS Systems Handbook (ISSSH)

- Drawing 6.41: PRELIMINARY AVIONICS AIR ASSEMBLY, sheet 1
- Drawing 5.15: LAB INTERNAL THERMAL CONTROL SYSTEM OVERVIEW, sheet 2, coordinate I5

### ***1.3.6. Electrical Power System (EPS) Support***

While installed in the U.S. Laboratory, the CHeCS rack receives secondary power from power channels 2A and 3B. This power supplies the VOA, AAA, and smoke detector. The CHeCS rack has only one secondary power source, so the CHeCS rack is zero fault tolerant in the event of a secondary power system interruption.

The Medical Operations Group has a Memorandum of Agreement with the Operations Support Officer Group for the maintenance of the RPCM for the CHeCS Rack.



**Figure 10. CHeCS Power Supply**

### ***1.3.7. Crew Interfaces for Operations***

The majority of operational interfaces will occur through the CHeCS hardware subsystems. Rack interface points for these subsystems include:

- Stowage Trays
- Nitrogen gas interfaces
- Power/data interface (CHeCS Receptacle)
- AED Locker access and deployment
- VOA front panel access, rear interfaces for nitrogen, power/data, seat track interfaces

### ***1.3.8. Resupply/Maintenance Schedule***

At this time, MSFC/Boeing Huntsville has not identified any scheduled resupply/ maintenance for the CHeCS rack.

### ***1.3.9. Data/Commanding Capabilities***

N/A

### ***1.3.10. Hazard Concerns***

The CHeCS rack is in compliance with Flight Crew Interface requirements as detailed in SSP 50005. MSFC/Boeing Huntsville has not identified any additional hazard concerns.

*Note: Refer to Phase II Safety Data Package for details on hazards.*

## **2. Countermeasures System (CMS)**

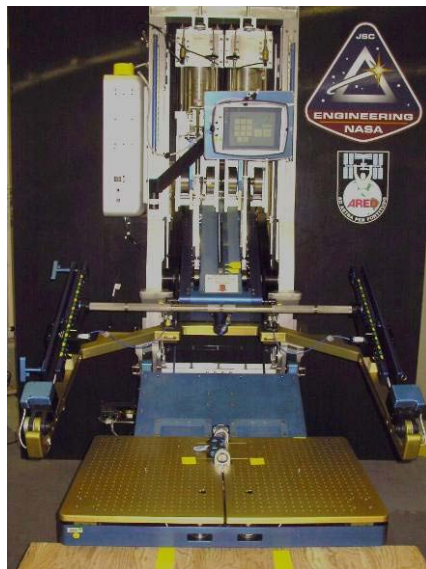
- 2.1. Advanced Resistive Exercise Device (ARED)**
- 2.2. Blood Pressure/Electrocardiograph (BP/ECG)**
- 2.3. Cycle Ergometer with Vibration Isolation & Stabilization (CEVIS)**
- 2.4. Heart Rate Monitor 2 (HRM2)**
- 2.5. Medical Equipment Computer (MEC)**
- 2.6. Resistive Exercise Device (RED)**
- 2.7. Treadmill with Vibration Isolation & Stabilization (TVIS)**
- 2.8. Treadmill 2 (T2)**

## 2.1. Advanced Resistive Exercise Device (ARED)

### 2.1.1. ARED Description

ARED is a device that is used to maintain muscle strength, bone strength, and endurance through the simulation of free weights by providing both a constant and inertial load. For Lift Bar exercises, the load ranges between 0 and 600 lb. The Exercise Rope can provide up to 150 pounds of load, and a maximum 72 inch stroke. Crewmembers perform both Exercise Rope (Cable) and Lift Bar exercises to strengthen all major muscle groups. Some of the lifts include deadlifts, bent over rows, bicep curls, bench presses, shoulder presses, shoulder raises, squats, and heel raises. ARED also incorporates a Vibration Isolation System (VIS) to minimize the impact of ARED on the station.

A touch screen display allows the crewmember to find and select their exercise prescriptions. Once the exercise session is complete, the software stores the information for later download so the crewmember will not need to manually enter their exercise session.



**Figure 1. ARED**

ARED is located in the forward hatch alcove of Node 3 (NOD3F2).

### 2.1.2. ARED Component List and Description

- Frame
  - a) Cable Arms (two)
    - Tension Mechanism
  - b) Pivot Arms (two)
  - c) Platform
    - Pulley Access Panel
    - Attachments for calibration tools and accessories
    - Exercise Rope Exit and Rope Guide
    - Load Cells (eight)
  - d) Load Adjustment Unit



- PIP Pins (two)
  - Load Scale and Indicator
  - Load Adjustment Crank Handle
  - Load Adjustment Trigger Handle
  - Load Cells (two)
  - Rotation Sensor
- Belt Pulley
  - a) Spiral Pulley
  - b) Exercise Rope
  - c) Cable Arm Ropes (two)
- Cylinder Flywheels (two)
  - a) Cylinder
  - b) Flywheel Latch
  - c) Flywheels
  - d) Piston Rod
- Main Arm
  - a) Lift Bar
  - b) Lift Bar Slide Tracks
  - c) Lift Bar Height Adjustment Handles
  - d) Load Cells (two, internal)
  - e) Rotation Sensor
- VIS
  - a) Left VIS
  - b) Right VIS
  - c) Yoke Beam
  - d) Left Seat Track Interface
  - e) Right Seat Track Interface
- ARED Display with stylus
  - a) Touchscreen
  - b) Hard Drive
- Instrumentation Box
  - a) Power Switch
  - b) Circuit Breaker
- Accessories
  - a) Exercise Bench
  - b) Hand Grip (Shared with RED)
  - c) Ankle Cuffs (Shared with RED)
  - d) 26" Weight Bar
  - e) Heel Block
- Calibration Tools
  - a) Proving Ring
  - b) C Hook
  - c) Compression Stand
  - d) ARED Calibration Blocks (two)
  - e) Tension Bracket
  - f) Rope Eye Connector

**Table 2.1.2-1 Hardware Specific Parameters**

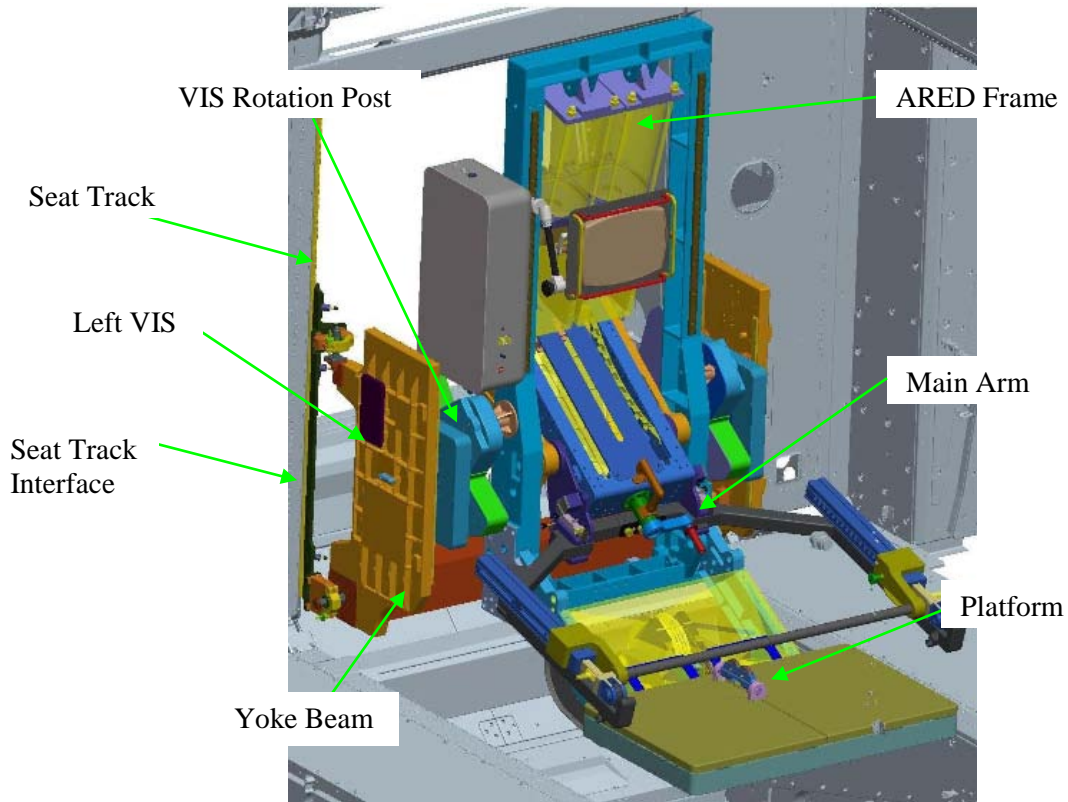
Power Requirements	Avg = 55W Peak = 100W			
Power Source	16.8 V A31p 120VDC Power Supply			
Measurement Parameters/ Analysis Capabilities:	<b><u>Display Parameter</u></b>			
		<b><u>Units</u></b>	<b><u>Range</u></b>	<b><u>Precision</u></b>
	Exercise Session	N/A	N/A	N/A
	Exercise Prescription	Set: RX Reps: RX Load	N/A	N/A
	Crew ID	N/A	N/A	N/A
	Date and Time	Day month year hh:mm:ss		
	Set	N/A	N/A	N/A
	Repetitions	N/A	N/A	N/A
	Exercise Name	N/A	N/A	N/A
	Load @ Point of Application	lbs/kgs	See below	See below
	Load @ Point of Support	lbs/kgs	See below	See below
	Displacement	degrees	-22 to 22	+0.3%
	Force at Application Point (during repetition)	lbs/kgs	See below	See below
	Exercise Duration	hh:mm:ss	N/A	N/A
Operating Ranges	0 – 600 lbs for Lift Bar and 0-150 lbs for Exercise Rope (5 – 100 lbs ± 1.0 lb and 101 – 600 lbs ± 1.0%) Nominal Values of Parameters: N/A Sensor Error: N/A Indications for Out-of-Range Parameters: N/A			

**Table 2.1.2-2 General Component Specifications**

Component List	Mass M(E)	Dimensions M(E)	Nominal Stowage Location	Operating Temp (°F)	Operating Pressure (psia)
ARED- Assembled	1200 lbs (±20)	72.7" x 60.5" x 82.9"	Node 3	63 to 87	13.9 - 14.9
Platform	78 lbs.	40.0" x 29.5" x 9.0"	Node 3	63 to 87	13.9 - 14.9
Load Adjustment Unit	94 lbs.	39.8" x 19.8" x 8.7"	Node 3	63 to 87	13.9 - 14.9
Cylinder Flywheels	95 lbs	36.3" x 9.5" x 16.6"	Node 3	63 to 87	13.9 - 14.9
Belt Pulley	71 lbs.	28.0" x 17.7" x 11.5"	Node 3	63 to 87	13.9 - 14.9
Main Arm with Lift Bar	110 lbs	53.8" x 21.0" x 7.6"	Node 3	63 to 87	13.9 - 14.9
VIS (Right)	121 lbs	39.1" x 24.1" x 13.6"	Node 3	63 to 87	13.9 - 14.9
VIS (Left)	129 lbs	39.1" x 25.0" x 13.6"	Node 3	63 to 87	13.9 - 14.9

**2.1.2.1. ARED Assembly**

ARED utilizes Left, Right Seat Track Interfaces that are attached to the forward seat tracks of Node 3 (NOD3F2). The Yoke Beam attaches to these Seat Track Interfaces. The Left VIS attaches to the Yoke Beam and the Left Seat Track Interface while the Right VIS attaches only to the Yoke Beam. The ARED Frame attaches to the Left and Right VIS via the VIS Rotation Posts. In addition to the VIS, attached to the ARED Frame are the Load Adjustment Unit, Platform Arms, Cable Arms, Pivot Arms, Main Arm, Upper Stops, Instrumentation Box, ARED Display on a Multi-Use Bracket, Handrails and Cylinder-Flywheels.

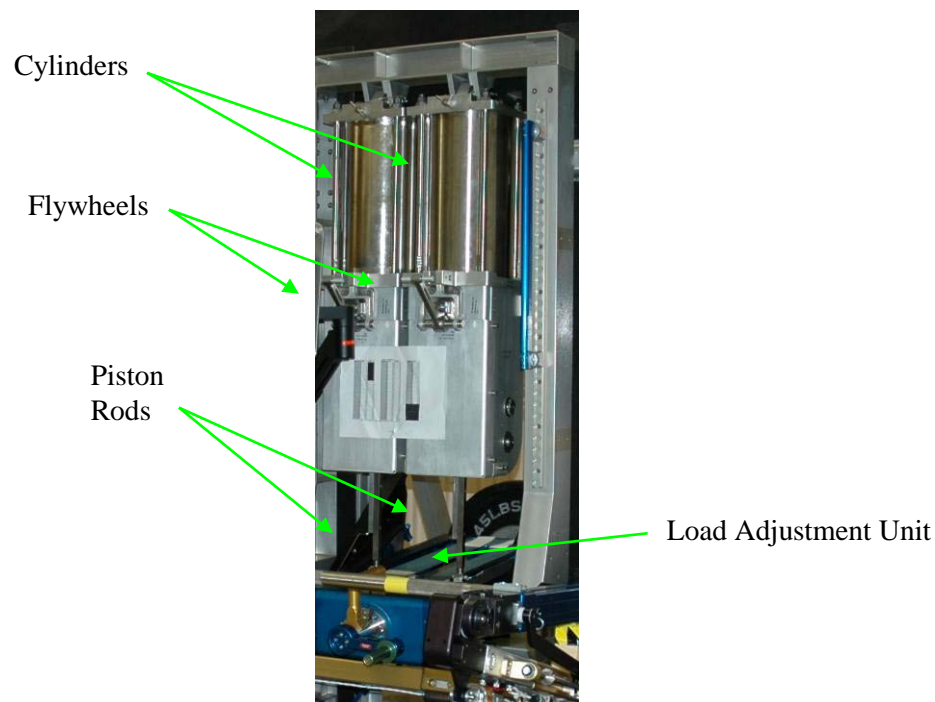


**Figure 2. ARED Attachment Points**

Load is provided by the vacuum cylinders with flywheels providing an inertial component (when desired). The Cylinder Flywheel assembly is attached to the Frame and Load Adjustment Unit. The Load Adjustment Trigger Handle and Load Adjustment Crank Handle work together to move the Load Adjustment Unit about the Piston Rod. This changes the moment arm and thereby changes the resistance crewmembers use for exercise. The resistance is transmitted to the Cable Arms and Pivot Arms which are both connected to the Load Adjustment Unit. Cable Arms transfer the load to the Exercise Rope via the Belt Pulley. Pivot Arms also attach to the Main Arm where it can transfer the load to the Lift Bar. The Lift Bar has Lift Bar Slide Tracks attached to it which adjust the height of the Lift Bar. A Platform is connected to the bottom of the Frame for crewmembers to stand on. An Exercise Bench or Heel Block can attach to the Platform. A Handle, 26" Weight Bar, or Ankle Cuffs can attach to the French Clip on the end of the Exercise Rope for rope exercises. In instances that the Exercise Rope is too short, the Vectran Cord can be attached to lengthen the Exercise Rope.

### 2.1.2.2. Cylinder Flywheel

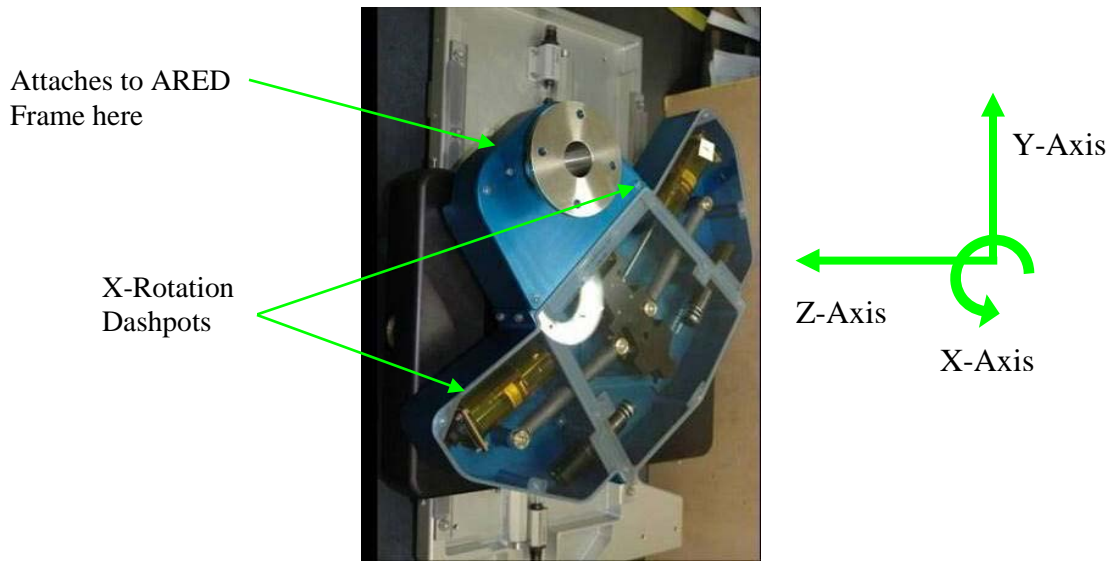
The Cylinders provide the constant load (vacuum) necessary for the operation of ARED (can provide up to 600 pounds of force). For maintenance, the crew will be required to reestablish the vacuum in the cylinders once per week. This is done by opening the Cylinder Valve, adjusting the load to maximum, closing the Cylinder Valve, and then adjusting the load back down to zero. The Flywheels provide the inertial force to make the system more realistic. These flywheels can be disengaged if desired, but is not a nominal configuration for exercise. When the flywheel is engaged, the handle is pulled out (as shown in Figure 3). When the flywheel is disengaged, it is pushed in.



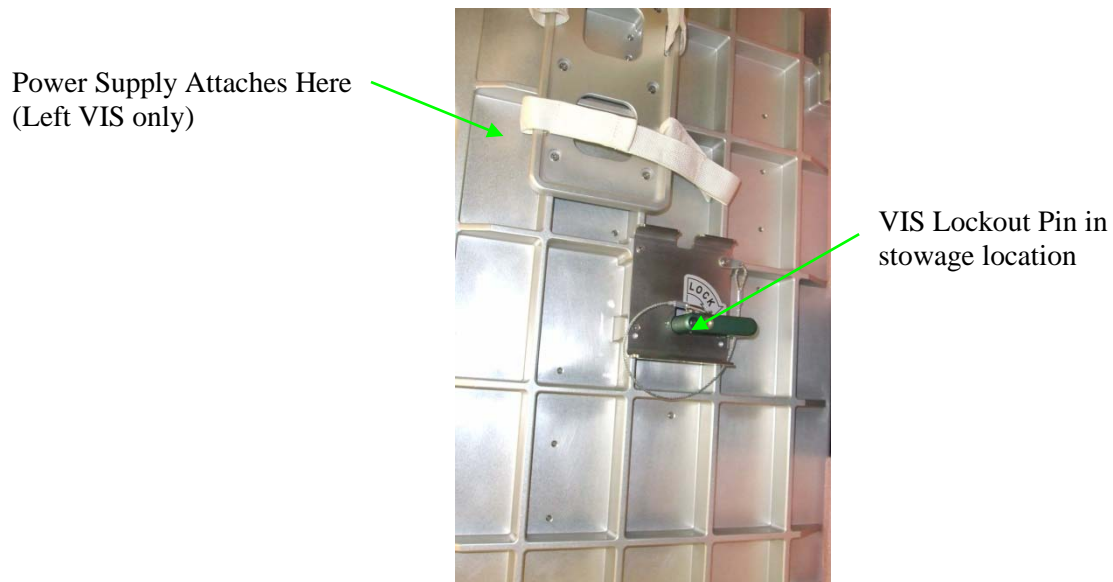
**Figure 3. Cylinder Flywheel**

**2.1.2.3. Vibration Isolation System (VIS)**

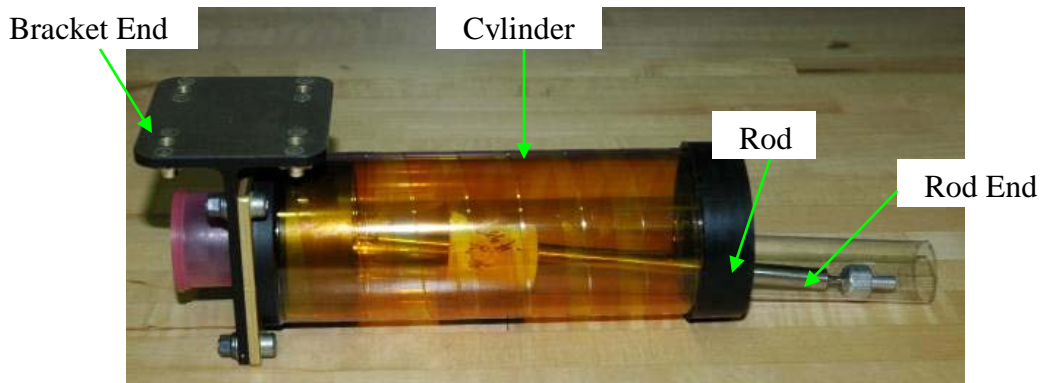
ARED has a passive Left, Right VIS that lessens the vibration in three degrees of freedom. The y-axis and z-axis absorb the translational components while the x-axis absorbs the rotational component. All three components work independently and simultaneously. Dampers and shock absorbers dissipate the energy while the springs help the system return to the center. When ARED is not in use, VIS Lockout Pins will hold the VIS in place. The translational components slide along rails. A visual inspection of the y-axis VIS rails is required every two weeks to inspect for debris, binding, and rust while a greasing of both the y-axis and z-axis rails is required every two months. Both the Left and Right VIS contain two X-Rotation Dashpots, which are visually inspected before each exercise session.



**Figure 4. VIS**



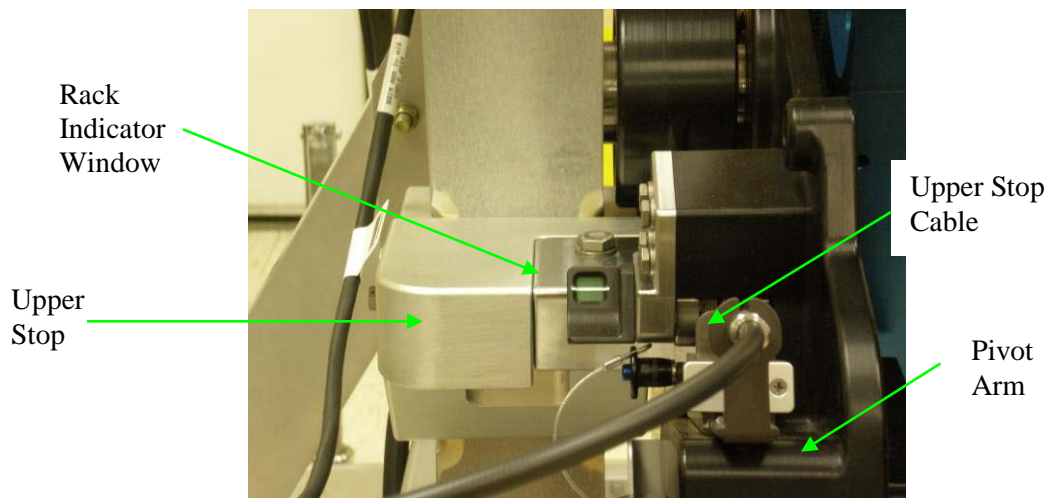
**Figure 5. Back of Left VIS**



**Figure 6. X-Rotation Dashpot**

#### **2.1.2.4. Main Arm**

The Main Arm rests in either the racked position (on the Upper Stops) or in the un-racked position (on the Lower Stops) and attaches to the Pivot Arms. Any time the Cable Arm Ropes are tensioned the Main Arm should be resting on the Lower Stops. The Upper Stops are greased every four months, or every other VIS Rail Greasing, to prevent scraping. A Rack Indicator Window assists the crew member in determining if the Main Arm is racked or un-racked.

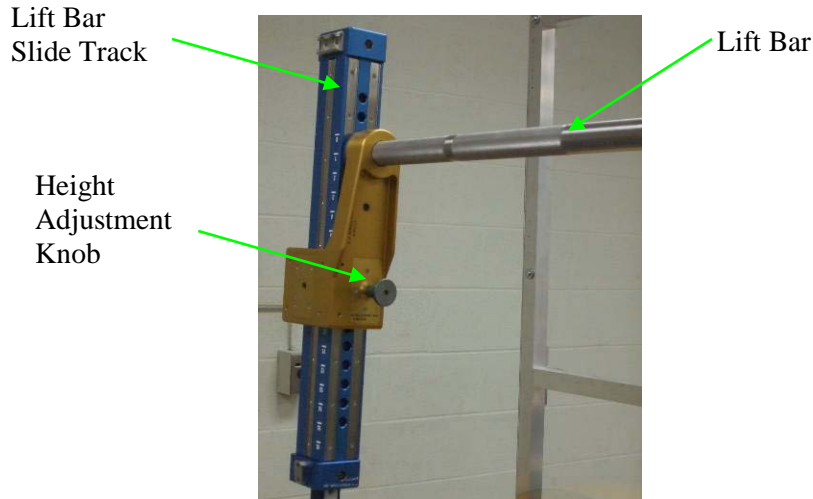


**Figure 7. Rack Indicator Window**

#### **2.1.2.5. Lift Bar**

The Lift Bar is attached to Lift Bar Slide Tracks which are attached to the Main Arm. The height of the Lift Bar is adjustable. To adjust the height, the Height Adjustment Knob is pulled out and the Lift Bar Height Adjustment Handles slide along the Lift Bar Slide Tracks. If more height is needed, the Lift Bar Slide Track can be rotated 180°. By doing this, the Lift Bar can accommodate heights ranging from the 5% Japanese Female to the 95% American Male. The Lift Bar provides a maximum load of 600 lbs.

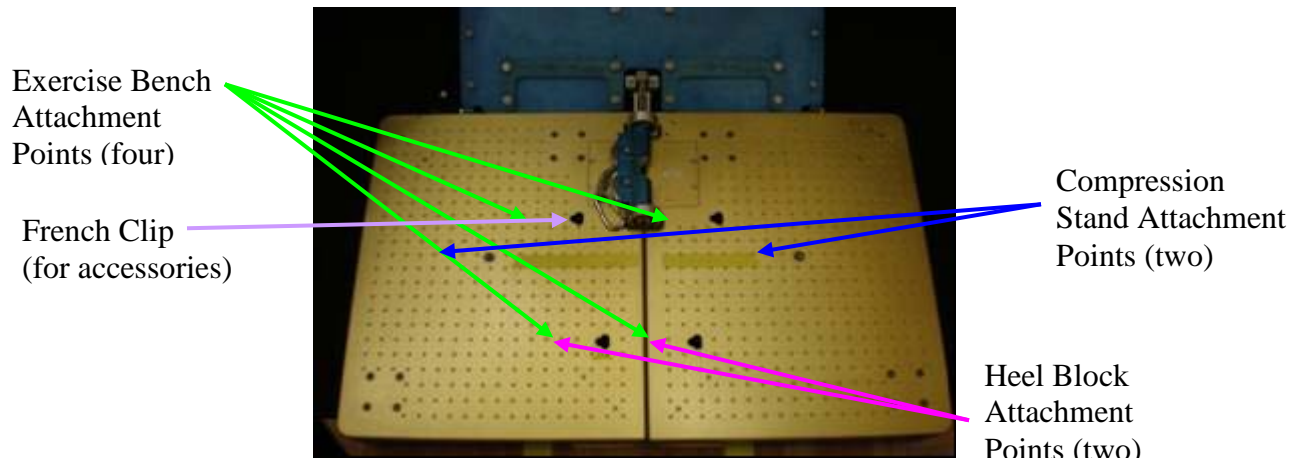




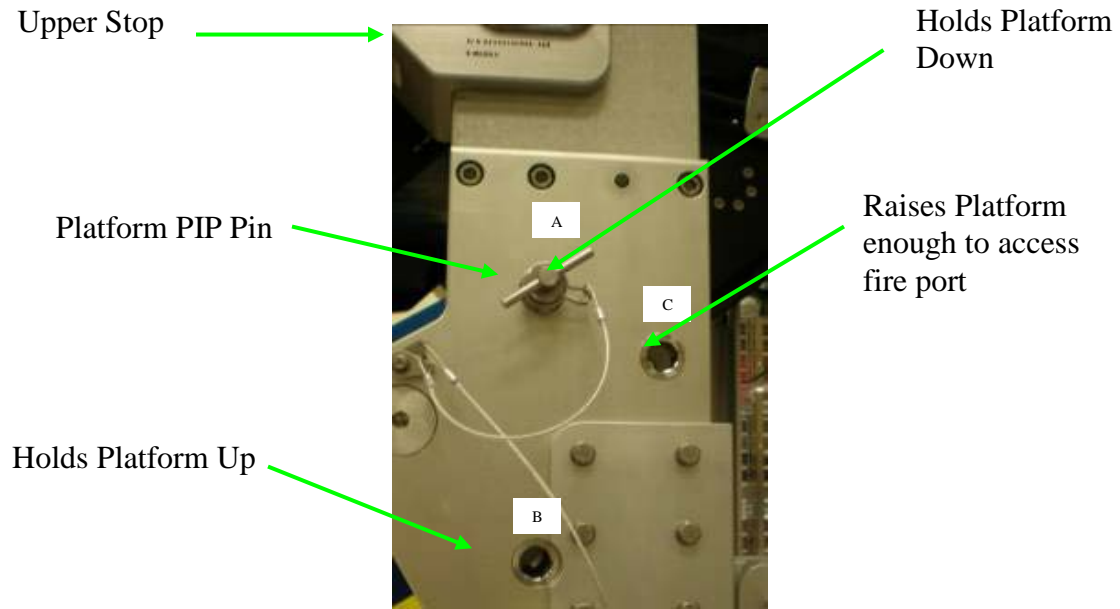
**Figure 8. Lift Bar and Lift Bar Slide Tracks**

**2.1.2.6. Platform**

The Platform is located at Node 3 Zenith. It attaches to the Platform Arms which attach to the ARED Frame. If stowage or access to the fire port is needed, the Platform can be folded up and secured with the Platform PIP Pins (one per side). Platform PIP Pins lock into one of three possible positions labeled A, B, and C. The Exercise Rope comes through the Platform to allow for exercises that require the Ankle Cuffs, Handle, or 26” Weight Bar that are attached with a French Clip. The Heel Block and Exercise Bench can also attach to the Platform.



**Figure 9. Platform**

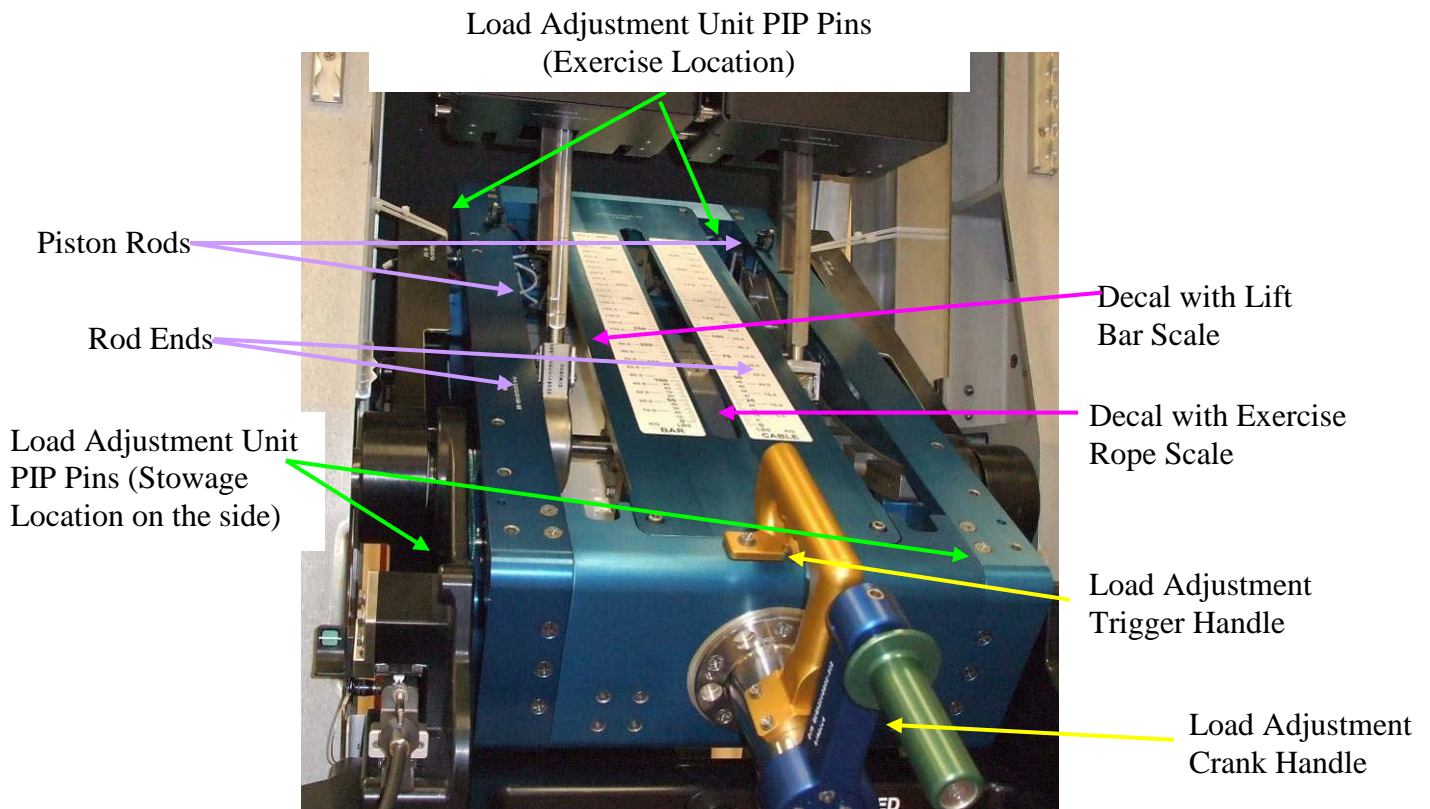


**Figure 10. Platform PIP Pin Locations**



### 2.1.2.7. Load Adjustment Unit

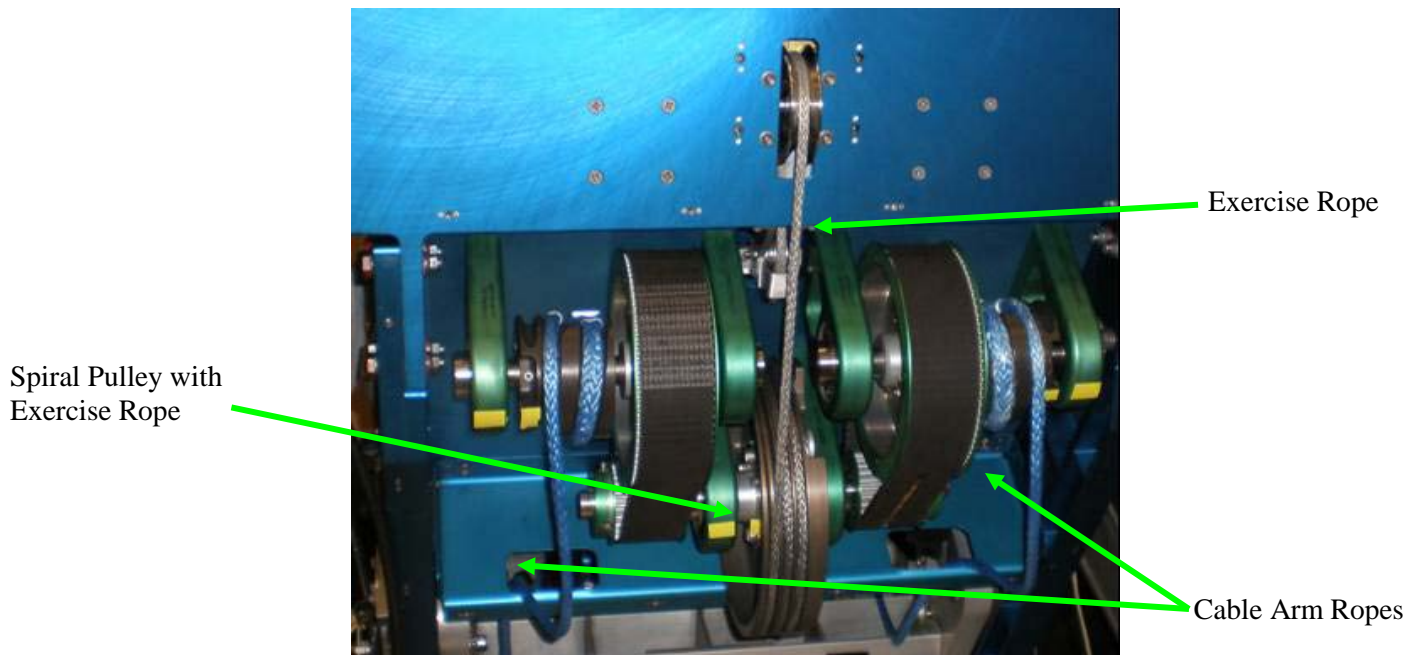
The Rod Ends on the Load Adjustment Unit attach to the Pistons on the Cylinder Flywheels. The Load Adjustment Trigger Handle and Crank Handle are attached to the front of the Load Adjustment Unit. The load is adjusted by squeezing the Trigger Handle and depressing the Crank Handle as it is turned. A decal is used for the load scale.



**Figure 11. Load Adjustment Unit**

### 2.1.2.8. Belt Pulley

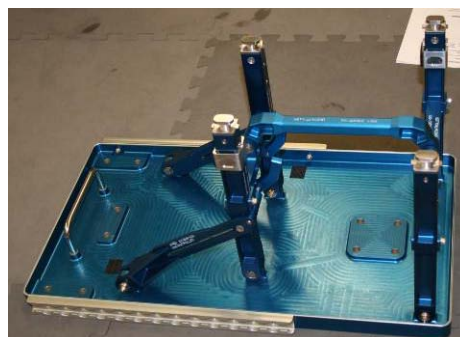
The Belt Pulley is mounted on the bottom of ARED Between the Frame and the Platform. It attaches to the Platform Arms. Cable Arms are located on the sides of the ARED Frame next to the Load Adjustment Unit. They transfer the load to the Cable Arm Ropes (one per side) which attach to the Belt Pulley. The Belt Pulley then transfers the load to the Exercise Rope which can provide a maximum of 150 lbs. The Exercise Rope is replaced every 31,500 cycles while the Cable Arm Ropes are replaced every 69,306 cycles.



**Figure 12. Belt Pulley**

#### **2.1.2.9. Exercise Bench**

The Exercise Bench supports the crewmember's back during certain exercises. The handle underneath is pulled and causes the legs to unfold and lock in place. There are four holes in the Platform for the Exercise Bench. Crew members place the legs of the Bench in these holes, slide to the left, and then use collars located on two legs to lock it into place. A cushion with an Exercise Bench Cover provides comfort for crewmembers when using the Bench and the cover is replaced as needed.



**Figure 13. Exercise Bench**

**2.1.2.10 Heel Block**

The Heel Block is used to provide the extra height needed when performing heel raise exercises. It mounts to the Platform through two holes.



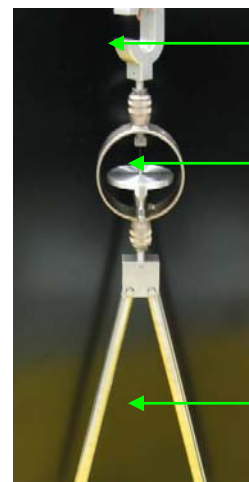
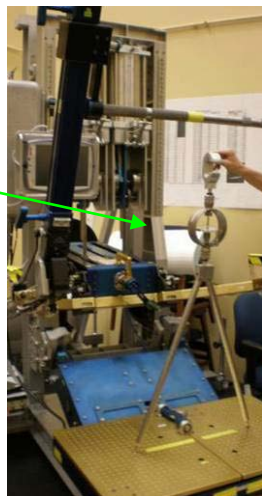
**Figure 14. Heel Block**

**2.1.2.11. ARED Calibration Tools**

The ARED Calibration Tools calibrate the load cells and position sensors (not the actual load).

When calibrating the load cells in compression, the C Hook, Proving Ring, and Compression Stand are used. The Compression Stand attaches to the top side of the Platform in designated holes, the Proving Ring attaches to the compression stand, and the C Hook attaches to the Proving Ring and the Lift Bar.

Calibration tool attached to platform for compression



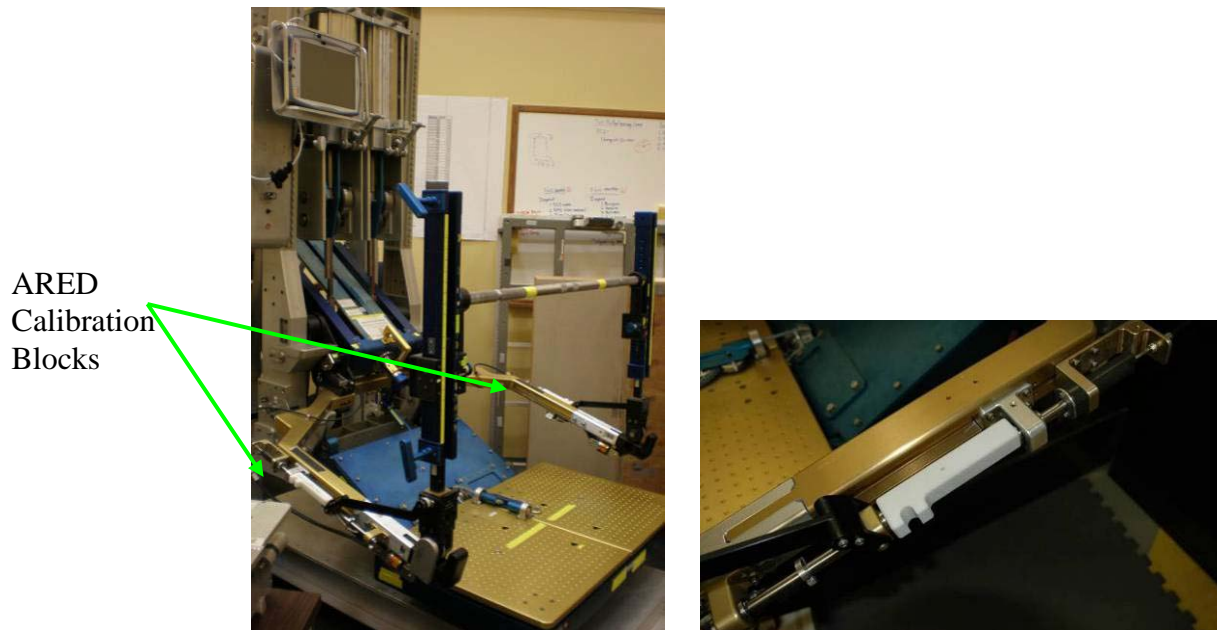
C Hook

Proving Ring

Compression Stand

**Figure 15. ARED Calibration Tool Installed for Compression Load Cells**

Calibration of the Rotational Sensors only requires the ARED Calibration Blocks which rest on the Main Arm and stay in place using magnets.



**Figure 16. ARED Calibration Block Installed on Main Arm for Rotational Sensors**

During calibration of the load cells in tension, the Tension Bracket, C Hook, Proving Ring, and Rope Eye Connector are used. The Tension Bracket mounts to the bottom side of the Platform, the C Hook attaches to the Tension Bracket, the Proving Ring attaches to the C Hook, the Rope Eye Connector attaches to the Proving Ring and the French Clip on the Exercise Rope.



**Figure 17. ARED Calibration Tool Installed for Tension Load Cells**

During the calibration process, a software program on the ARED Display guides the crew in the execution of the calibration procedure. Calibration is performed once per year.

### ***2.1.3. ARED Instrumentation System***

To utilize ARED’s software as a crew interface, the crew uses a Tablet PC referred to as the ARED Display. A Multi-Use Bracket attaches the ARED Display to the Frame. Prescriptions are sent to the ISS LAN via S-Band/KU-Band. A wireless signal transmits the prescription to the ARED Display. The Display must be powered on and the Flight Software must be closed in order to upload new protocols. Crewmembers select the icon with their picture and enter their PIN number keeping the system secure.

The next available exercise protocol will open and they can begin exercising. Russian crew members do not have protocols available on the Display, thus they use the deviate function each time for exercise.

Once the crewmember selects start, the software will count the number of actual sets, repetitions and loads.

The software only counts a repetition if it is performed correctly. Information regarding the actual load is sent to the ARED Display through the Instrumentation Box which obtains the data from load cells and rotational sensors on ARED. After each set, they select stop before moving on to the next type of exercise. A graph is available to aid the user in proper technique, and an exercise guide is also available to help provide instructions for a particular exercise.

Crewmembers may also choose to add exercises to their prescriptions by using the deviate function. A menu is available for them to select the additional exercise. Once they are done with their session and log off, the software stores all the data generated for that session. It is then transmitted back through the wireless network to the ISS LAN for download to the ground. The software parameters are available in both metric and English. The ARED Display also has the software for calibrating the system.

Several Error Codes are associated with ARED Data Acquisition system and are summarized in the ARED DAQ Error Codes document on SharePoint. The most common error codes (5360, 5361) are a result of a lack of communication between the Display and DAQs, and can be caused by a bad connection at the Display Dongle.

Power from station is provided through an A31p 120VDC Power Supply connected to a Junction Box, which is connected to a standard Utility Outlet Panel (UOP4) in Node 3. Power is fed to ARED via the ARED Main Power Cable and the ARED Capacitor Cable. These two cables connect the power supply to the Instrumentation Box. Any time ARED is required to be powered down the crew should follow this power down sequence:

ARED Display → ARED Instrumentation Box → Power Supply → Wait one minute and power on in reverse order.

ARED utilizes seven cables (ARED Capacitor Cable, ARED Main Power Cable, Main Arm to Instrumentation Box Cable, Arm Base to Instrumentation Box Cable, Platform to Instrumentation Box Cable, ARED Display Cable, and US DC Power Cable).



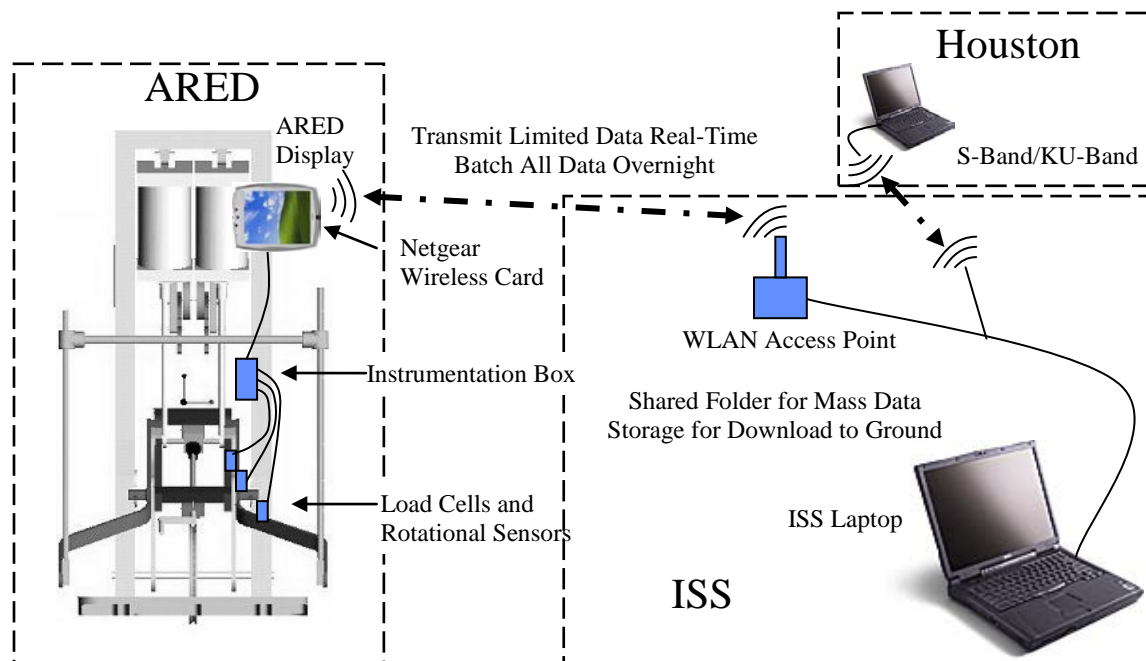


Figure 23. ARED Instrumentation System

2.1.3.1. File Types on the ISS Network

ARED exercise data can be saved to three different locations on the ISS Network. After an exercise session, the data is saved directly onto the ARED Display, which is the primary method of data storage/transfer. The data is also transmitted from the ARED Display through the wireless network to the ARED File Server on the ISS LAN. Alternative to saving to the Display, the crew can also enter their exercise data into a spreadsheet on the MEC. All of this data can be downlinked to the ground with the following file extensions and from the following locations on the ISS Network:

Activity	File Extension	Location
ARED Display	*.*	\\XXX.XXX.XX.165\ARED\Data\ \\XXX.XXX.XX.165\ARED\Logs\ \\XXX.XXX.XX.165\ARED\Summary\
ARED File Server	*.*	T:\ARED\
ARED Spreadsheet	*.xls	M:\Documents and Settings\All Users\Desktop\ M:\Documents and Settings\MEC\Desktop

There are three files created for each exercise session associated with ARED. **Data** files provide info on the sensor data. **Log** files contain information of when summary and data files were created, as well as, a record of DAQ errors experienced. **Summary** files provide actual exercise data including the exercise, set, and actual and prescribed reps and loads.

#### ***2.1.4. Maintenance***

- Cylinder Flywheel Evacuation – 15 min, 1 crewmember , every week
- VIS Rail Inspection – 15 min, 1 crewmember, every 2 weeks
- VIS Rail Greasing – Alternates between 60 min and 75 min, 1 crewmember, every 2 months
- Exercise Rope Replacement – 75 min (35 min), 2 crewmembers, every 31,500 cycles (approx every 3+ months).
- Cable Arm Rope Replacement – 60 min, 1 crewmember, every 69,306 cycles (approx 6+ months)
- Sensor Calibration – 75 min, 2 crewmembers, yearly

NOTE: Rheolube is the lubrication used for all greasing activities. Braycote is **only** used when the detents need greasing (crew discretion).

#### ***2.1.5. Resupply Schedule***

New Exercise Ropes and Cable Arm Ropes are flown up regularly based on crew rotation and ARED cycle counts. X-Rotation Dashpots, Exercise Bench Buckles, Upper Stop Cables and Exercise Bench Covers are flown periodically on an as-needed basis.

#### ***2.1.6. Hazard Concern***

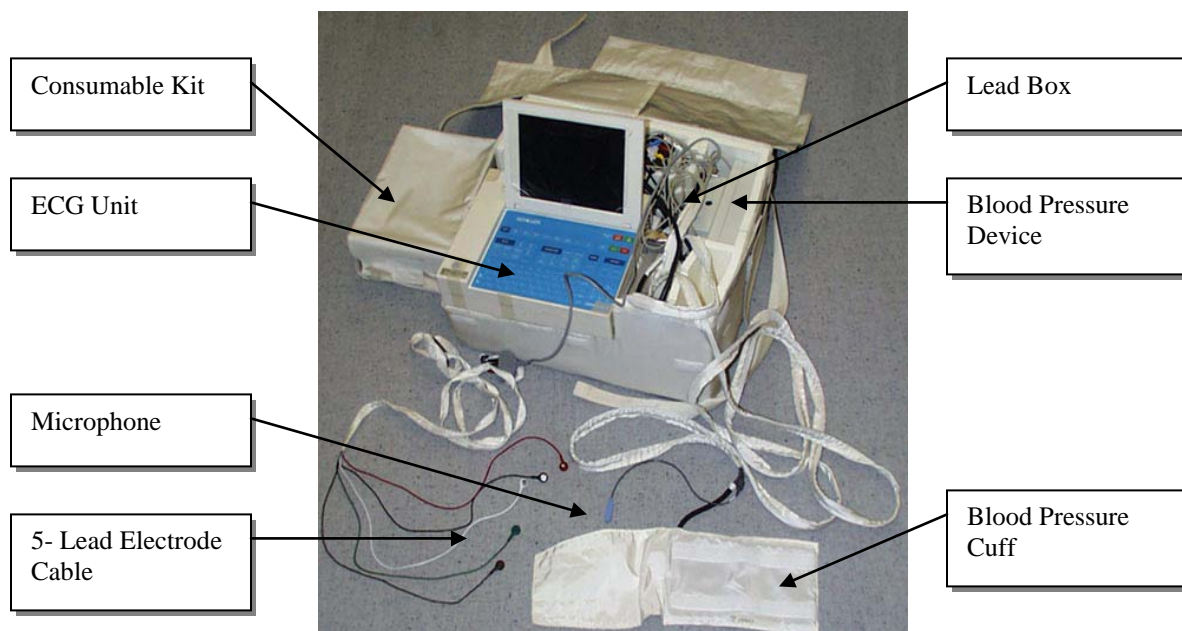
Reference: Risk Assessment Executive Summary Report for the Advanced Resistive Exercise Device (ARED) (JSC 29739).

## 2.2. Blood Pressure/ Electrocardiograph (BP/ECG) (modified COTS)

### 2.2.1. BP/ECG Description

The BP/ECG Monitor provides the capability for automated, auscultative, noninvasive systolic and diastolic blood pressure measurements and the capability to monitor and display accurate heart rates/ECG waveforms on a continual basis during the performance of exercise countermeasures on orbit. The BP/ECG Monitor is used during the periodic fitness evaluations, for contingency purposes for health status evaluations, and by the Human Research Facility to support scientific experiments on cardiovascular physiology.

The ECG unit was modified for the capability to run at either 120VDC at 1 Amp or 28VDC at 3 Amps. In addition, the ECG unit and the Blood Pressure device were both modified, allowing the ECG unit to power the Blood Pressure device.



**Figure 1. BP/ECG**

### 2.2.2. BP/ECG Assembly Contents List and Component Description

- ECG unit
- Blood Pressure Device
- Lead Box
- Consumable Kit (Contents are consumables)
  - a. 20 (6x6) Ziploc bags inside 1 (10x10) Ziploc bag
  - b. 1 (10x10) Ziploc bag for trash
  - c. 1 (10x10) Ziploc with Printer paper
  - d. 1 (6x6) Ziploc with three 1 Amp fuses
  - e. 1 (6x6) Ziploc with three 3 Amp fuses
  - f. 1 (6x6) Ziploc with three Microphones



**Table 2.2.2-1 General Hardware Specifications**

Kit and Component List	Mass M(E)	Volume M(E)	Dimensions M(E)	Nominal Stowage Location	Storage Temp °C (°F)	Operating Temp °C (°F)	Operating Pressure mmHg (psia)
BP/ECG Kit	13.6 kg (30 lbs)	0.046 m <sup>3</sup> (1.62 ft <sup>3</sup> )	49.5 cm x 41.9 cm x 22.1 cm (19.5" x 16.5" x 8.7")	LAB105_G1	-31-52°C (-25-125 °F)	10-40° C (50-104 °F)	13.5 - 15.2 psia
Consumable Kit	6.8 kg (15.0 lbs)	8009.2 cm <sup>3</sup> (488.8 in <sup>3</sup> )	29.2 cm x 12.7 cm x 21.6 cm (11.5" x 5.0" x 8.5")	Inside BP/ECG Kit	N/A	N/A	N/A

**2.2.2.1. ECG Unit**

The ECG unit measures and displays ECG and heart rate of subject, and contains an integral printer (Cardiovit AT-10 manufactured by Schiller) not nominally used.



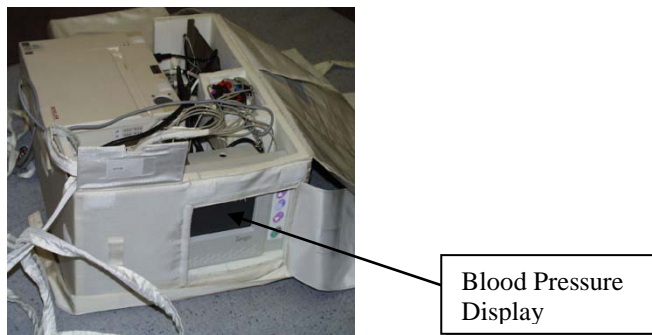
**Figure 2. ECG Unit**

**Table 2.2.2.1-1 Hardware-Specific Parameters**

Power Requirements	24VDC. Unit can be used in the Russian Segments as well as the U.S. Segments. It will convert 120 VDC from the U.S. power source to 28 VDC using DC-to-DC converters. The 28 VDC from the DC-to-DC converter or from the Russian Service Module is converted to 24 VDC using another DC-to-DC converter. <b>Power cable is 20 feet in length.</b>
Power Source	ISS electrical power systems (CHeCS UOP) via primary power cable.
Sampling Frequency	4 kHz
Digital Resolution	2.5 uV
Dynamic Range	± 16 mV
Maximum Electrode Potential	± 300 mV
Frequency Response	0 to 350 Hz (-3 dB)
Common Mode Rejection	>100 dB/50 or 60 Hz
Input Impedance	>100 M ohm
Patient Input	Fully floating & isolated, defibrillator protected
Patient Leakage Current	<5 uA
Protection Class	1
Relative Humidity	25 - 95% (non-condensing)

**2.2.2.2. Blood Pressure Device**

Tango Stress BP device measures and displays subject’s systolic and diastolic blood pressure at preset intervals or manually by the operator (Manufactured by SunTech Medical Instruments). The BP device operates in one of two modes: automatic or manual. The automatic mode records readings at regular intervals between 1 and 9 minutes. The manual mode measures at any desired time. For nominal Periodic Fitness Evaluation operations, manual mode will be used. The BP cuff was labeled to aid the crew in proper donning of the cuff.



**Figure 3. Blood Pressure Unit**



**Figure 4. Outside and Inside Label on BP Cuff**

**Table 2.2.2.2-1 Hardware-Specific Parameters**

Power Requirements	10 VDC
Power Source	Receives power from the ECG unit via a secondary power cable that is hardwired to the EASI lead box.
Fluid/Gas Description	N/A
Measurement Range	0 - 300 mm Hg ± 3 mmHg or ± 2 % of full scale for blood pressure
Heart Rate	0 - 240 ± 2 BPM
Pressure Cuff Limit	<310 mmHg; time duration <180 sec.

### 2.2.2.3. Lead Box

EASI Lead Box - Dower Box – Derives a 12 lead ECG from 5 patient electrodes (Manufactured by Zymed). Ten (10) alligator clips, each labeled on top with their corresponding location, are attached to the Lead Box.



**Figure 5. Lead Box with Alligator Clips**

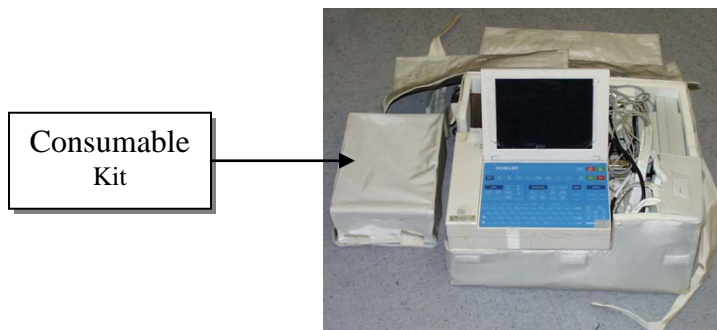
**Table 2.2.2.3-1 Hardware-Specific Parameters**

Power Requirements	9 VDC (initially 12 VDC regulated to 9 VDC)
Power Source	Receives power via a secondary power cable from ECG unit (cable is hardwired to the EASI lead box).
Frequency Response	>0 – 10 kHz
Input Dynamic Range	>=500 mV
Gain Error	<2%
Gain Stability	Better than 1% per hour
Input Impedance	20 M ohms
Direct current to patient – electrodes	0.2 uA
Noise	<10 uV p-p

### 2.2.2.4. Consumable Kit

The Consumable Kit contains supplies needed to measure ECG, HR, and blood pressure. Inside is a 10 x 10 Ziploc Bag with 20 (6 x 6) Ziploc Bags (also called BP/ECG Subpacks), and another 10 x 10 bag designated for trash. Each 6 x 6 Ziploc bag (BP/ECG Subpack) contains:

- 1 razor
- 5 Ag/AgCl foam electrodes
- 4 Benzalkonium Chloride pads (BK wipes)
- 1 adhesive tape remover pad
- 2 gauzes
- 1 microphone pad



**Figure 6. BP/ECG and Consumable Kit**

### ***2.2.3. Hardware Interfaces with Vehicle***

- Interfaces with an ISS electrical power system (CHeCS RPCs) via a primary power cable, either 28V or 120V
- Attaches to rack via a seat track adapter

### ***2.2.4. Resupply Schedule***

The BP/ECG unit is resupplied every three years. Approximately every 6 months, the Consumable Kit will be resupplied. Subpacks can fly outside of the Consumable Kit and will be manifested on an as needed basis. There is no routine maintenance scheduled.

### ***2.2.5. Data/Commanding Capabilities***

The data obtained by the BP/ECG is transferred via an RS-232 cable and stored onto the MEC using the Early Generalized Data Handling (EGDH) software (see Section 2.5.5.1 for file extensions and locations on the MEC). This software allows data from 8 of the 12 leads to be stored on the MEC. This data can be downlinked to the ground through file transfers, or via extended data dumps (8-lead data) or normal data dumps real-time (3 pre-defined lead data). The remaining leads are calculated on the ground to provide the 12-lead capability. The subject or operator commands the BP/ECG unit to begin measuring and recording data through the ECG unit keyboard. Once data has been obtained by the BP/ECG and transferred to the MEC, it is then downlinked to the ground. Data acquisition by the MEC is verified by the crewmember by ensuring the status window indicates “Acquiring medical data.” If the status window indicates “Data acquisition not active,” a cable connection or software setting is not correct and should be checked.

### ***2.2.6. Hazard Concerns***

Sharp razor in resupply kit  
Refer to safety hazard analysis

## 2.3. Cycle Ergometer with Vibration Isolation & Stabilization (CEVIS)

### 2.3.1. CEVIS Description

CEVIS provides aerobic and cardiovascular conditioning through cycling activities. CEVIS can be used for either leg or arm ergometry. The Handle Crank and Pedal Crank assemblies are attached with identical interfaces and can be changed out by a crewmember during an exercise session.

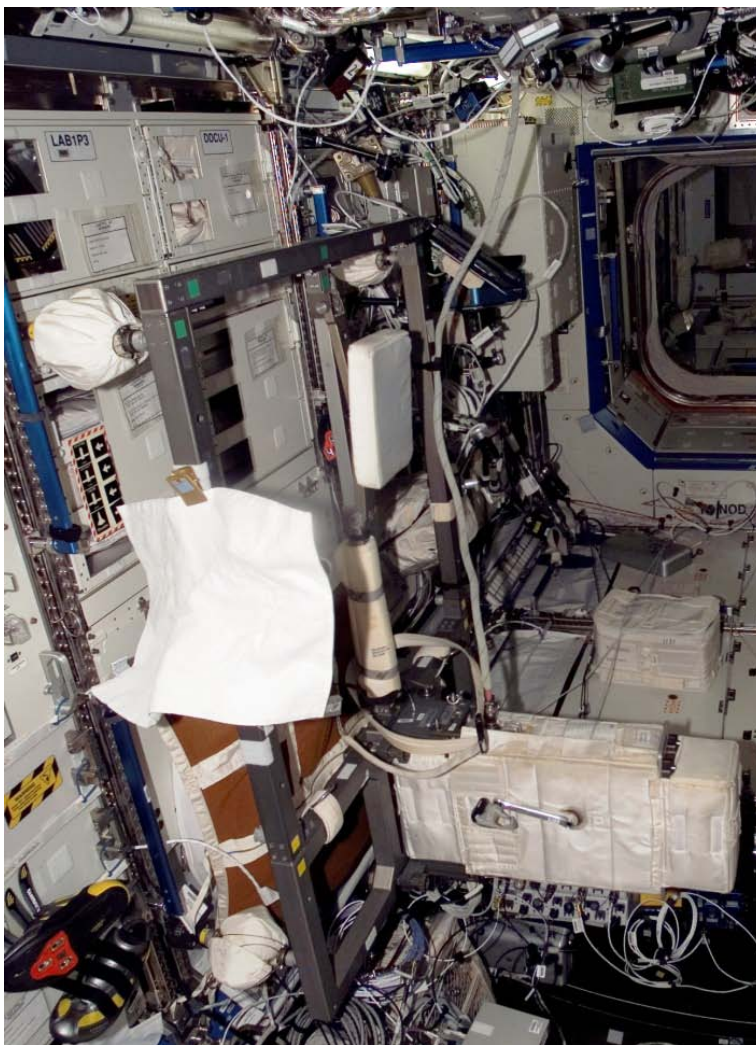


Figure 1. CEVIS side view (left)

### 2.3.2. CEVIS Control Panel

- Windows XP based.
- Takes approximately 5 minutes to power up.
- Upon completion of exercise, the Control Panel takes approximately one minute to finish writing the data to the PCMCIA card; the Crew should not shutdown the Control Panel until after the data has been saved.
- Must be powered down using the shutdown method; if the Control Panel is not shut down, the operating system could be damaged.



- To swap out PCMCIA cards between exercise sessions, the Control Panel should be the nominal 'ISS Ergometer' screen as in Figure 2. Once a card is removed, Figure 3 will appear. The crew should simply insert the next PCMCIA card without touching either the 'Yes' or 'No' buttons. The 'No storage media...found' screen will go away when the next card is inserted.



ISS018E043439

Figure 2. CEVIS Control Panel



Figure 3. 'No storage media... found' screen

**2.3.3. Component List and Specifications**

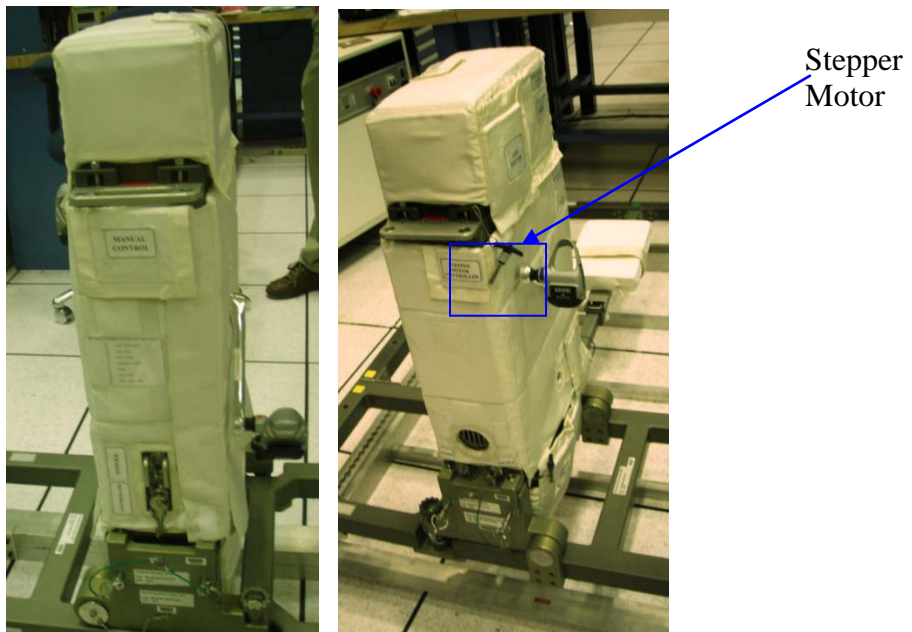
- CEVIS Ergometer
- Red IVIS Box
- Blue IVIS Box
- On-Orbit Mounting Frame
- Seat Cushion
- Isolator Kit Assembly
  - a. Four 4” isolators
  - b. Four 6” isolators
- CEVIS Accessory Kit (\* indicates item is installed)
  - a. Power Cable Assembly\*
  - b. CEVIS Display Cable\*
  - c. Seat Track Interface Adapter Assys (four\*)
  - d. CEVIS Control Panel\*
  - e. Left/Right Pedal Crank Assy\*
  - f. Manual Control Knob
  - g. Hardmount Stud Assy (six)
  - h. Pedal Wrench Assy
  - i. Left/Right Handle Assy
  - j. Push Rod Assembly
  - k. Capture Bracket Assy
  - l. CEVIS Contingency Controller
- CEVIS Resupply Kit
  - a. CEVIS PCMCIA Cards (4-6)

**Table 2.3.3-1 General Component Specifications**

<b>Kit and Component List</b>	<b>Mass M(E)</b>	<b>Volume M(E)</b>	<b>Dimensions M(E)</b>	<b>Nominal Stowage Location</b>	<b>Storage Temp °C (°F)</b>	<b>Operating Temp °C (°F)</b>	<b>Operating Pressure mmHg (psia)</b>
CEVIS Assembly	179 lbs (81.19 kg)	Approx. 2.97 ft <sup>3</sup> (0.08 m <sup>3</sup> )	N/A	LAB1P3	0-49 °C (32-120 °F)	0-49 °C (32-120 °F)	13.5 - 15.2 psia
CEVIS Ergometer	65 lbs		16.7 in x 7.2 in x 23.0 in	LAB1P3			
IVIS Box, red	25.1 lbs		12 in x 6 in x 6 in	LAB1P3			
IVIS Box, blue	28.8 lbs		12 in x 6 in x 6 in	LAB1P3			
On-orbit Mounting Frame	100.0 lbs		47 in x 18 in x 22 in	LAB1P3			
Isolator Kit Assembly	12.0 lbs		18.8 in x 8 in x 12 in	crew preference			
CEVIS Accessory Kit	30.0 lbs		22 in x 14.5 in x 12 in	crew preference			
CEVIS Resupply Kit			6in x 6in Ziploc Bag with 4 PCMCIA Cards inside.	crew preference			
CEVIS Power Cable Assembly			19 feet long	LAB1P3			
CEVIS Display Cable			78.7 inches long	LAB1P3			

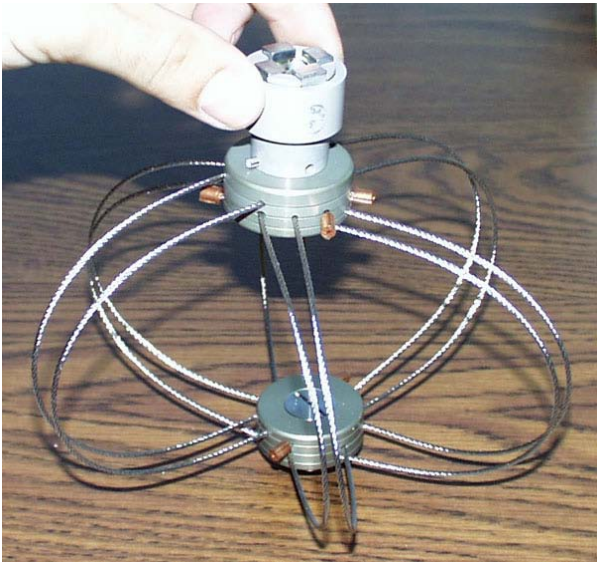
**Table 2.3.3-2 Hardware-Specific Parameters**

Power Requirements: Source	60 W: 120 VDC or 28 VDC
Measurement Parameters/ Capabilities	<ul style="list-style-type: none"> <li>• Not to exceed 60 W</li> <li>• Power Usage: 113 – 126 VDC</li> <li>• Display/Control use: 5 VDC and 12 VDC</li> <li>• Workload range: 25 – 350 Watts</li> <li>• Cycling Speeds Range: 30 – 120 rpm for manual controller 50 – 120 rpm for electronic controller</li> <li>• Sensor Error: <math>\pm 2\%</math></li> </ul>



**Figure 4. CEVIS Tower (front, back)**





**Figure 5-6. CEVIS Isolator Assembly (6" Shown)**



**Figure 7. CEVIS Isolator Kit**

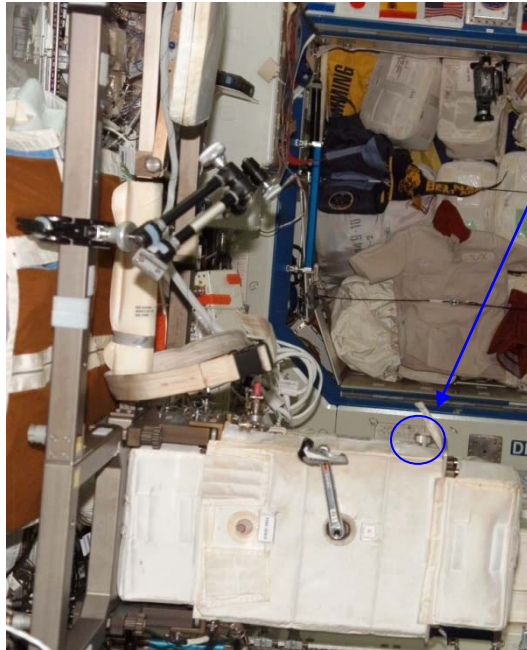


Figure 8. CEVIS Tower (front)

Manual Control Knob

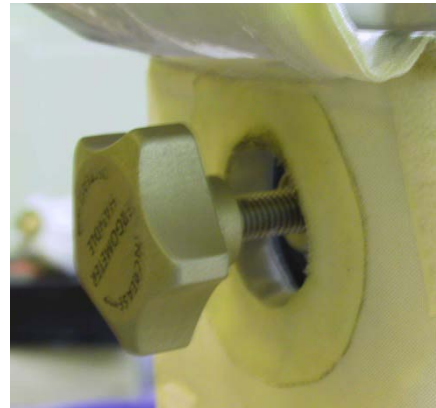


Figure 9. Manual Control Knob

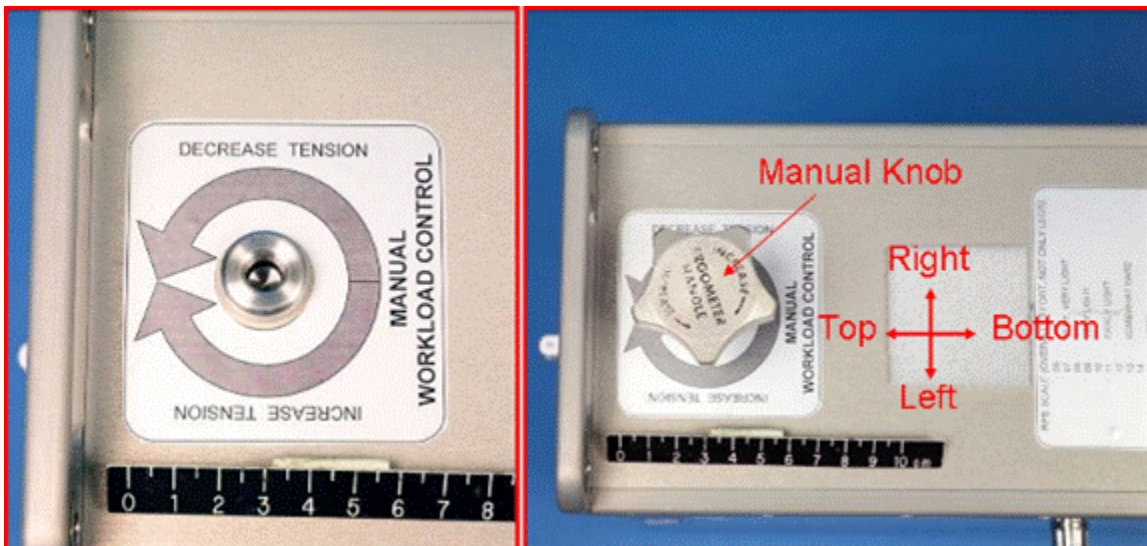
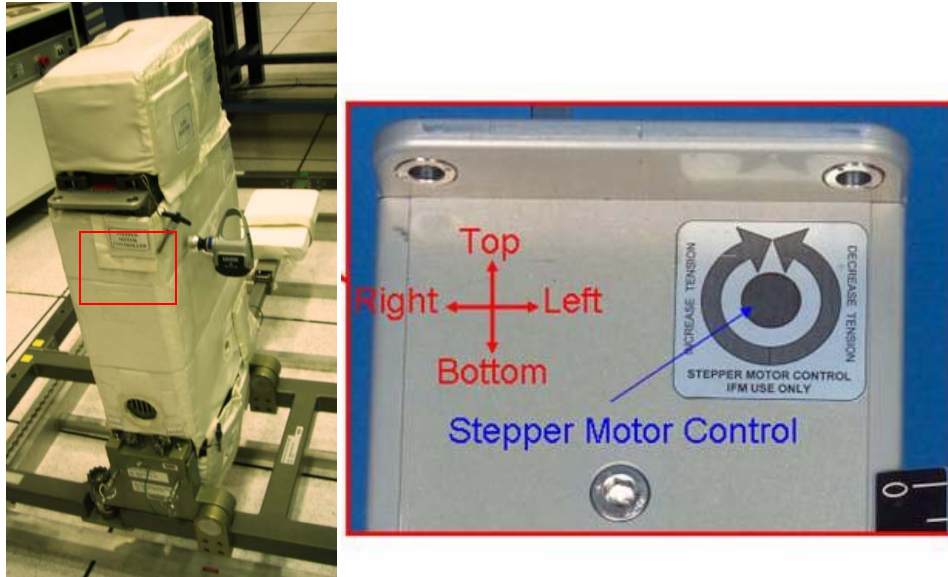


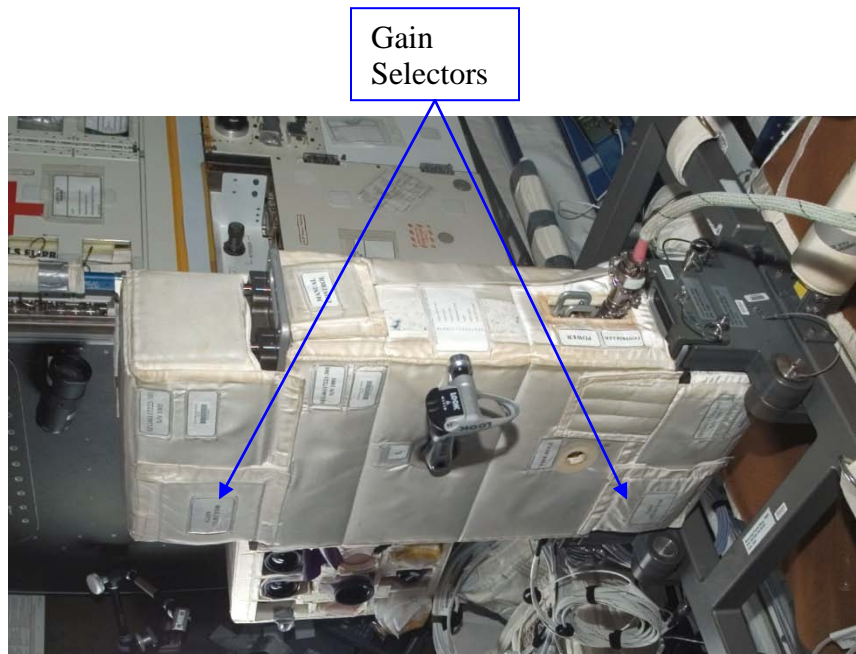
Figure 10. Manual Workload Control with Acoustic Cover removed



**Figure 11. Stepper motor**

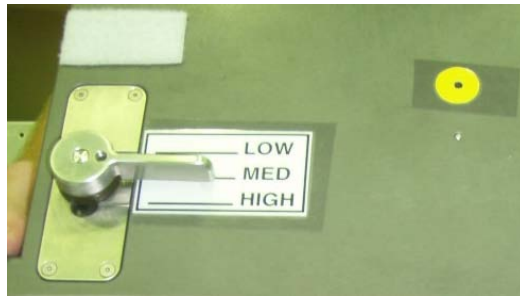


**Figure 12. Stepper Motor punctured**

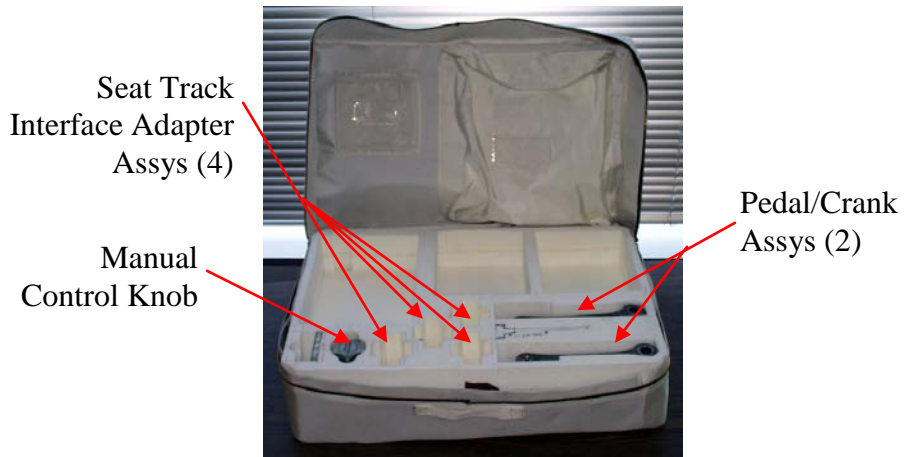


**Figure 13. Gain Selectors**

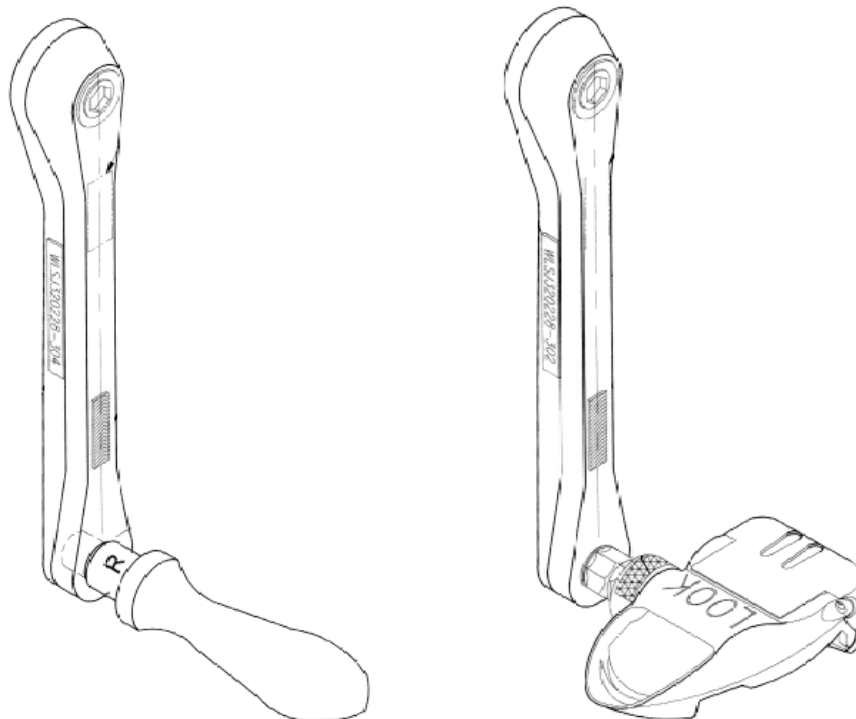




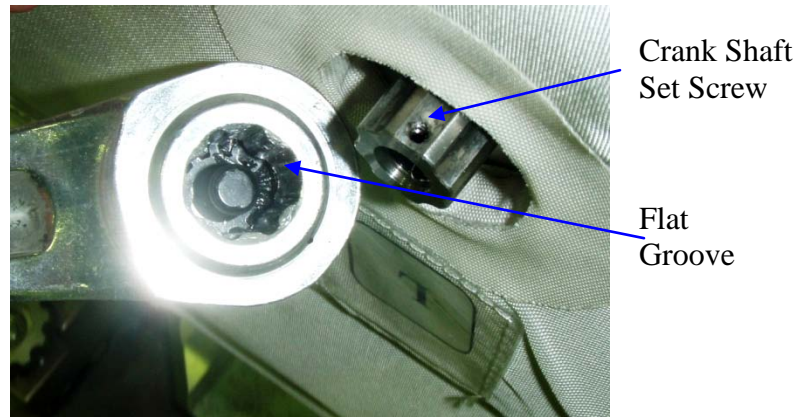
**Figure 14. Gain Selector (cover off)**



**Figure 15. CEVIS Accessory Kit**



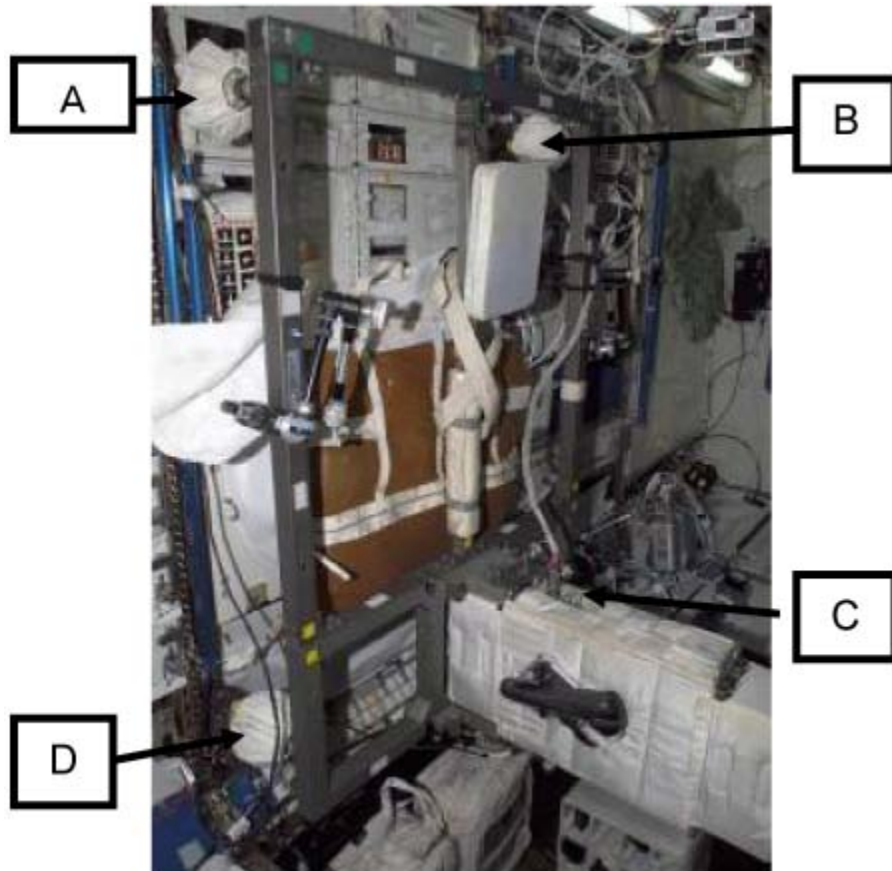
**Figure 16. Handle Crank and Pedal Crank Assemblies**



**Figure 17. Left Pedal Crank Installation**

**2.3.4. Hardware Interfaces with Vehicle**

CEVIS is mounted on the Mounting Frame, which is attached to seat tracks on an ISS rack via four isolators. There are two sizes of isolators. Either size can be installed per crew preference, however all four installed must be the same size to provide for even load distribution. Currently, CEVIS is located at LAB1P3 and the proper locations for the Seat Track Adapters are as follows: Top two (A & B) should be at the 10<sup>th</sup> seat track hole from the Overhead. Bottom two (C & D) should be at the 9<sup>th</sup> seat track hole from the Deck.



**Figure 18. CEVIS Isolator Reference**

Hardmounting the CEVIS is currently not certified for nominal exercise due to structural concerns. Hardmounts can be used for Exercise prebreathe if the crewmember feels CEVIS is too unstable. The Hard Mount Stud Assemblies (six) should be used in place of the Isolators and Seat Track Interface Adapters.



**Figure 19. Hard Mount Stud Assembly**

### ***2.3.5. Resupply Schedule***

The CEVIS Resupply Kit (4-6 PCMCIA Cards) is resupplied via Shuttle.

### ***2.3.6. Data/Commanding Capabilities***

Data is downlinked through the MEC (see Section 2.5.5.1 for file extensions and locations on the MEC).

1. Exercise sessions and protocols stored on PCMCIA cards.
2. Control panel can display:
  - Cycling speed
  - Deviation from target speed
  - Elapsed Time
  - Target Workload
  - Actual Workload
  - Target heart rate
  - Actual heart rate

All commanding is performed by the crew on-board (no ground-commanding capabilities):

1. Protocol - personal exercise protocol stored on PCMCIA cards and inserted into control panel
2. Online - manual or electronic workload selection and target speed (rpm) via control panel.
3. External device - Manual Control Knob or the Stepper Motor Controller can be used to adjust CEVIS parameters in contingencies.

4. Gain Selector – one on both IVIS boxes (both on left side of Tower) changes the distance of the throw mass movement inside the boxes. Normally set to Medium, but can be moved to Low or High to aid in achieving stability in CEVIS movement.

**2.3.7. Hazard Concerns**

Reference “CEVIS Phase II Safety Review” data packages.

**2.3.8. CEVIS Contingency Controller (CCC)**

During Expedition 6, the CEVIS Display/Control Panel failed. On 15P, a CEVIS Contingency Controller was flown. The CEVIS Contingency Controller is kept onboard in case of CEVIS Display/Control Panel failure.

The CCC has no data collection capabilities. Prescriptions must be relayed to crewmember, and the heart rate watch must be worn and downloaded weekly to provide data for the ground to monitor.

The CCC uses the same Ergometer Display Cable Assy as the Control Panel, and uses power provided by the Ergometer. The crewmember can control their workload by dialing in a voltage, viewed on the top LCD, between 0 – 8V which corresponds linearly to 0 – 350W. A reference card is velcroed to the back of the CCC to aid in workload to voltage and speed (rpm) to voltage conversions. (0.1V corresponds to 4.375W, 0.1V corresponds to 15rpm)

The crewmember can view their speed in rpm in the lower left LCD, and the torque which the Ergometer is providing is displayed on the lower right LCD. A speed is recommended by the ground, but the torque is of no value unless the ground decides troubleshooting of the unit needs to occur in the event of a contingency.

The CCC has a camera mount affixed to the back to allow for easy deployment with a Multi-Use Bracket (Bogen arm).



**Figure 20. CEVIS Contingency Controller and reference Card**



**Figure 21. CEVIS Contingency Controller Installed On-Orbit**



## 2.4. Heart Rate Monitor 2 (HRM2) (COTS and modified COTS)

### 2.4.1. HRM2 Description

The HRM2 provides heart rate monitoring capability and exercise level control during exercise activities. A watch, transmitter, and chest strap are assigned to each crewmember. The watch is COTS hardware and the transmitter is modified COTS. An RF Transmitter board was put inside the transmitter in order for heart rate to be transmitted to the TVIS, CEVIS, and T2 receiver boards.



Figure 1. Heart Rate Monitor Kit

### 2.4.2. Component List and Description

- Heart Rate Monitor Kit contains:
  - A. HRM Resupply Kit which contains:
    - i. HRM Component Kit (-301; quantity 4) contains:
      - i. HRM Watch
      - ii. HRM Transmitter
      - iii. HRM Chest Strap



Figure 2. HRM Component Kit (-301)

- B. HRM Component Kit (-302; quantity 1) contains:

- i. HRM/MEC Interface Device (2)
  - ii. HRM Transmitter Battery Kit (1 kit containing 4 batteries; Battery P/N CR2025)
- HRM Component Kit (-303)
    - i. Contains 4 HRM Chest Straps (this kit can fly on its own and is not nominally part of the Heart Rate Monitor Kit)

**Table 2.4.2-1 General Component Specifications**

Kit and Component List	Mass M(E)	Volume M(E)	Dimensions M(E)	Nominal Stowage Location	Storage Temp °C (°F)	Operating Temp °C (°F)	Operating Pressure mmHg (psia)
HRM Kit	1.15 kg (2.53 lbs)	7306.2 cm <sup>3</sup> (444.4 in <sup>3</sup> )	32.8 x 16.5 x 13.5 (cm) (12.9" x 6.5" x 5.3")	LAB1P3_D2	0-50°C (32-122 °F)	0-50° C (32-122 °F)	13.5 - 15.2 psia
HRM Resupply Kit	0.64 kg (1.42 lbs)	126 in <sup>3</sup>	15.2 x 7.6 x 17.8 (cm) (3" x 6" x 7")	LAB1P3_D2			
HRM Component Kit (-301)	0.13 kg (0.28 lbs)		15.2 x 3.8 x 15.2 (cm) (6.0" x 1.5" x 6.0")	LAB1P3_D2			
HRM Component Kit (-302)	0.18 kg (0.40lbs)		15.2 x 3.8 x 20.3 (cm) (6.0" x 1.5" x 8.0")	LAB1P3_D2			
HRM Component Kit (-303)	0.16 kg (0.35 lbs)		15.2 x 3.8 x 15.2 (cm) (6.0" x 1.5" x 6.0")	LAB1P3_D2			
Heart Rate Watch			5.4" X 1.8"	Crew preference			
Chest Strap			45" long x 1.1" high (Fully extended)	Crew preference			
Transmitter			2.5" x 1.5"	Crew preference			
HRM/MEC Interface Device			4.7" x 1.8" x 1.4" RS232 Cable: 48" Long	LAB1P3_D2			

**Table 2.4.2-2 Hardware-Specific Parameters**

Power Source	Battery only: Watch – 3V Lithium-Manganese Dioxide battery (CR2430) Transmitter – 3V Lithium-Manganese Dioxide battery (CR2025) HRM/MEC Interface Device – Medical Equipment Computer (MEC) power
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**Figure 3. HRM/MEC Interface Device**



**Figure 4. HRM Chest Strap with HRM Transmitter and HRM Watch**

**2.4.3. Hardware Interfaces with Vehicle**

Hardware does not interface directly with the ISS vehicle; it interfaces directly with the crewmembers and the MEC.



**Figure 5. Correct Transmitter Placement**

#### **2.4.4. Resupply Schedule**

- HRM Resupply Kit is resupplied approximately every 12 months.
- The HRM/MEC Interface Device is resupplied as deemed necessary.
- HRM Transmitter batteries may be replaced on orbit per the maintenance procedure.
- HRM Watch will be returned to vendor for battery and seal replacement.
- Average battery life for both the HRM Watch and HRM Transmitter is one year.

#### **2.4.5. Data/Commanding Capabilities**

- HRM Watch displays heart rate, elapsed time, and time of day.
- Data is downloaded from the watch to MEC via HRM/MEC Interface Device (see Section 2.5.5.1 for file extensions and locations on the MEC).
- Records heart rate (HR) data at 5, 15, or 60 second intervals. The crewmember has the ability to change this rate when the watch is in recording mode (transmitter is not required). The watches are set to record at 5 second intervals before they are flown (this is the preference of surgeons and ASCRs; provides most data points with plenty of memory still available).
- The watches have their Options menu locked before they are flown (via the Polar software). They are set to BasicUse which means there are no heart rate limits, alarms, or timers set.
- HRM Watch can store approximately 99 data files, ranging from 42 hr 30 min to 99 hr 59 min (depending on heart rate interval)
- HRM watches have two time settings. Time1 will be set to GMT and Time2 will be set to Houston local time. Time1 will appear in the time of day screen.
- Transmitter transmits at a frequency of 5 KHz to the HRM Watch, and 868.35 MHz to the receivers in the TVIS, and CEVIS control panels and the T2 receiver which is mounted on the rack.
- Heart rate data is sent to HRM/MEC Interface Device via an infrared signal at a frequency of 5 KHz
- After data downlink, flight surgeons can review the data and diagnose the crewmember accordingly.
- Transmitter can be worn without watch to transmit data to CEVIS, TVIS, or T2 receiver boards.
- There are no commanding capabilities.

#### **2.4.6. Hazard Concerns**

Due to the length of the RS232 cable on the HRM/MEC Interface Device, the cord is considered a flammable hazard. The hazard is considered controlled by keeping the HRM/MEC Interface Device unstowed for less than 1 hour per day via the On-Orbit crew procedure “Heart Rate Monitor2 - Data Download to MEC”.

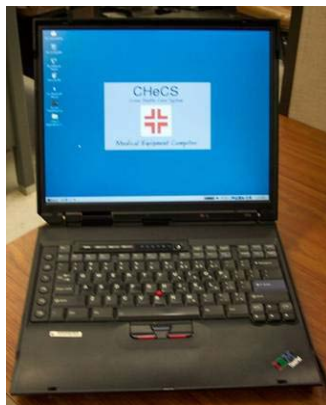
***Note:** Refer to JSC 63454 “Risk Assessment Executive Summary Report (RAESR) for the Crew Health Care System (CHeCS) Second Generation Heart Rate Monitor (HRM2)” for details on hazards. This can be found on the HRM2 project page under the documents section.*

## 2.5. Medical Equipment Computer (MEC)

### 2.5.1. MEC Description

The MEC is a standard IBM A31p Laptop with a customized Medical Operation Software load. The purpose of the MEC is to:

- Display physiological data from exercise devices
- Collect and store CHeCS data
- Maintain medical records
- Tool to assess crew health
- Provide uplink/downlink capability through the C&DH system or Ops Local Area Network (LAN)



**Figure 1. A31p MEC Laptop**

### 2.5.2. Component List and Description

The MEC Kit was originally flown for the 760 XD MEC. Certain components may be reused or kept on orbit for the A31p. The only A31p hardware flown by CHeCS is the Disk Image CD set located in the ISS CD Library.

The following 760XD components are deployed:

The MEC Kit (Ziploc bag) contains:

- 1553 Card/Cable
- RF LAN Card

The ISS CD Library contains the following MEC components:

- MEC Disk Image, version 19 (760XD Version)
- MEC Disk Image, version NGL 1.0 (7 CDs)
- MEC Disk Image, version NGL 2.0 (1 DVD)

**Table 2.5.2-1 General Component Specifications**

Kit and Component List	Mass M(E)	Volume M(E)	Dimensions M(E)	Nominal Stowage Location	Storage Temp °C (°F)	Operating Temp °C (°F)	Operating Pressure mmHg (psia)
A31p MEC	7.8 lbs	0.16 ft <sup>3</sup>	10.8" x 13" x 2"	Deployed LAB1D4	10 – 35° C (50 – 95 °F)	10 – 25° C (50 – 95 °F)	13.5 – 15.2 psia
MEC Kit			Ziploc	NOD1D4_K1	10 – 35° C (50 – 95 °F)		
MEC Software Kit				Inside MEC Kit	10 – 35° C (50 – 95 °F)		

**2.5.2.1. MEC Description**

**Table 2.5.2.1-1 Hardware-Specific Parameters**

Power Requirements	20 VDC, <40W
Power Source	<ul style="list-style-type: none"> <li>• 28 VDC or 120 VDC</li> <li>• Rechargeable Battery (Internal)</li> </ul>
Battery Description	9.6- volt Li-Ion

**2.5.2.2. MEC Software Description**

A Disk Image CD, which contains the MEC software load, is flown as part of the ISS CD library. When a new load is required onboard, the MEC will be reloaded with the latest software version. The MEC load contains the following individual CHeCS Applications:

- 1553 (allows for ground commanding)
- Audio Dosimeter
- Carbon Dioxide Monitor log (for contingencies)
- Compound Specific Analyzer – Combustion Products log (for contingencies)
- EarQ (Hearing Assessment)
- EGDH (Blood Pressure – Electrocardiogram) (for “store and forward” of data)
- Exercise Data Management (EDM)
- GDH (EGDH (Blood Pressure – Electrocardiogram)) (for real-time downlink)
- In-Flight Examination Program (IFEP)
- IV-CPDS
- Noise Explorer (Sound Level Meter log)
- Nutrition (questionnaire)
- Polar (Heart Rate Watch data log)
- TEPC (Tissue Equivalent Proportional Counter) log (for contingencies)
- TOCA (Total Organic Carbon Analyzer) log (for contingencies)
- TVIS Card Format Utility
- WinSCAT (Spaceflight Cognitive Assessment Tool for Windows)

**2.5.2.3. MEC Exercise IDs**

The Exercise Software allows the crew to select only the following Crew IDs: CDR, PLT, FE1, FE2, SS1, SS2, EV1, EV2, IV, R1, R2, CMO.

January 2010, Engineering approved OTL creating the exercise file and uplinking it with the following additions: FE3, FE4, FE5, FE6. This allows the correct crew id to be displayed when the crew downloads data in the Exercise Data Management Software. Any other programs using crew IDs are not affected by this update (Ex: TVIS Protocol Utility).

**2.5.3. Hardware Interfaces with Vehicle**

- RF LAN
- CHeCS PCR
- 1553 Card/Cable Assembly
- RS232 cable
- 3COM Network Card (hardware borrowed from CIO console)

**2.5.4. Resupply Schedule**

New software will be supplied when requests are made to update software applications.

**2.5.5. Data/Commanding Capabilities**

The MEC will transmit data via the Ops LAN or 1553.

Ops LAN:

The MEC can be connected to the Ops LAN with either a RF LAN card or a 3Comm card. The RF LAN card transmits information over the Ops LAN via radio frequency. It is inserted into the MEC just like a PC Card only with an antenna sticking out. The 3Comm card creates a hardline connection to the network.

1553 Ground Commanding:

The following commands are available from the ground via 1553:

- MEC Start Normal Data Dump
- MEC Start Extended Data Dump
- MEC Variable Field Command

**2.5.5.1. File Types on the ISS Network**

The following data can be downlinked from the MEC with the specified extensions and locations:

Activity	File Extension	Location
Acoustic SLM	*.nxp	M:\CHeCS\SLM\*.nxp
ARED Spreadsheet	*.xls	M:\Documents and Settings\All Users\Desktop\ M:\Documents and Settings\MEC\Desktop



Audio Dosimeter	*.xls	M:\CHeCS\Audio\*.xls M:\My Documents\*.xls
Audiogram/EarQ	*.*	M:\CHeCS\EarQ\folders\*.*
BP-ECG	*.dat	M:\CHeCS\egdh\*.dat
CDMK	*.csa	M:\CHeCS\CSA-CP\data\*.csa
CEVIS	*.*	M:\CHeCS\exer\cevis\cdr\*.* M:\CHeCS\exer\cevis\fe1\*.* M:\CHeCS\exer\cevis\fe2\*.*
CSA-CP	*.csa	M:\CHeCS\CSA-CP\data\*.csa
HRM	*.*	M:\Program Files\Polar\Polar Precision Performance\'\'Crewmember Name\'\'
IFEP	*.mde	M:\CHeCS\Ifep\IFEP_data.mde
IRED	*.dat	M:\CHeCS\exer\ired\cdr\*.dat M:\CHeCS\exer\ired\fe1\*.dat M:\CHeCS\exer\ired\fe2\*.dat
MicroBiology	*.mdb	M:\CHeCS\Micro\*.mdb
Nutrition FFQ	*.mdb	M:\CHeCS\Nutrition\*.mdb
TEPC	*.zip	M:\CHeCS\Tepc\in\data\*.zip M:\datadump\*.*
TVIS	*.raw *.txt	M:\CHeCS\exer\tvis\cdr\*.raw,*.*.txt M:\CHeCS\exer\tvis\fe1\*.raw,*.*.txt M:\CHeCS\exer\tvis\fe2\*.raw,*.*.txt
WinSCAT	*.*	M:\WScat\data\*.*

**2.5.6. Hazard Concerns**

None

*Note: Refer to Phase II Safety Data Package for details on hazard*

## 2.6. Resistive Exercise Device (RED)

### 2.6.1. RED Hard Mounted Description

The RED is designed to prevent atrophy of the major muscle groups and to minimize bone loss in the zero gravity environment by maintaining strength and endurance. The device provides eccentric and concentric contraction through a full range of motion of the following exercises: squats, deadlifts, hip extension, hip flexion, hip abductions, hip adductions, leg curls, heel raises, bent over rows, upright rows, shoulder raises, shoulder presses, bicep curls, tricep extensions, wrist curls, bench presses and sit ups. The RED is mounted on the RED Hardmount Adapter Plate Assembly in Node 1 until ULF2 stage when it will be taken down. It is still being decided if RED will be stowed or relocated as a contingency. If relocated, it will be mounted in Node 2's overhead radial port for Increment 18.

Components attach through the use of seat track adapters, long and short rods (four of each length) in tension and compression, alignment pins, and captive 3/16 inch Allen Head Cap Screw fasteners.

When not in use, the RED components will be stowed on the IRED Adapter Plate Assembly.



**Figure 1. RED Assembled in Wooden Node 1 Mock-up**

### 2.6.2. RED Components List and Description

- RED Assembly, Fore and Aft
- IRED Squat Support Assembly (2)
- IRED Adapter Plate Assembly
- RED Resupply Kit
  - a) Canister Maintenance Kit (5 pairs of cords )
  - b) Harness Maintenance Kit (4 individual harness cords)

- c) Harness Pads (3 right, 3 left)
- RED Accessory Kit
  - a) Squat Harness
  - b) Ankle Cuffs (2) (Shared with ARED)
  - c) Stabilized Hand Grips (2) (Shared with ARED)
  - d) Extender Straps
  - e) Safety Straps
  - f) French Clips (4)
  - g) Short Bar
  - h) Exercise Log Book
  - i) Hand Cranks (unless installed)
- RED Calibration Tool Kit

**Table 2.6.2-1 General Component Specifications**

Kit and Component List	Mass M(E)	Volume M(E)	Dimensions M(E)	Nominal Stowage Location
RED-Assembled	322 lbs.	Total = 4 Middeck Locker Equivalents (MLEs)		Node 1, Zenith Alcove, hard mount
RED Canister			19.5" x 13.5" x 12.5"	Node 1, Zenith Alcove. Spares stowed in Node volume.
RED Adapter Plate Assembly		1.57 ft <sup>3</sup>	51" x 28" x 1.9"	Node 1, Zenith Alcove
RED Removable Heel Block		~220 in <sup>3</sup>	22" x 4" x 2.94"	disposed on 14P
RED Squat Support Assembly			50 in long combined.  Top: 32.75" high, 1.625 inch diameter Bottom: 19" high, 1.75in diameter	Node volume (crew preference)
RED Resupply Kit		1.03 ft <sup>3</sup>	18.5" x 11.5" x 8.38"	NOD1D4
RED Accessory Kit		1.54 ft <sup>3</sup>	18.5" x 16" x 9"	Node Volume (crew preference)

### 2.6.2.1. RED Assembly

The RED Assembly consists of an aluminum canister that encloses a stack of Flexpacks attached to a spiral pulley. Each Flexpacks consists of an Acetal disk with two “wheels” of elastomer straps. An entire Flexpack stack consists of a Gear-Hub, 8 Flexpacks, 9 Spacers, 9 External Splines, a Spiral Pulley, and Center Shaft. The Flexpacks, Spacers, and External Splines are changed out every 289,009 cycles.

The Center Shaft of the stack is secured to the inside top plate of the RED canister, providing lateral stability to the stacked Flexpacks. Also attached to the inside top of the RED canister is

the Gear-Hub, which is made of a molded in-place metal drive spline. This Gear-Hub engages with the first Flexpack via an External Spline. Between each Flexpack are a Spacer and External Spline. Each Flexpack engages with the adjacent Flexpacks via an External Spline. The final Flexpack engages with the Spiral Pulley at the bottom of the RED canister with the last External Spline.

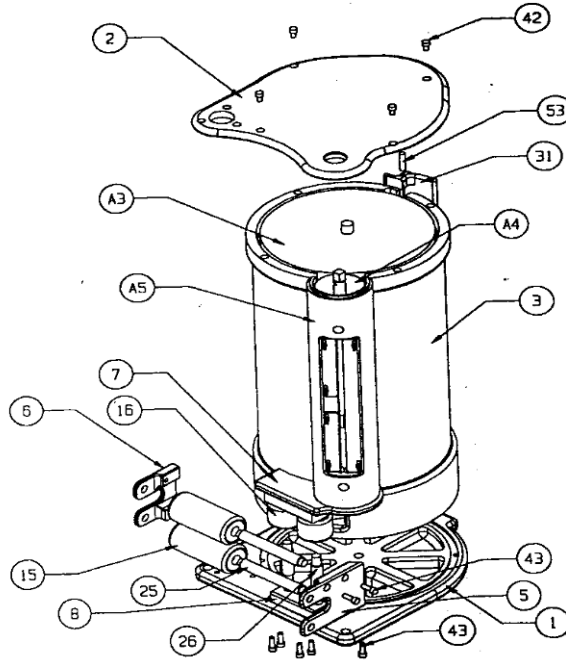
The Spiral Pulley has a cord wrapped around it. The Spiral Pulley is in line with the Flexpacks and transmits resistance from them to the cord which the crewmember then pulls on to perform various exercises. As the cord exits the canister housing, it is routed through two sets of rollers, which allow the cable to exit in any direction. Resistance is obtained by pulling on the cable, which rotates the spiral pulley attached to the Center Shaft joining the hubs of the Flexpacks. As the Flexpacks rotate, resistance is created as the elastomer straps wrap around the hub.

The IRED Assembly includes a Locking Handcrank that mounts to the top of each IRED Assembly. The Locking Handcrank rotates the Gear-Hub on the inside top of the RED canister, thus rotating the Flexpacks. The resistance is adjusted for the series of Flexpacks by depressing a safety lever on the side of the canister and rotating the Locking Handcrank to attain the desired load. The Locking Handcrank includes a safety feature that prevents back-driving when the safety lever is inadvertently depressed during adjustment of resistance. An indicator scale with a range from 0 to 5.5 on the exterior of the housing shows a number that represents the amount of resistance obtained by pulling on the cable. The Locking Handcrank is certified to 185,400 turns. When used with the IRED Canister, the Locking Handcrank is turned 100 times per exercise sessions and is certified for 1,854 exercise sessions.

New Flexpacks are calibrated on the ground and on-orbit to determine the correlation between each indicated setting and load in pounds. As Flexpacks are used on-orbit and new cables installed, they must be re-calibrated with a Calibration Tool to determine what load each setting achieves.

**Table 2.6.2.1-1 Hardware-Specific Parameters**

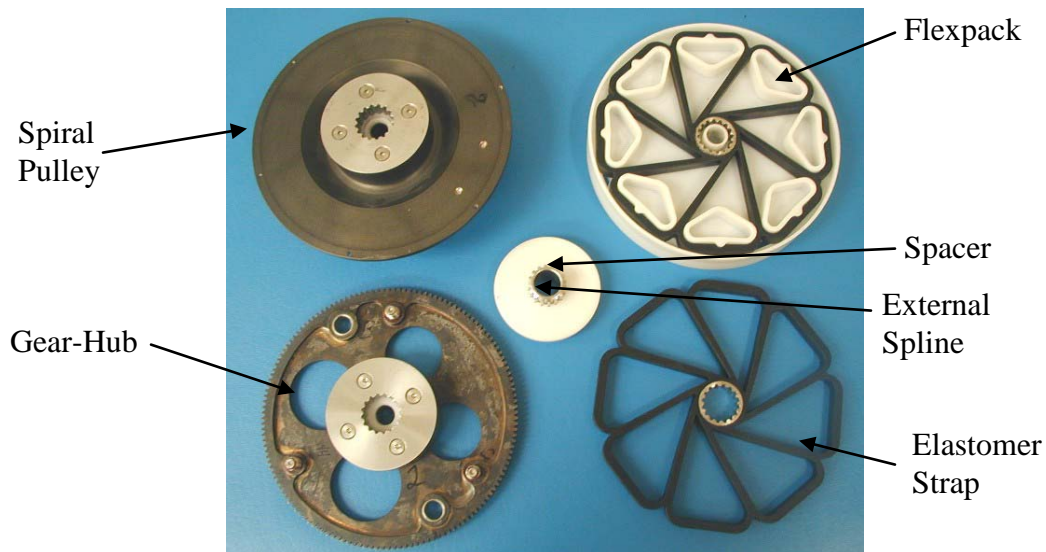
Operating Ranges	10 lbs - 160 lbs per RED Assembly (i.e. canisters) $\pm$ 2 lbs (4.5 – 113.5 kg $\pm$ 0.9 kg) Nominal Values of Parameters: N/A Sensor Error: N/A Indications for Out-of-Range Parameters: N/A
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**Figure 2. RED Assembly and its external components**



**Figure 3. RED Assembly Internal Stack**



**Figure 4. Flexpack Assembly Components**

#### **2.6.2.2. RED Squat Supports**

The RED Squat Supports are used for squats and other heavy resistance exercises requiring support. They provide a method to preload the RED assemblies with the cable extended to various positions and are launched in two sections. The bottom section is a stainless steel rod, and the top section is aluminum tube. The top section contains 5 support pins which screw into the aluminum tube 10.2 cm (4 inches) apart and protrude 6.4 cm (2.5 inches). The top and bottom sections are screwed together to form a 127 cm (50 inch) long RED Squat Support. One RED Squat Support is placed into the tube on the side of each RED Assembly. Each RED Squat Support is secured in place with two quick release pins. The height of the RED Squat Support is adjustable in 5 cm (2 inch) increments.

#### **2.6.2.3. RED Adapter Plate Assembly**

The RED Adapter Plate Assembly provides the interface for mounting the RED Assemblies and platform for the crewmember to perform the exercises. The Adapter Plate is 129.5 cm x 71.1 cm x 11.4 cm (51 inches x 28 inches x 4.5 inches) and made of aluminum. There is a 3-hole pattern on each end of the Adapter Plate for mounting the RED Canister Assemblies. The Adapter Plate utilizes the Rod End Assemblies consisting of a Long Rod and Short rod at each corner of the Plate, which provide a connection to the Seat Track Bridge Bracket Assemblies. These Seat Track Bridge Bracket Assemblies attach to the Node structure via the Seat Track Adapters. The Rod End Assemblies and Seat Track Bridge Bracket are made of stainless steel. Additional lateral stability and support is provided by the Support Block Assemblies, which interface to the walls of the Node Alcove mounting location.

#### **2.6.2.4. Heel Block**

The Heel Block is an additional accessory that is installed onto the Hardmount Plate to support the performance of heel raises. The Heel Block provides a slightly elevated platform, allowing for heel movement during heel raises. Originally, the Heel Block had two pins at each end, but

due to Adapter Plate warping, two pins on one end were removed to aid in installation/removal between exercises. However, due to the increasing difficulty of installation/removal and lack of use by increment crews, the original Heel Block was disposed on Progress 14.

### **2.6.2.5. RED Resupply Kit**

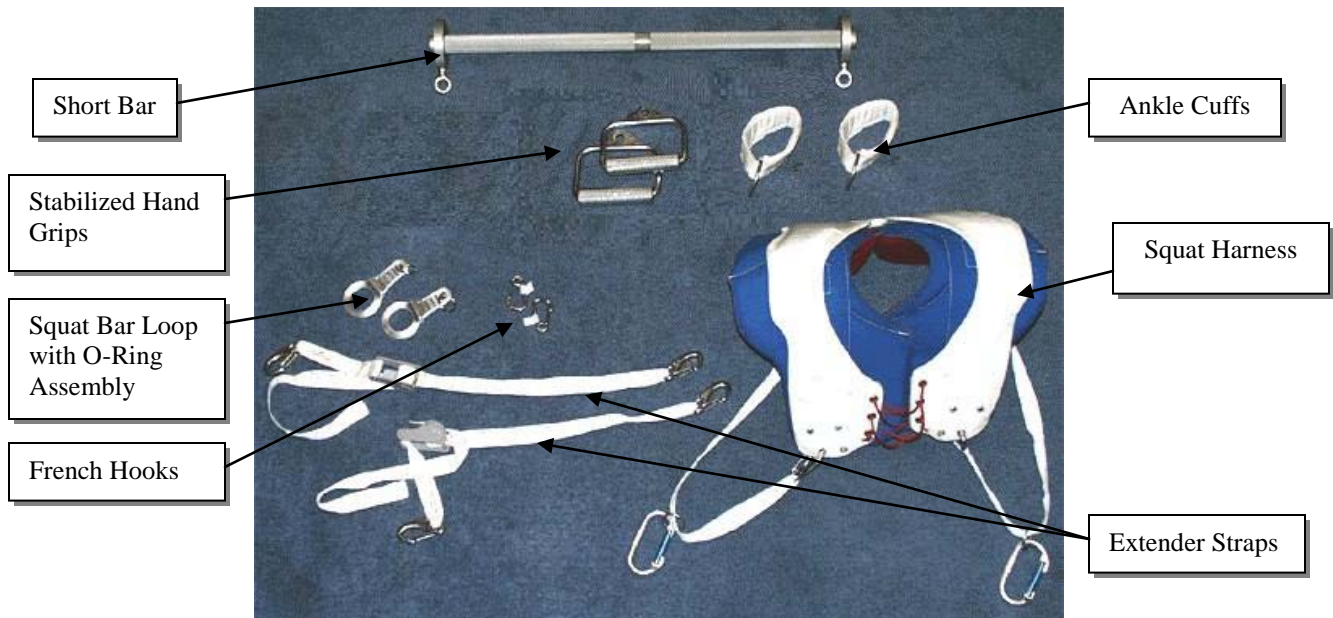
RED Resupply Kit was originally flown with each crew to provide new Canister Cords, Harness Cords and Harness Pads. These components can be flow individually as piece parts. The Canister Cords are replaced every 53,515 cycles and are certified up to a maximum load of 160 lbs. The cords are marked with a single line at 22”, a double line at 25”, and another mark is located at 50”, which is not visible to the crew when the cord is installed. These cord markings indicate extension limits based on the load setting at which the canisters are set. The Harness Cords are replaced as needed per bi-monthly inspection. One set of Harness Pads is provided for each crewmember for sanitary reasons, however most crews have reported they use one set for the duration of the increment.

### **2.6.2.6. RED Accessories**

RED Accessories were originally launched in a RED Accessory Kit, and are now deployed in the Node 1 volume surrounding the RED.

<b>Item</b>	<b>Qty</b>	<b>Notes</b>
Squat Harness	1	Used to perform squats, good mornings, straight-leg deadlifts, bent-leg deadlifts, and heel raises
Short Bar	1	Used to perform straight leg deadlifts, bent-leg deadlifts, bend-over rows, upright rows, bicep curls, shoulder presses, and wrist curls
Sliding Hand Grips – disposed of	1 pair	Intended for upper body exercises. Crews used them attached to bungees for EVA Pre-breath on CEVIS until they became damaged and were thrown away on a Progress. Stabilized handgrips were deemed adequate and there are no plans for replacement.
Stabilized Hand Grips	1 pair	Used to perform hammer throws, shoulder raises, shoulder presses, bicep curls, tricep extensions, wrist curls, bent-over rows, and upright rows
Ankle Cuffs	1 pair	Used to perform hip abductions / hip adductions, knee raises, and leg curls
Extender Straps	4	Used to extend the length of the IRED cables for exercises requiring more range than the cables allow
French Clip	4	Used to shorten the cable attachment point
Exercise Logbook	1	Used to record prescribed and actual exercise protocol for each crewmember
Hand Crank	2	Installed on top of RED Canisters, used to pre-load canisters to desired resistance





**Figure 6. RED Accessories**

### **2.6.2.7. RED Calibration Tool Kit**

The RED Calibration Tool Kit is provided to perform periodic calibrations of the load provided by the RED Canisters. Over time, the flexpacks can begin to degrade and the load provided gradually decreases. Approximately every two months and each time new Canister Cords or new Flexpacks are installed the Calibration tool is used to calibrate the canisters so the ASCRs can update exercise prescriptions and the status of the hardware can be tracked.

### **2.6.3. *Hardware Degradation Criteria***

The hardware may show early signs on performance degradation. This degradation can be detected through a list of signs and symptoms. The performance degradation is defined as follows:

Maximum load of 135 pounds not achievable, or Cord does not retract properly (at setting 0.0, cord is extended > 4 inches prior to an exercise session), or 50% of calibration data points drop >20% between on-orbit calibrations.

Note: It is acceptable to re-clock the pulley or put on an additional wrap to compensate for slow degradation.



**Figure 7. Calibration Tool**

#### ***2.6.4. Hardware Interfaces with Vehicle***

RED Hardmount plate attached to seat tracks on zenith alcove of Node 1 via seat track interface fittings (Long Rod, Short Rod and Support Block Assemblies).

Daily RED exercise, in general, involves these 4 steps:

1. Obtain exercise prescription.
2. Unstow and set-up RED with appropriate accessories.
3. Conduct exercise session.
4. Clean-up and stow RED and accessories.

Depending upon the exercise, different accessories (from the Node 1 volume) will be attached to the RED cables. A hand crank will be used to adjust the resistance provided at the cable. The crewmember will stand on the RED Hardmount Adapter Plate Assembly while performing RED exercises. After completing and logging the resistive exercises, the RED accessories will be removed and stowed in the Node 1 volume, and the resistance will be zeroed-out. The RED Assemblies will remain mounted on the RED Hardmount Adapter Plate Assembly.

#### ***2.6.5. Resupply Schedule***

New Harness Pads, Canister Cords, Harness Cords, and Flexpack Components are flown up as needed based on crew rotation and RED canister usage.

#### ***2.6.6. Data/Commanding Capabilities***

Each RED Assembly provides a mechanical display of the resistance provided at the cable. The RED exercise parameters (load, number of repetitions, number of sets) will be stored and displayed on the Medical Equipment Computer (manual data entry) (see Section 2.5.5.1 for file extensions and locations on the MEC).

There are no on-orbit or ground commanding capabilities.

### ***2.6.7. Hazard Concerns***

Reference: Risk Assessment Executive Summary Report for the Government Furnished Equipment Interim Resistive Exercise Device (IRED) (JSC 49614).

### ***2.6.8. Contingency Resistive Exercise System (CRES)***

In the event RED canisters are not available for exercise, a complement of Contingency Resistive Exercise System (CRES) bungees are available to provide minimal resistive capabilities until the RED Canister capabilities can be recovered. These bungees are identical in design to the TVIS Series Bungee System (SBS). The CRES bungees would be attached to the CRES block at the bottom of each canister and can be used to perform Deadlifts, Heel Raises and Squats. Some crewmembers have been prescribed to use them in parallel with nominal RED Cables to provide additional load when RED Canisters have had load placards due to contingencies. If used with the Squat Harness, Adjustable CRES Harness Pulley Attachments are provided in place of the nominal Squat Harness Pulley Attachments.



**Figure 8. Example of CRES Bungees Attached to RED Assemblies**

## 2.7. Treadmill with Vibration Isolation and Stabilization (TVIS)

### 2.7.1. TVIS Description

The Treadmill is a device used to compensate for the negative influence of microgravity on crewmembers. TVIS provides aerobic conditioning by simulating 1-g running or walking in the microgravity environment of the ISS. With appropriate loading, treadmill exercise also provides impact forces and maintains neuromuscular and postural mechanisms. The treadmill is designed to allow walking and running, knee bends, and resistive exercise in a zero gravity environment for maintenance of cardiovascular fitness, muscular strength, and the exercise of neurophysiological pathways and reflexes required to walk upon return to the Earth. The Vibration Isolation and Stabilization (VIS) system is intended to minimize the transfer of dynamic forces caused by operation of the treadmill to the structure of the Service Module (SM) and other parts of the ISS, while maintaining a stable running/walking surface at the same time.

TVIS is permanently mounted in the Service Module Pit between panels 130 and 137. Prior to exercise the crewmember configures the TVIS for exercise, unstows their necessary hardware, and inserts the TVIS PCMCIA Card (also called CCM) into the TVIS Control Panel. They don their specific Treadmill Harness, and connect the Series Bungee System (SBS) Assemblies to the Eyebolt. The crew can also connect the Subject Load Devices (SLDs) to the Y- strap. The Subject Positioning Devices (SPDs) – if in use – connect to the harness. When done with exercise, the TVIS is powered down and the necessary hardware is temporarily stowed.

The treadmill provides the following operating modes:

- Motorized Treadbelt - Motorized operation with speed control adjustable from 0 - 10 mph (0 -16 kph) in increments of 0.1 mph (0.16 kph).
- Non-motorized Treadbelt (also referred to as Passive Mode) - Functional without a motor, allowing the subject to drive the tread at speeds ranging from 0 to 10 mph (0 to 16 kph), dependent on subject capability, with variable mechanical resistance. Control Panel and VIS must still be powered on for non-motorized mode.
- Locked Treadbelt - Treadbelt locked into position so that it does not move.

**Note:** In Motorized mode, maximum treadmill speed may be limited due to applied subject load (weight) and running style, both of which affect power consumption. Heaviest subjects may be limited to 8 mph (12.8 kph).



**Figure 1. TVIS Exercise, SBS and SLD.**

### ***2.7.2. TVIS Component List and Description***

- Treadmill Assembly
  - a) Belt
  - b) Belt Slats
    - i. Panhead Screws
    - ii. Weld Nuts
  - c) Front and Rear Drums
  - d) Roller Bearing Assemblies (C)
    - i. Roller Assy
    - ii. Roller Assy Nut
    - iii. Roller Assy Bolt
    - iv. Bushing-Bolt Side
    - v. Bushing-Nut Side
    - vi. Viton O-ring
  - e) Inner Truss
- Forward Closeout Panels (two)
- Aft Closeout Panels (two)
- Closeout Skirt
- Control Panel
- PCMCIA Card (C)
- Electronics Box (C)
- Electronics Box Battery (C)
- Flywheel Case (C)
- Transfer Case (C)
- Treadmill Harness (C)
- Isolation Cage

- Subject Load Device (two) (C)
- Subject Positioning Device (two)
- Motor Box (C)
- Vibration Isolation and Stabilization (VIS)
  - a) Gyroscope (C)
  - b) Linear Stabilizers (four)
  - c) Motor Controllers (four)
  - d) VIS Controller (C)
- TVIS On-Orbit Kits
  - a) TVIS Assembly Kit (0.5 CTB S/N 1042)
  - b) TVIS Maintenance Kit (1.0 CTB S/N 1219)
    - i. TVIS Maintenance Tools Kit
  - c) Gyroscope Mount Cable Spare Parts Kit
  - d) Clamp Rope Spare Parts Kit

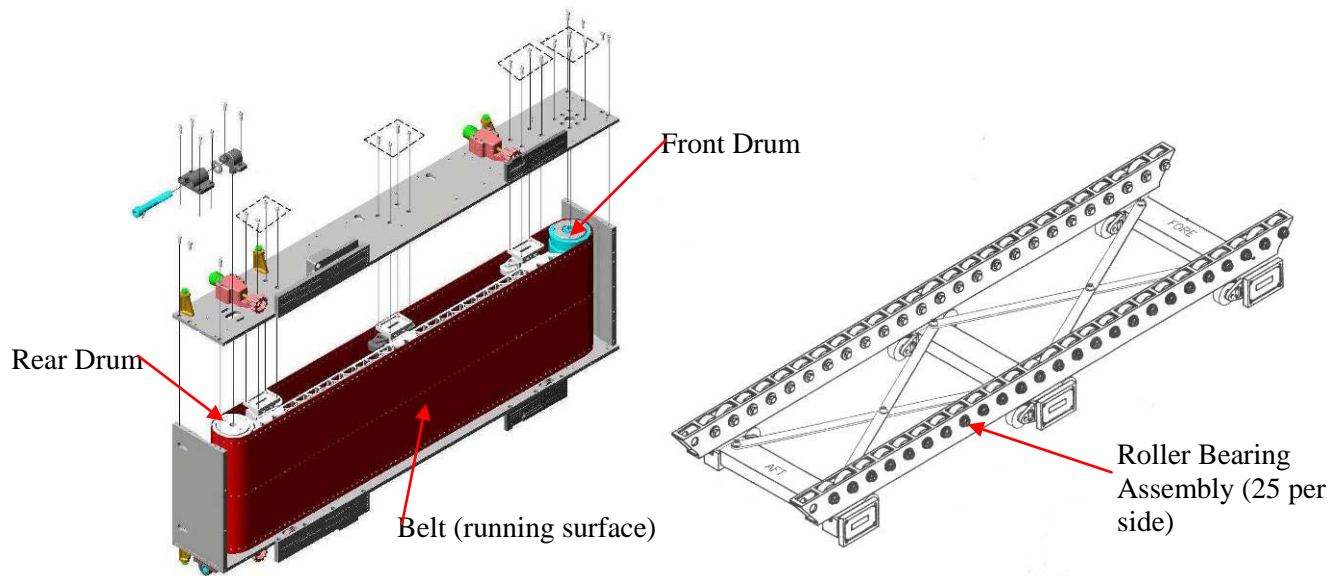
**Table 2.7.2-2 Hardware Specific Parameters**

Power Requirements	Avg = 260 W (at 0 mph) Peak = 920 W (at 10 mph)			
Power Source	28 VDC, dedicated 20 Amp outlet in SM pit			
Battery Description	One 3V Lithium-Magnesium Dioxide resides in the Treadmill Electronics Box. The battery is used for relay memory backup and maintains the system clock.			
Measurement Parameters/ Analysis Capabilities	<b><u>Display Parameter</u></b>	<b><u>Units</u></b>	<b><u>Range</u></b>	<b><u>Precision</u></b>
	Tread Speed	km/h or mph	0-16 km/h (0-10 mph)	0.2 km/h (0.1 mph)
	Restraint Force	Kg or lbs.	0-100 kg (0-220 lbs)	1 kg (1 lb)
	Distance	Km or mi	0-99 km (0-99 mi)	0.02 km (0.01 mi)
	Elapsed Time	HH:MM:SS	0 to 99 hrs 99 min	1 sec.
	Exercise Profile	N/A (Graphic)	N/A (Graphic)	N/A (Graphic)
	Heart rate	bpm	0 - 240 bpm	5 bpm
	<b><u>Control Parameter</u></b>	<b><u>Units</u></b>	<b><u>Range</u></b>	<b><u>Precision</u></b>
	Tread Speed (Motorized mode)	km/h or mph	0-16 km/h (0-10 mph)	0.2 km/h (0.1 mph)
	Restraint Force	Kg or lbs.	0-100 kg (0-220 lbs)	4.5 kg (10 lbs)

**2.7.2.1. Treadmill Assembly Description**

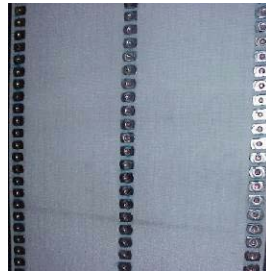
The Treadmill Assembly consists of Treadmill side plates, belt, belt slats, front and rear drums and Internal Chassis Structure Assembly (ICSA).





**Figure 2. Treadmill Assembly and ICESA**

Belt – Material belt surrounded by 159-160 aluminum slats, each mounted by three screws inserted into Weld Nuts. Weld Nuts orientation is inspected internally as part of the Periodic Chassis Inspection every 6 months.

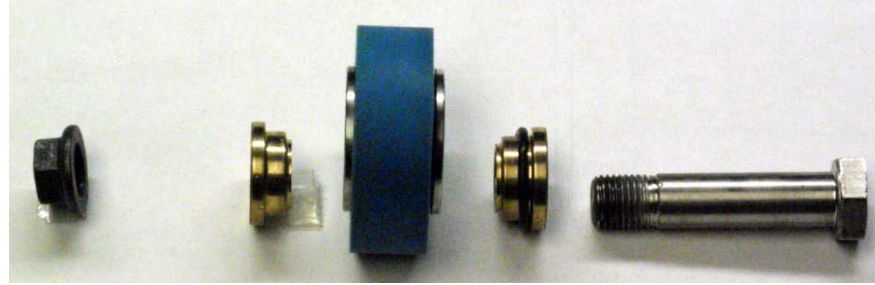


**Figure 3. Belt Underside with Weld Nuts**

Front and Rear Drums –Rear drum can be moved via external Belt Tensioner Assemblies to increase/decrease belt tension (removal from SM Pit is not required).

Roller Bearing Assembly – Fifty Roller Bearing Assemblies support underside of belt as it rotates. With the implementation of the new "Blue" roller design (high load capacity rollers), the life expectancy of the rollers is increased significantly and the life usage is no longer tracked. If Roller Bearing changeout is required, only 10 center-most bearings on each side, which receive the majority of loading, are replaced via center of truss structure.



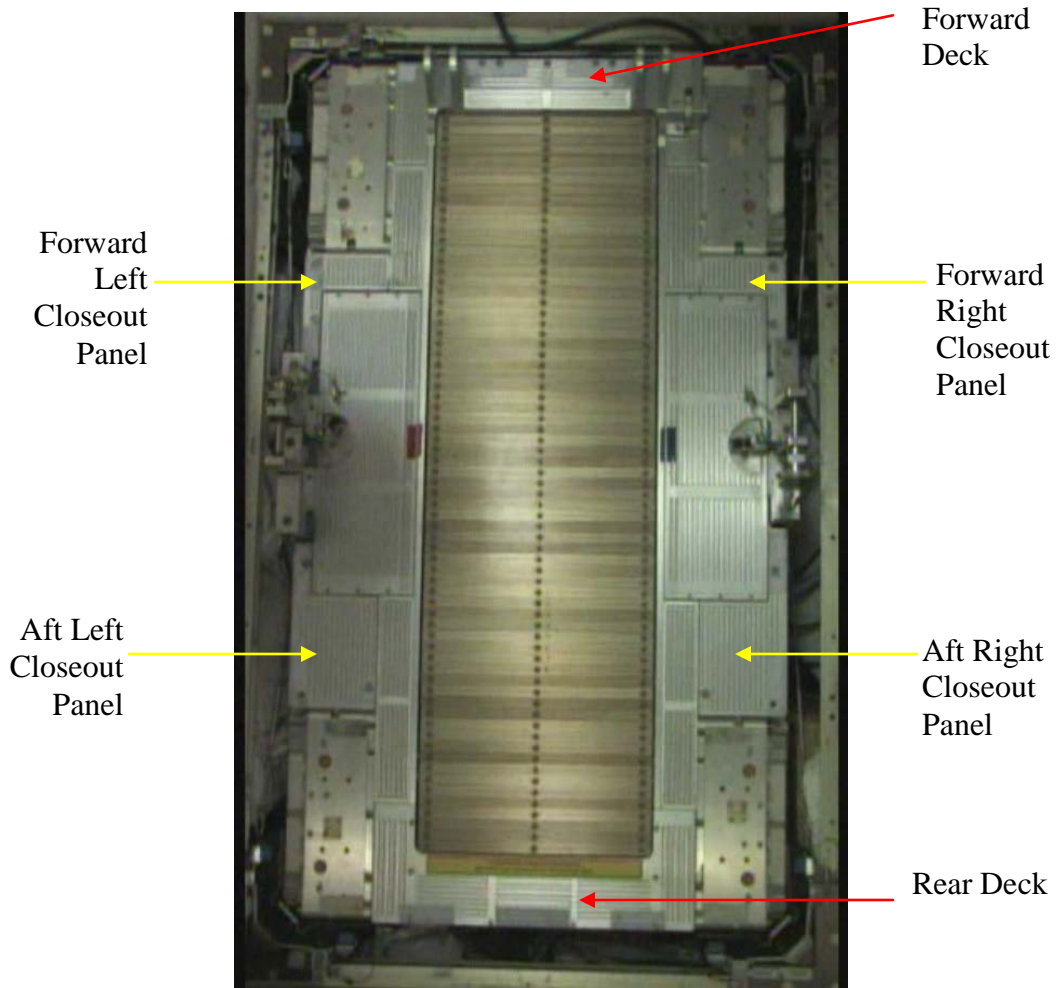


**Figure 4. Roller Bearing Assembly**

**2.7.2.2. Closeout Panels**

There are 4 Closeout Panels, two Forward (left, right) and two Aft (left, right), designed to close off the gaps between the VIS Stabilizers and Subject Load Devices.

NOTE: Aft, Left Closeout Panel and Aft, Right Closeout Panel may only have 2 out of 3 fasteners present.



**Figure 5. TVIS Closeout Panels and Deck Plates**



**Figure 6. Forward Closeout Panel**



**Figure 7. Aft Closeout Panel**

### **2.7.2.3. Deck Plates**

There are 2 Deck Plates, forward and aft, designed to close off the gaps between the Chassis and the Treadbelt. In order to remove the Aft Deck plate, the Aft Corner bolt of the Aft Right and Aft Left Stabilizer must be removed.

### **2.7.2.4. Closeout Skirt**

The Closeout Skirt is attached via Velcro around Treadmill and closes off any gaps in the perimeter between Treadmill and ISS Service Module Floor.

### **2.7.2.5. Control Panel**

The Control Panel is suspended in front of TVIS from SM or the SM Table with Multi-Use Brackets (Bogen Arms). Top right edge has four LEDs for STBL VIS, GYRO VIS, PWR TRD and MOTOR TRD. Top left edge has slot for TVIS PCMCIA Cards.

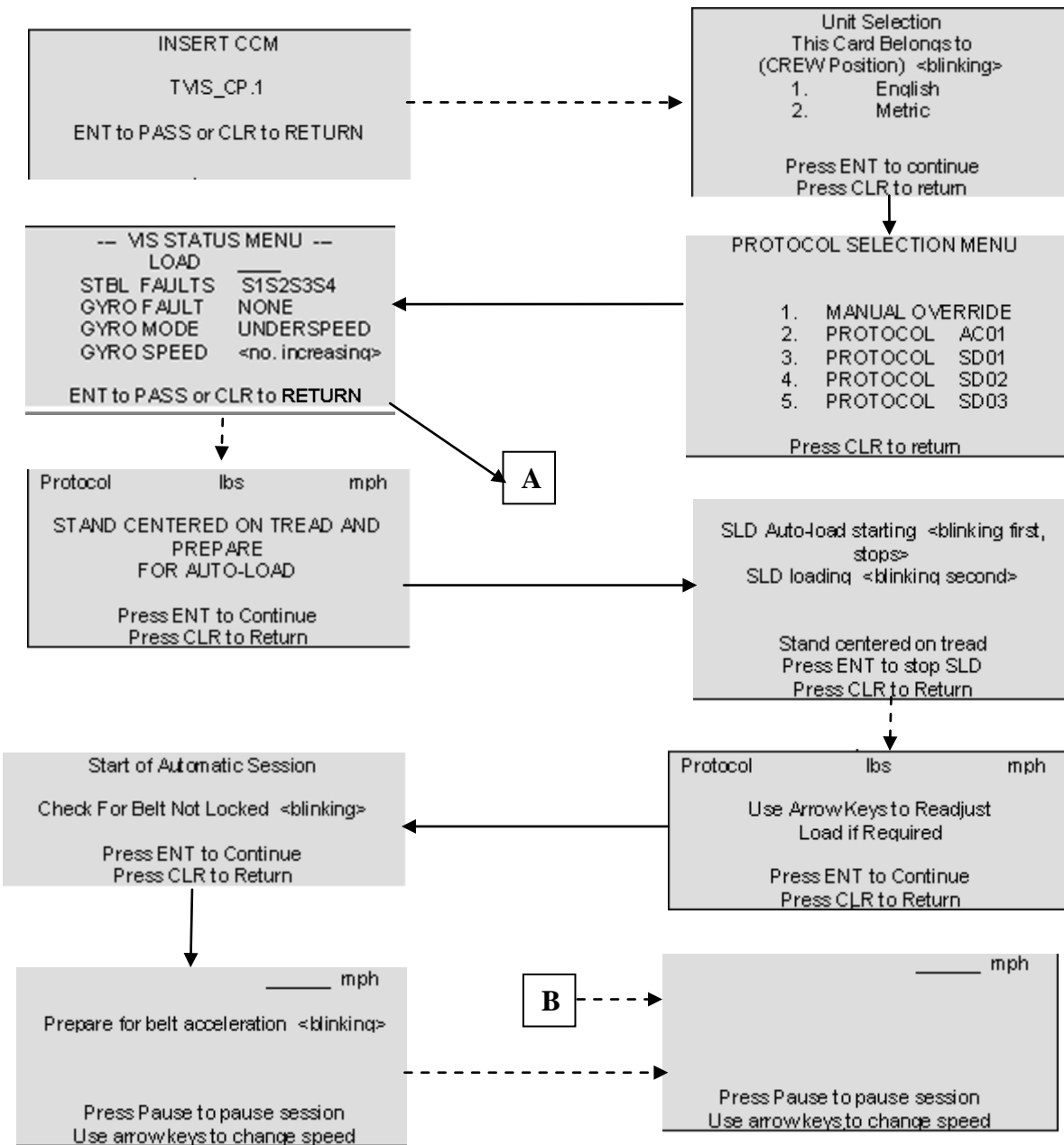


**Figure 8. TVIS Control Panel**

Emergency Stop Magnet – Provides mechanism to stop Treadmill Belt motion immediately. Magnet attaches to Control Panel face and is tethered to crewmember during exercise session.

**2.7.2.5.1. Control Panel Flowchart**

- - - - -> Proceeds automatically
- > Proceeds by user

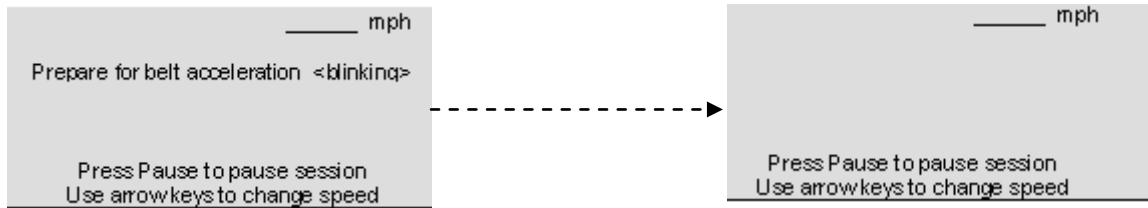


**When Session is completed, magnet is pulled or SYS Pause button is pushed:**

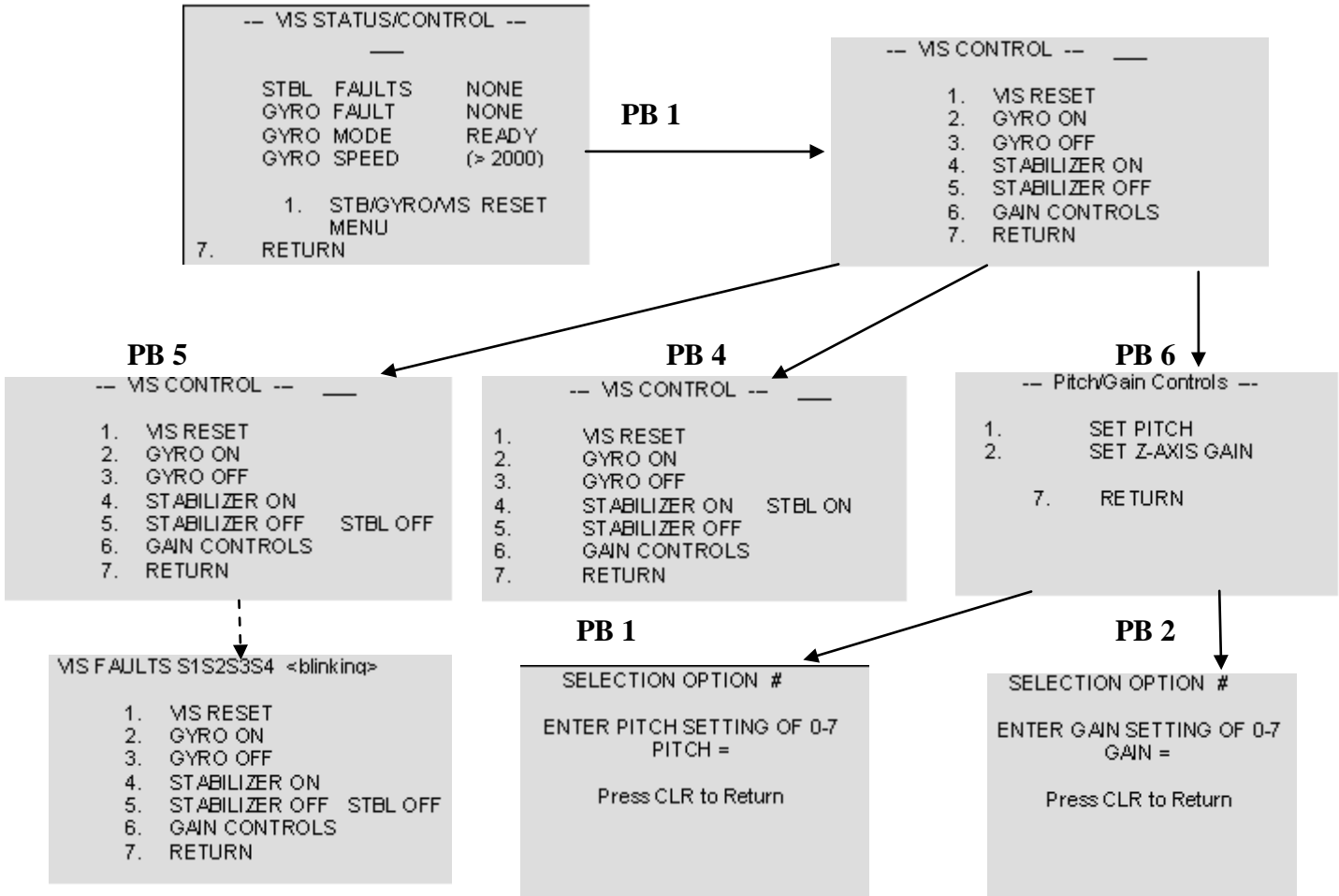
SYSTEM PAUSED	lbs
1. Resume Session	
2. MS Status/Control	
3. Diagnostic Menu	
4. Belt Speed Controls/Reset	
5. SLD Adjust	
7. Quit Session	

**From SYSTEM PAUSED menu:**

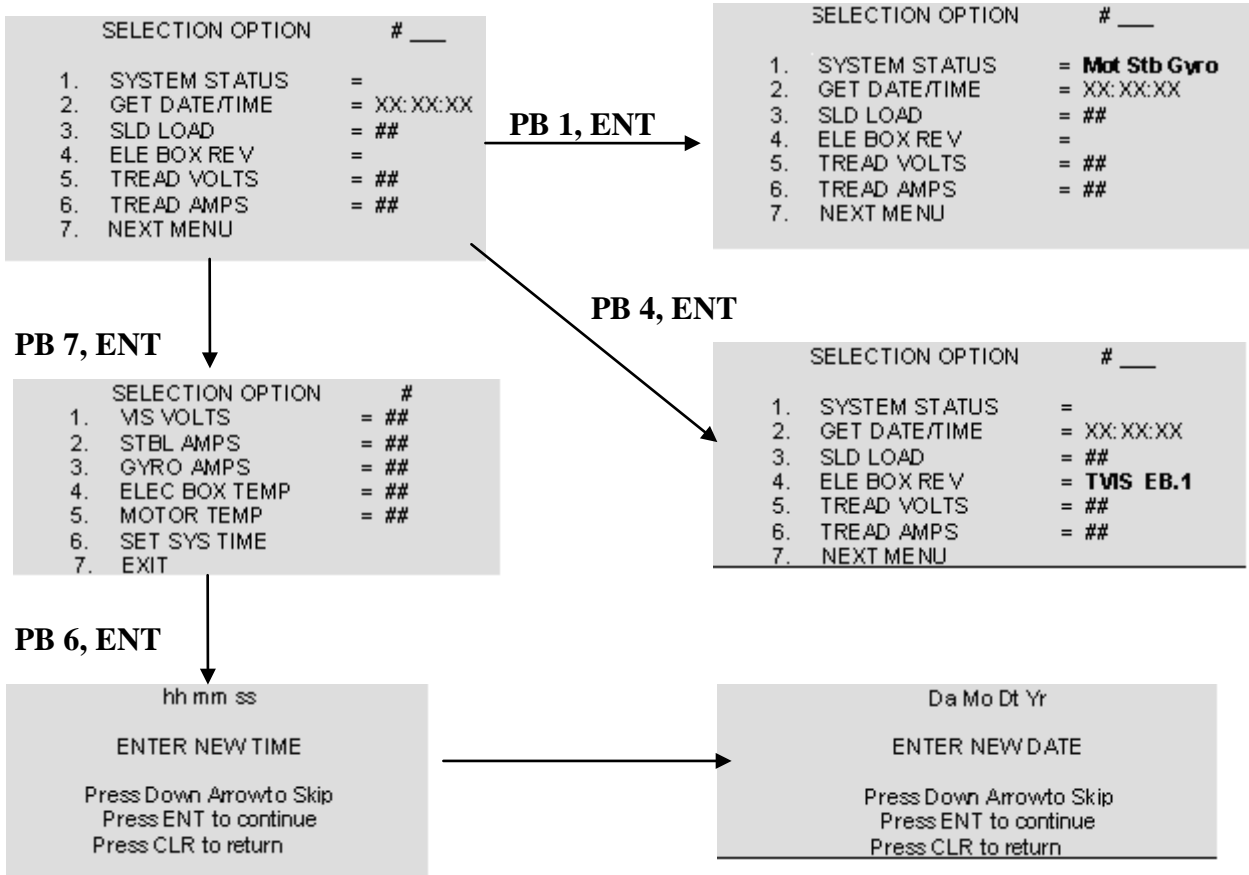
**PB 1, ENT:**



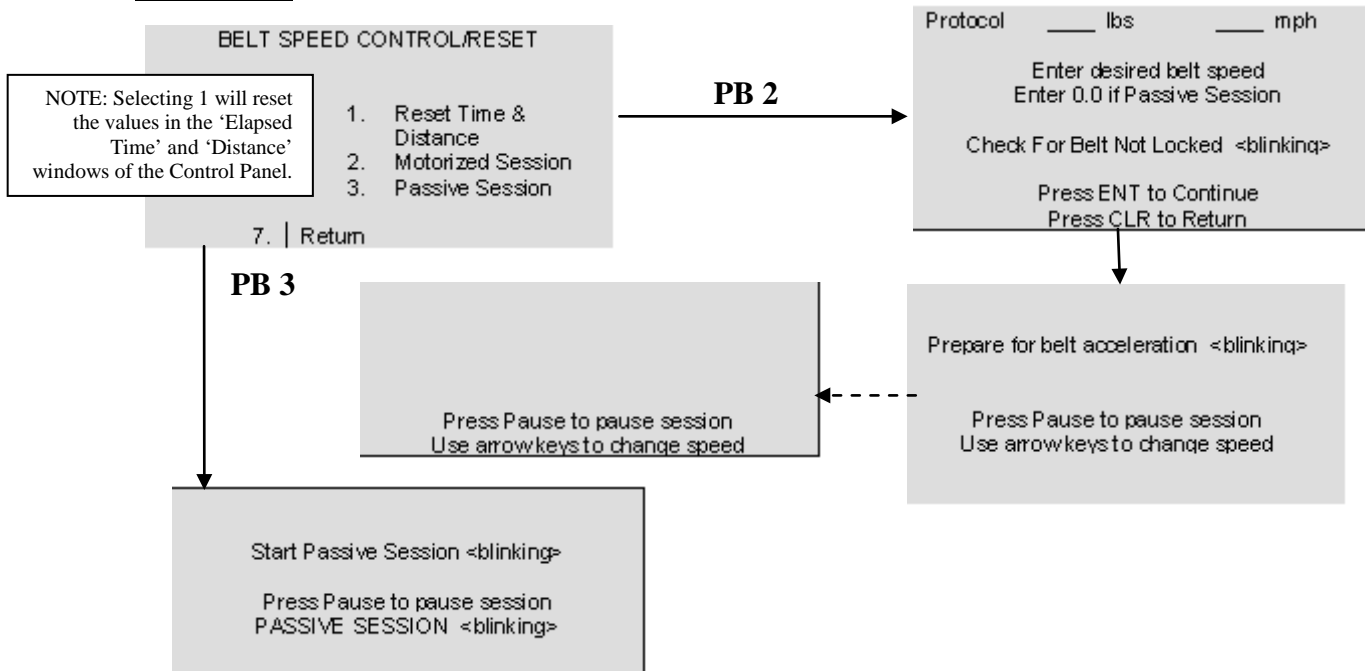
**PB 2, ENT:**



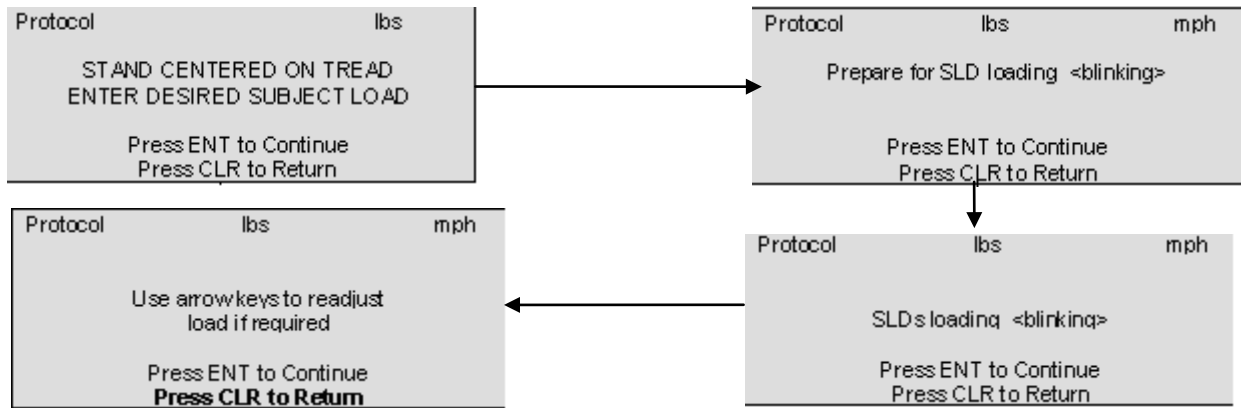
**PB 3, ENT:**



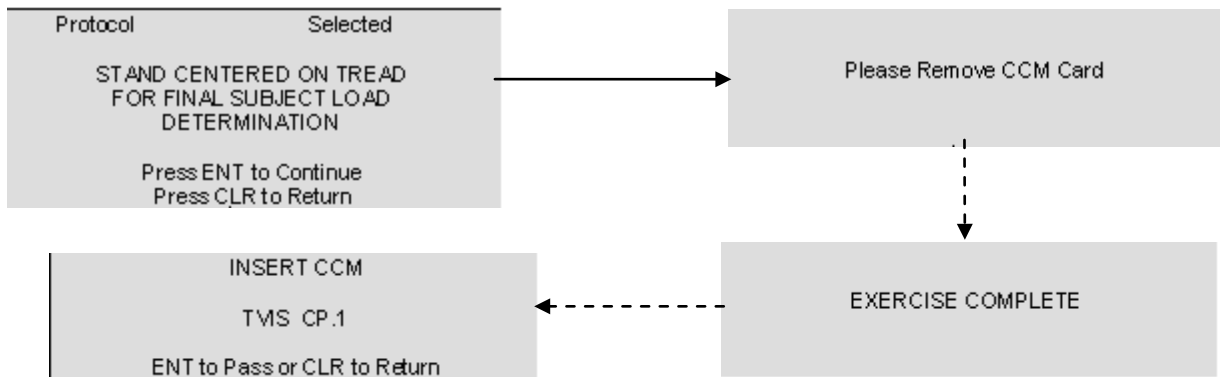
**PB 4, ENT:**



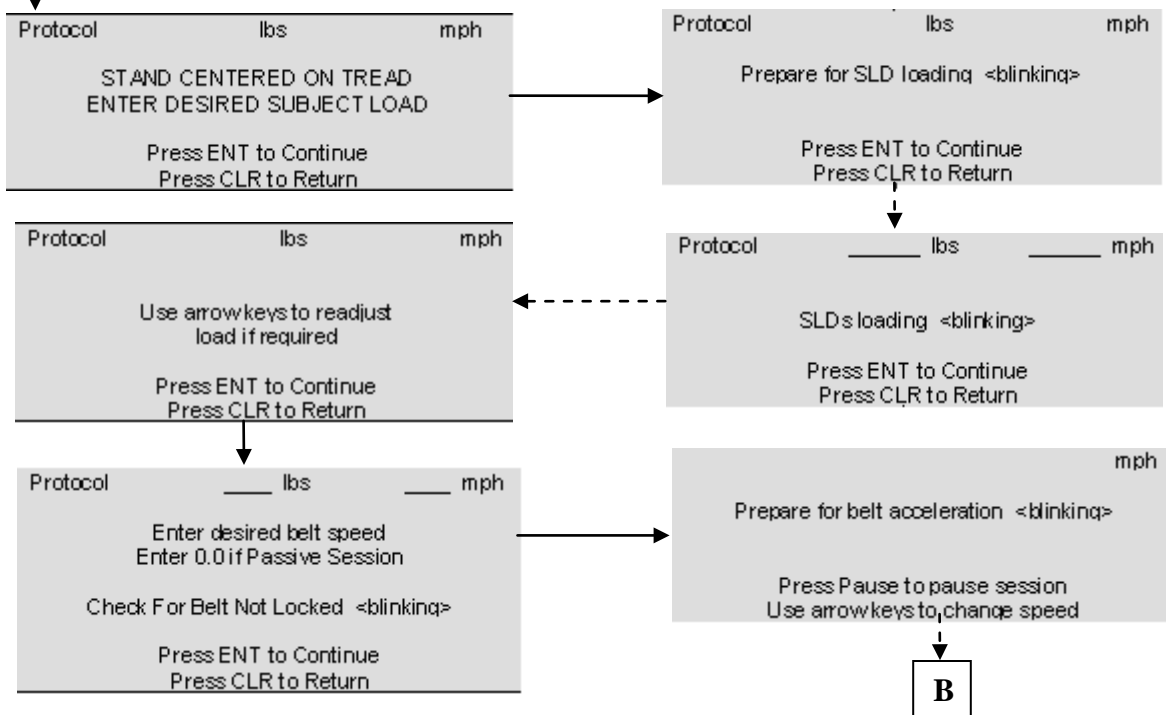
**PB 5, ENT:**



**PB 7, ENT:**



**A**

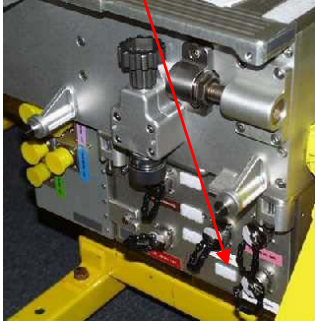


**2.7.2.6. Electronics Box**

The TVIS is not powered via a UOP. The Electronics Box receives power and distributes it between the Treadmill and VIS subassemblies. A 3V battery must be replaced every 6 months (unless Electronics Box is being swapped) to maintain Control Panel date/time.

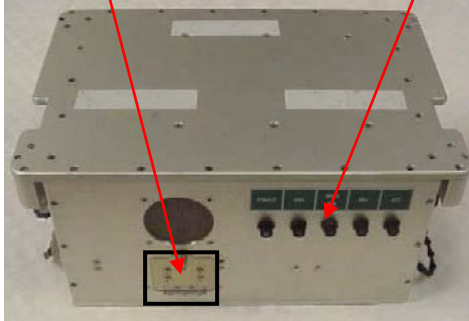
Electronics Box Circuit Breakers – There are 5 re-settable circuit breakers on the aft side, which correspond (left to right) with Gyro, VIS, EB PSB, TM and Control Panel.

Electronics Box  
(left side)



**Figure 9. Treadmill Aft, Left**

Battery Door



**Figure 10. Electronics Box**

Re-settable  
Circuit Breakers

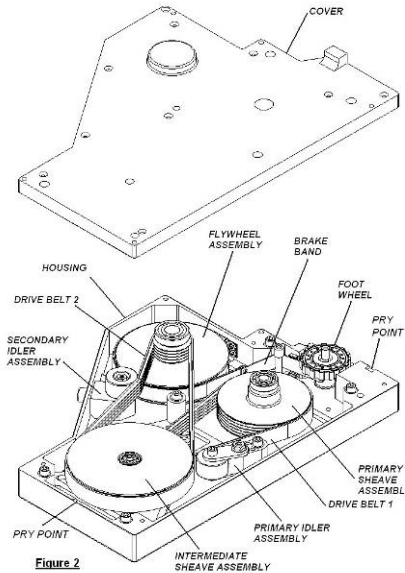
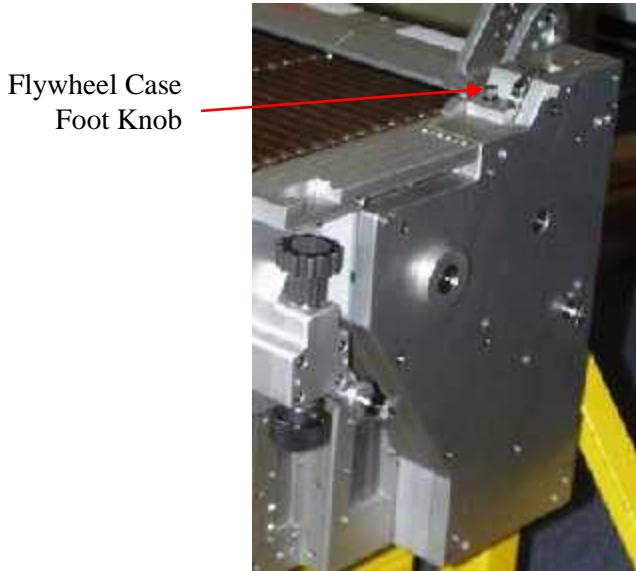


**Figure 11. EB Battery**



**2.7.2.7. Flywheel Case**

The Flywheel Case is at the forward, right end of Treadmill Assembly and provides inertia to the Treadmill running surface, helping to maintain smooth belt motion.

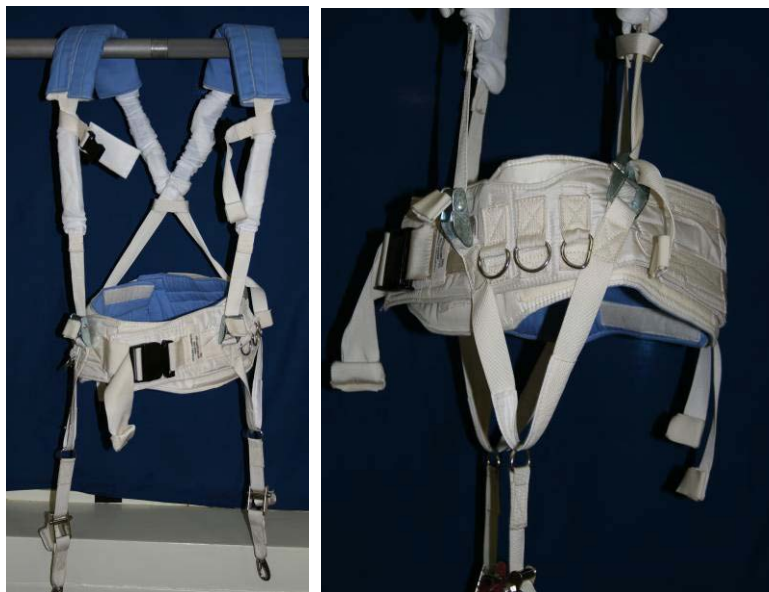


**Figures 12-13. Flywheel Case**

Flywheel Case Foot Knob - Top of Flywheel Case, knob turns to allow crewmember to dial added resistance to Treadmill Belt. Nominally set to 0.

**2.7.2.8. Treadmill Harness**

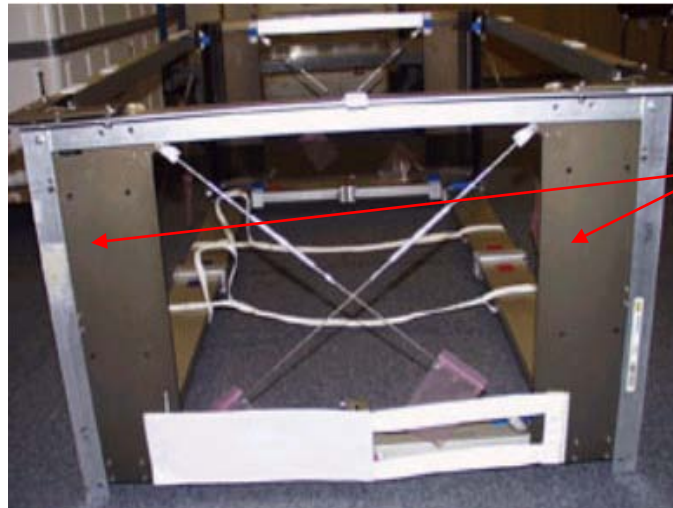
The Treadmill Harness is used to restrain subject to Treadmill running surface.



**Figures 14-15. Treadmill Harness – Front View and Side View**

### 2.7.2.9. Isolation Cage

The Isolation Cage is the envelope within SM Pit where TVIS is suspended. Corner Bracket Ropes tether TVIS to cage corners. To remove TVIS from SM Pit, remove Retainer Plates, open Clamp Assemblies, remove Isolation Restoration Bungee Assemblies (IRBAs), and raise TVIS by removing Tee-bars from linear bearings.

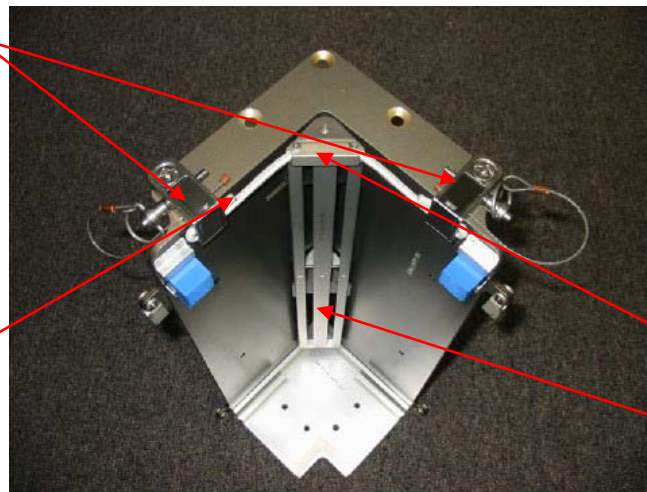


Corner Brackets  
(one per corner)

**Figure 16. TVIS Isolation Cage**

Clamp Assemblies

IRBA



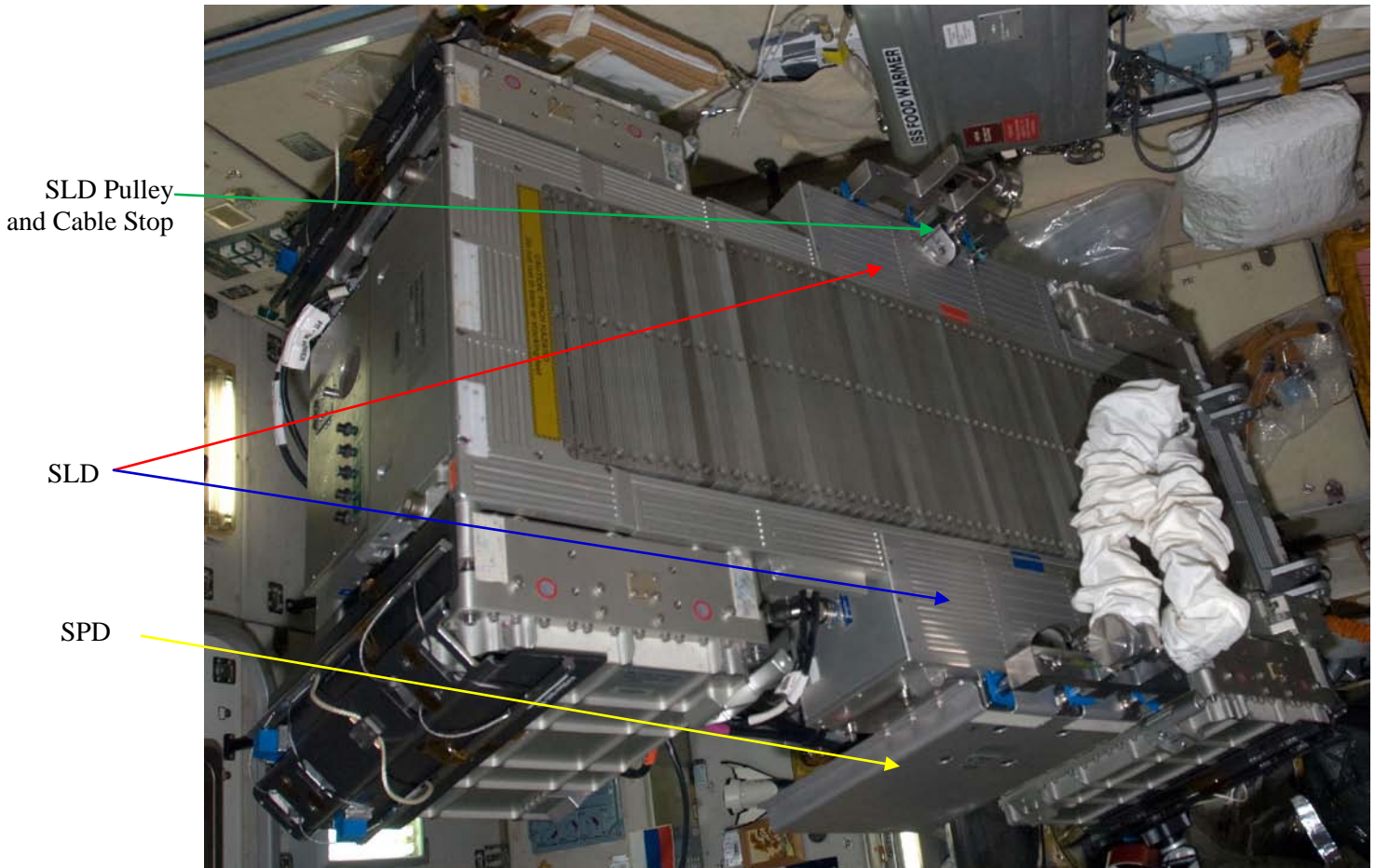
Retainer Plate

Linear Bearings

**Figure 17. Corner Bracket**

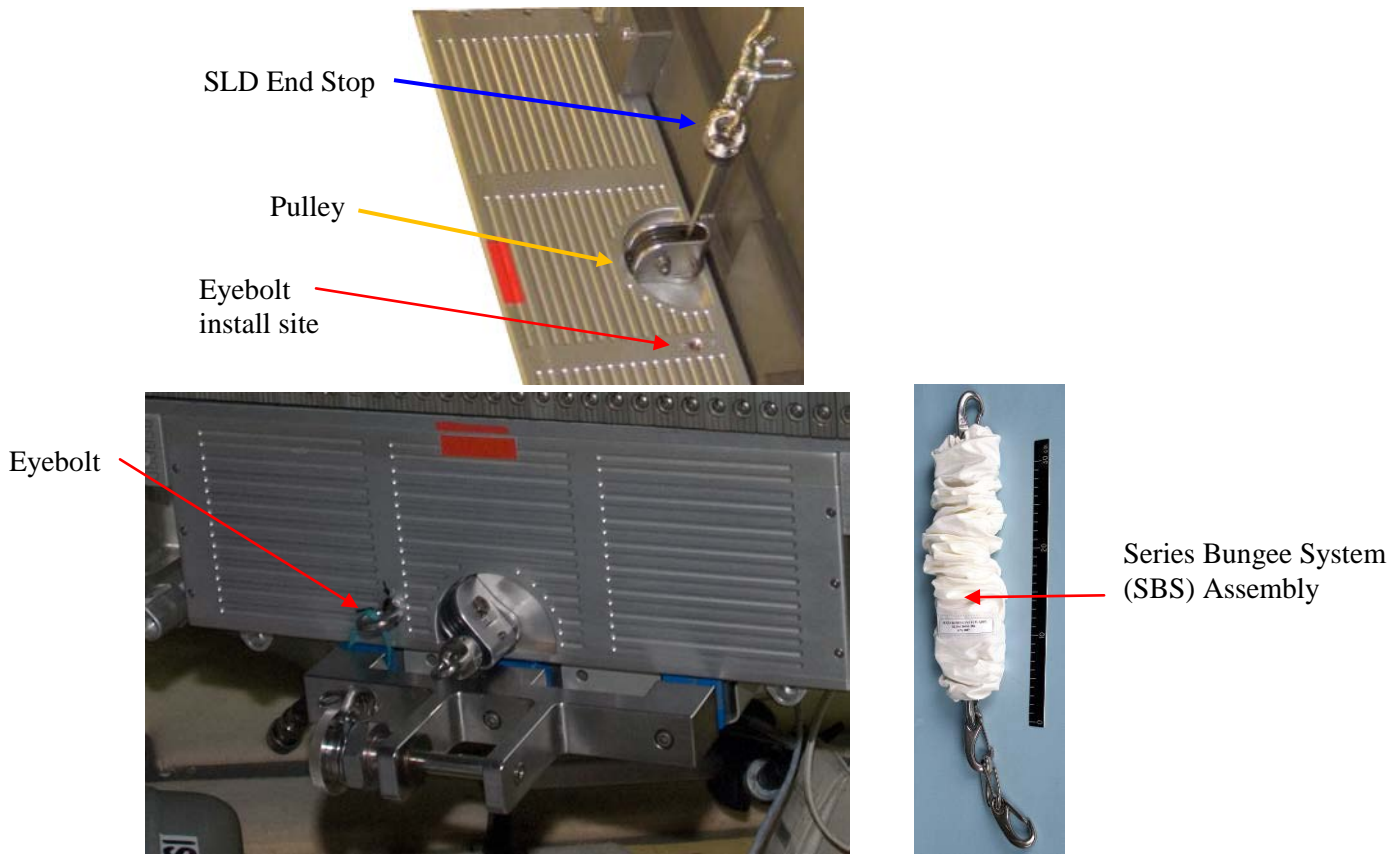
**2.7.2.10. Subject Load Device**

The Subject Load Device provides the restraint system necessary to secure an exercising subject to the treadmill in a microgravity environment. SLD cables can be attached directly to Treadmill Harness. The SLDs are changed out periodically and calibrated for use with each individual Electronics Box.



**Figure 18. TVIS SLD**

Eyebolts – Located slightly forward of SLD Cable Stop, serve as contingency attachment site for SBS Assemblies to achieve crewmember loading if SLDs are rendered unusable.



**Figure 19. SLD Eyebolt**



### 2.7.2.11. Subject Positioning Device

Subject Positioning Device (SPD) - Attach to Harness to keep subject in center of Treadmill belt. SPDs are important for walking or operating TVIS in non-motorized (passive) mode. Energy absorbing isolation material is used to prevent metal-to-metal abrasion/impact, and has a strong design to withstand kick load. SPD Top can be removed from Treadmill and temp stowed by unscrewing the Knob on the SPD Yoke Bracket. SPDs are only required for use for the first seven exercise sessions to mitigate the forces transmitted to station while a runner becomes accustomed to running in space on TVIS. SPD Extension Assemblies may be necessary for tall crewmembers (attach SPD Bottom Yokes to SPD Top Assemblies).



Figure 20. SPD Top

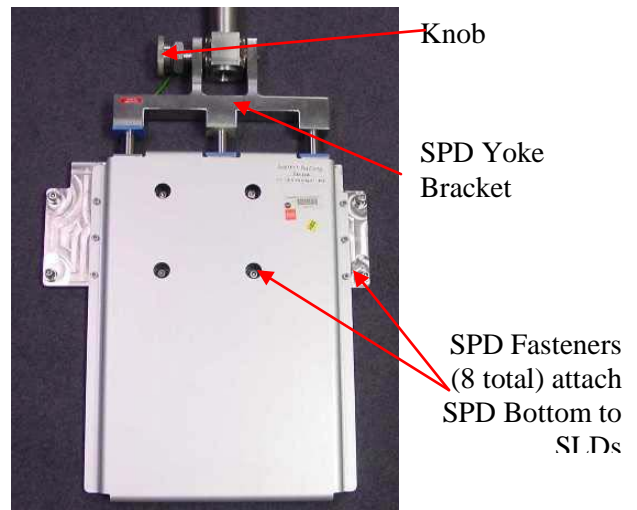


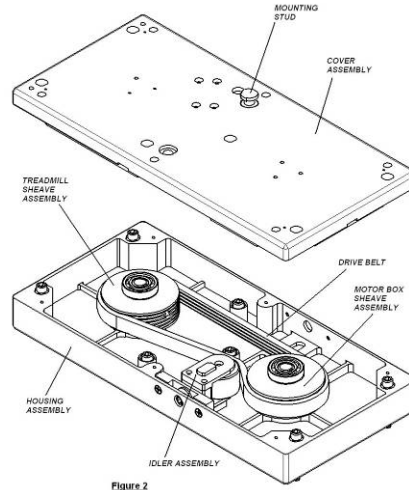
Figure 21. SPD Bottom



Figure 22. SPD Extension Assembly

**2.7.2.12. Transfer Case**

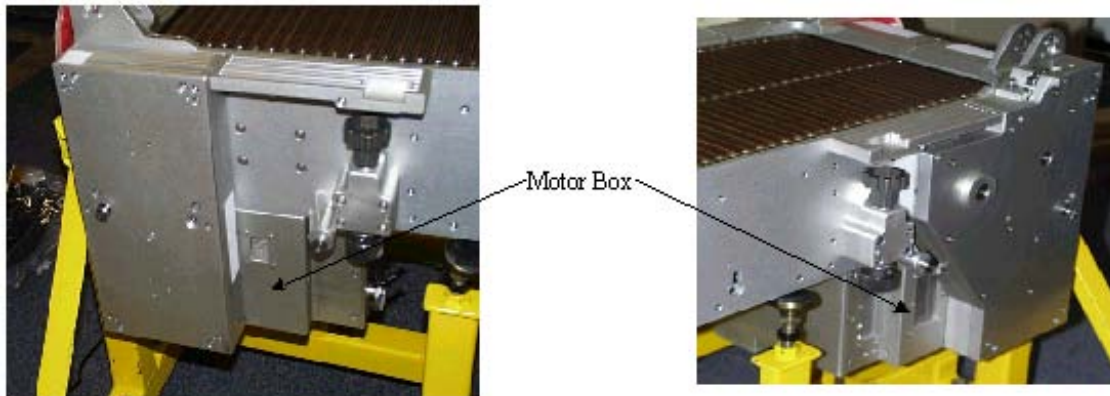
The Transfer Case is at the forward, left end of Treadmill Assembly and interfaces with the Motor Box and Treadmill Belt Front Drum via spline shafts. The transfer case transmits torque output from the motor to the front drum of the Treadmill to turn the belt.



**Figures 23-24. Transfer Case**

**2.7.2.13. Motor Box**

The Motor Box is located under the forward end of Treadmill Assembly between Transfer and Flywheel Cases. It contains the motor and controls electronics necessary to drive the Treadmill running surface.

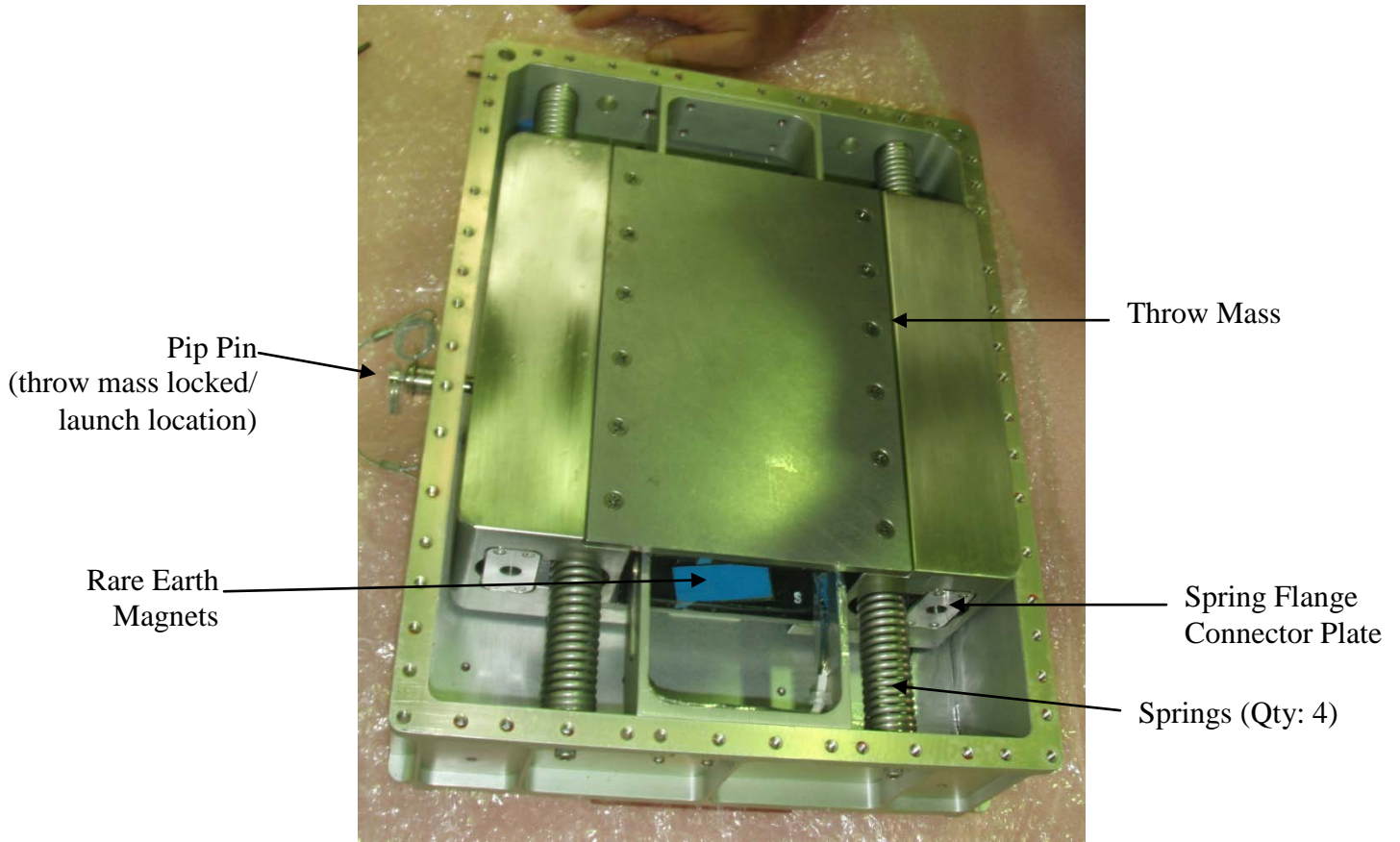


**Figures 25-26. Treadmill Motor Box (view of both sides)**

**2.7.2.14. Vibration Isolation and Stabilization (VIS)**

Vibration Isolation and Stabilization System provides a very flexible mechanical connection to ISS by stabilizing TVIS against excessive motion caused by exercise. The VIS is composed of Linear Stabilizers (four) with Motor Controllers (four), Gyroscope and VIS Controller.

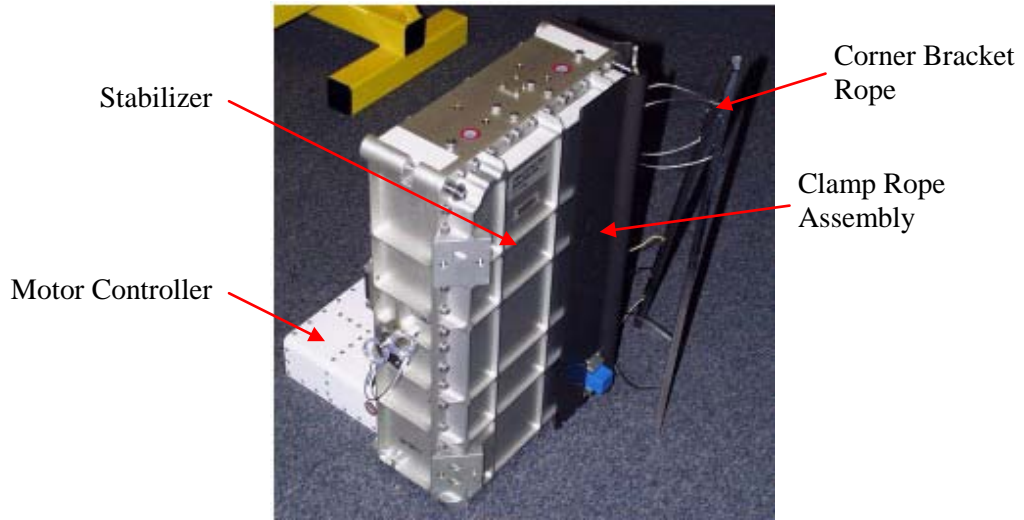
Linear Stabilizers – One per corner, stabilize against linear motion and pitch. Clamp Rope Assemblies attach to Stabilizers and hold TVIS to SM Pit along with Isolation Restoration Bungee Assemblies (IRBAs). Stabilizers require power for full functionality and contain accelerometers, which allow for feedback for linear motors to drive internal throw masses. The four stabilizers can each be installed on any corner.



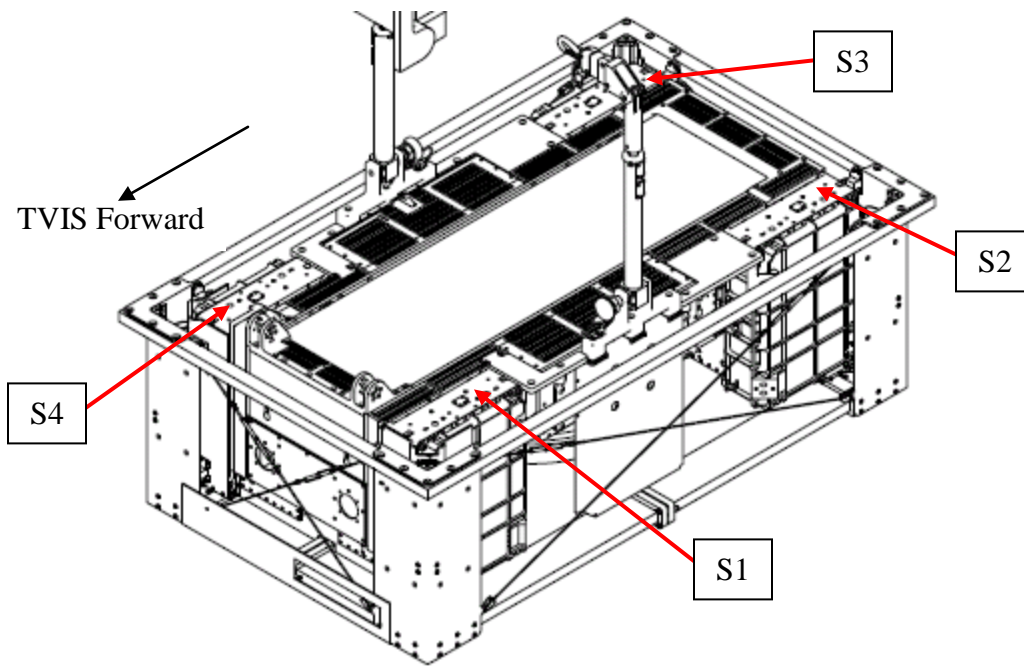
**Figure 27. Inside Stabilizer**

Motor Controllers – Attached to bottom of each Stabilizer; they process the accelerometer data and control linear motors in the Stabilizers; convert 28V to 98V for power to the Stabilizer motors.





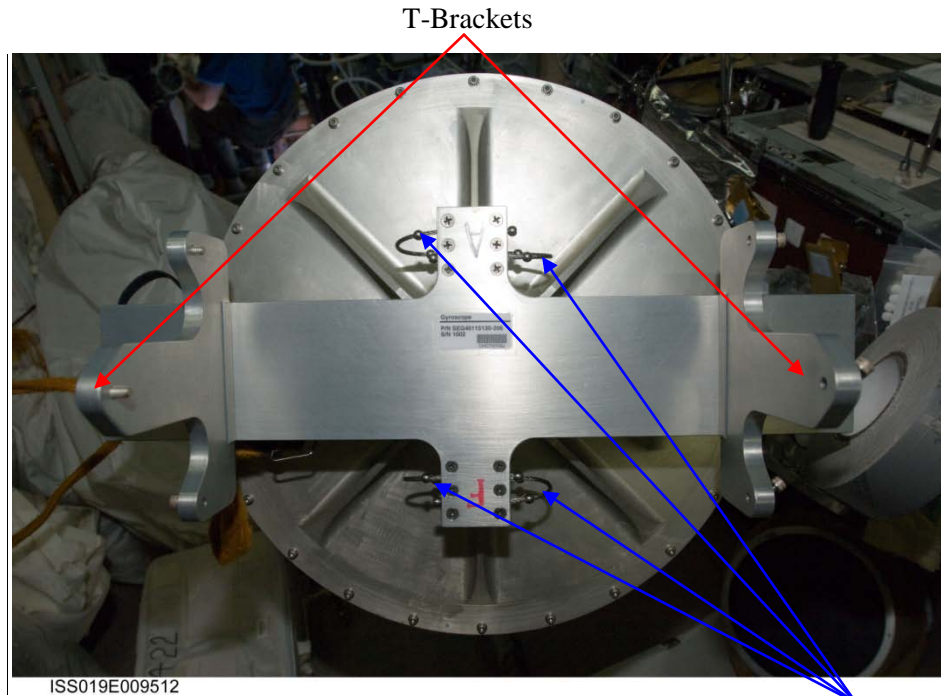
**Figure 28. Stabilizer with Corner Bracket Ropes**



**Figure 29. Stabilizers labeled according to software**

Gyroscope – Located under center of Treadmill Assembly, attaches to Treadmill Assembly sides with T-Brackets, gimbaled in the pitch plane, stabilizes against roll. Held in neutral position via two Gyroscope Wire Ropes, which must be inspected monthly and replaced yearly.

Gyroscope speed must reach 2000 rpm to begin nominal exercise, the higher the gyro speed the better the gyroscope responds to change. VIS Controller processes the Gyroscope RPM.

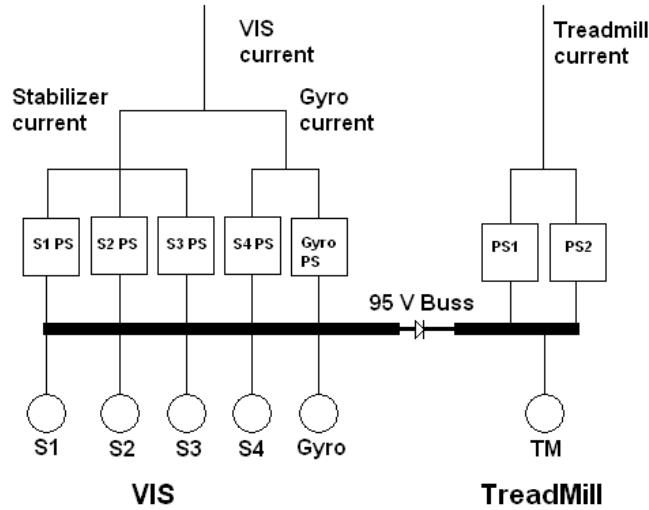


**Figure 30. TVIS Gyroscope**

Gyroscope Wire Ropes

VIS Controller – Under Aft end of Treadmill Assembly, attached to forward end of Electronics Box, acts as control for all command/data handling and power sharing for the Stabilizers and Gyroscope.

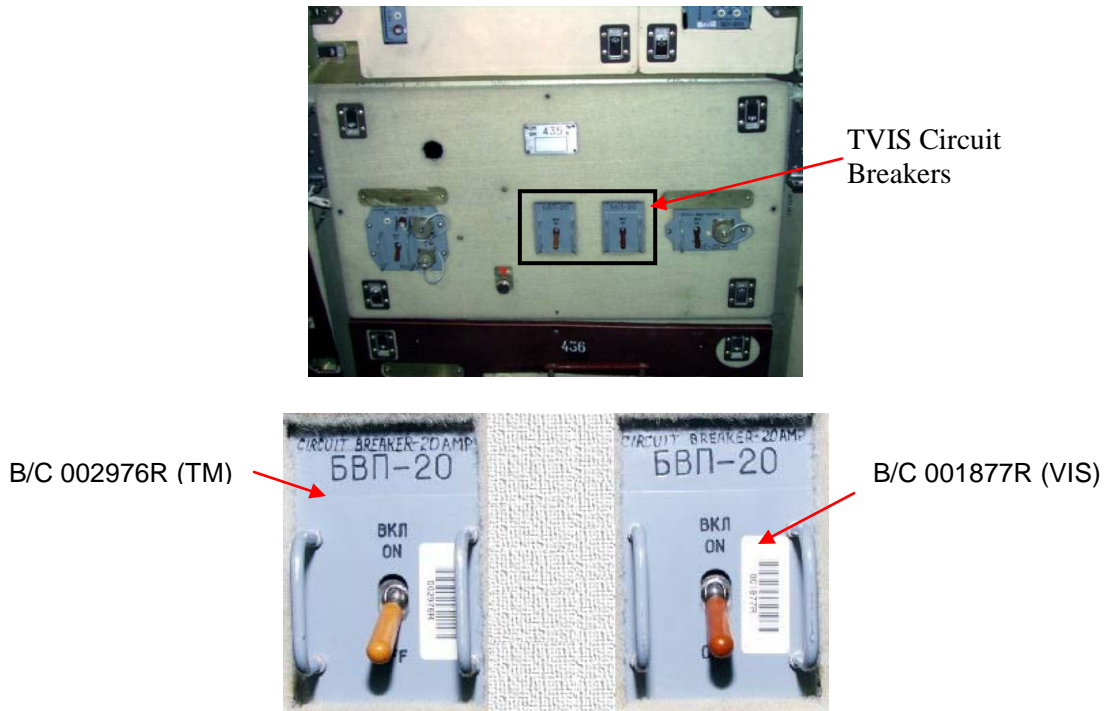
### 2.7.3. Power Sharing



- TVIS receives power from the SM via two 28V, 20A lines. One is dedicated to the Treadmill and the other to the VIS.
- **VIS:** The VIS Line powers the Stabilizers and Gyroscope. If the Treadmill Line requires additional power to maintain belt speed, the VIS Line can feed 100-200 Watts of power to the Treadmill Line.
- **Treadmill:** The system will "steal" power from the VIS if needed to maintain treadbelt speed.
  - This is accomplished by internal circuitry in the Treadmill electronics which will reduce the voltage on the Treadmill Line if its upper limit is met. The reduction in voltage (from 95 to 55V) creates a sudden potential difference between the VIS and Treadmill Line, allowing the VIS to send power to the Treadmill.
  - The amount of power required to maintain treadbelt speed is dependent on the style of individual runners. For example, someone who leans forward helps push the belt and requires less power than someone who leans backward and creates additional resistance that the belt must overcome.
  - The same factors which determine how much power is required to maintain belt speed may also determine how hard the VIS must work to maintain a stable platform.
  - If the treadmill must steal power from the VIS system, it is possible the VIS system will no longer have enough to maintain a stable platform and warning messages will be generated. In some instances, the crew must stop exercising to allow the system to recover before they can continue.

**2.7.4. Hardware Interfaces with Vehicle**

- **Cables:** 2 power cables extending from two connectors in SM pit to Electronics Box (Treadmill, VIS).
- Distribution panel number 435 for TVIS located under Table. Labeled **БВН -20**
  - CB with barcode 002976R is for Treadmill (TM)
  - CB with barcode 001877R is for VIS



**Figure 31-32. SM\_435 Treadmill and VIS Circuit Breakers**

- TVIS is also powered from the ROS EPS but has dedicated connections located in the floor of the Service Module (SM). The two connectors in the TVIS SM Pit each supply 20 amps. Although the exact power pathway for the TVIS is unknown at this time, it appears that power is drawn from one of the SM main buses.
- A fan in the SM must be on at all times when the TVIS is operating, and turned off if the TVIS will be removed from the pit. The fan is BnO-12, and is located at nnC-24.

**2.7.5. Resupply/Maintenance Schedule**

These components of the TVIS are scheduled to be replaced based on usage: Motor Box, Transfer Case, Flywheel Case, Subject Load Device, Electronics Box and Treadmill Assembly, Roller Bearing Assemblies, Corner Bracket Ropes and after 1 year: Isolation Restoration Bungee Assemblies (IRBA), Gyroscope Wire Ropes.

**2.7.6. Data/Commanding Capabilities**

The use of uplinked protocols to MEC for download on personal crewmember PCMCIA cards is not often utilized due to a minimum two-minute stage limitation in the software. Instead, each subject uses the Control Panel to manually control parameters to execute their desired prescription.

The Control Panel also provides for data acquisition, electronic storage, and recall of the following parameters using the PCMCIA card:

Crewmember	Treadmill Volts
Belt speed	Treadmill Amps
Restraint force (If SLDs operational)	VIS Volts
Distance	VIS Amps
Elapsed time	Stabilizer Amps
Achieved heart rate	Gyro Amps
Actual protocol performed	Gyro Speed
Pitch and Y gain	Gyro Status
Electronics Box Temperature	Stabilizer Fault Messages
Motor Box Temperature	Real-Time Clock

The same data is stored whether in motorized or passive mode. The Tread speed is the actual speed the belt is rotating at, measured by a tachometer in the Electronics Box.

Memory capacity is 4 MB per memory card (approximately four TVIS Sessions). All stored data can be downloaded to the MEC computer and downlinked to the ground as bar-delimited ASCII files (see Section 2.5.5.1 for file extensions and locations on the MEC). Data download is scheduled daily in order to prevent card from surpassing 4 MB capacity, in which instance the card header becomes overwritten and card functionality is lost.

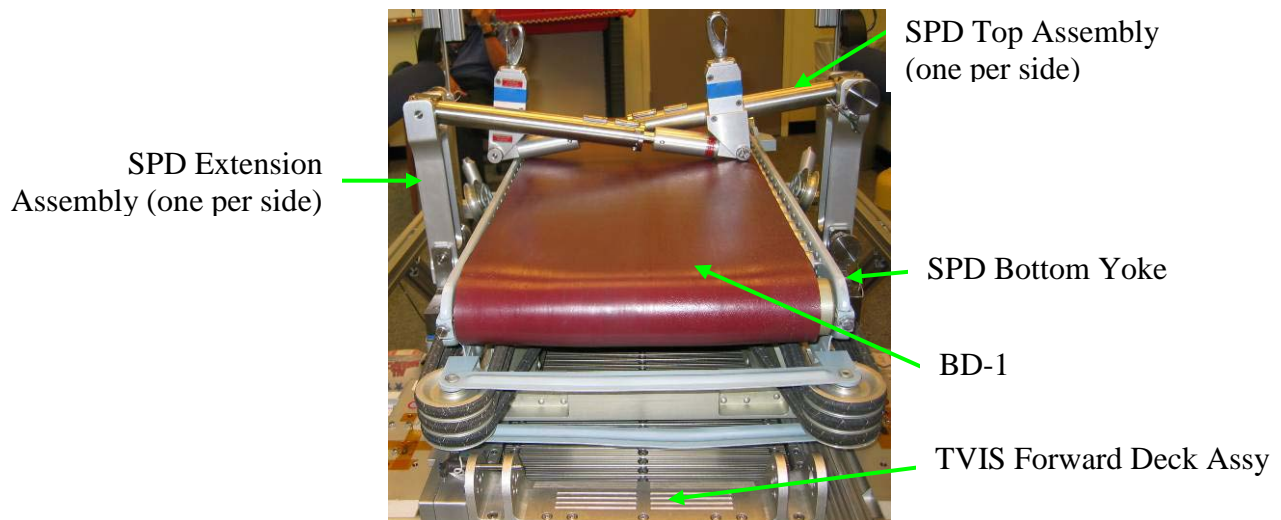
**2.7.7. Hazard Concerns**

*Note: Refer to Phase II Safety Data Package for details on hazards.*

**2.7.8. Failed/Obsolete Hardware**

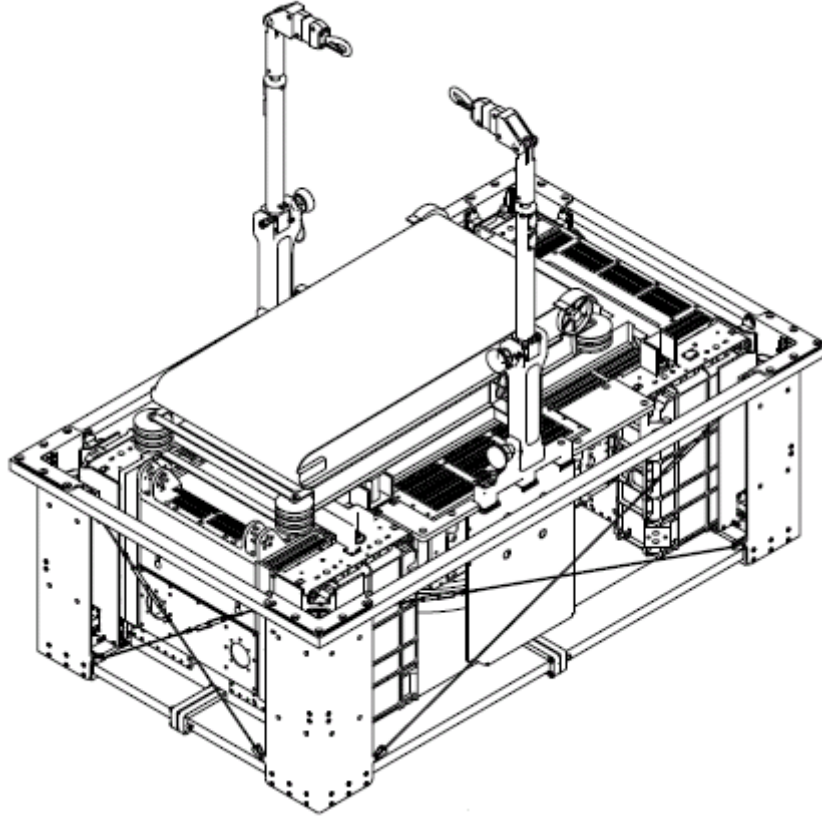
**2.7.8.1. BD-1 (Russian Treadmill)**

BD-1 is a Russian Treadmill (passive) that was launched on 9S (2004) and mounts on top of TVIS Chassis as a contingency. It provides its own loading system, but BD-1 Installation and Operations requires a fully functional Vibration Isolation and Stabilization System (TVIS Maintenance activities will be impacted if БД-1 is installed). An integrated Activation and Checkout has been developed by the CMS community. There are two Russian BD-1 compatible harnesses (flown on 16P) on board to support BD-1 Activation and Check-Out (ACO). BD-1 Installation requires the CES Installation Kit. BD-1 Operations requires the SPD Extension Assemblies (two) to attach the SPD Bottom Yoke and the SPD Top Assemblies.



**Figure 33. BD-1 Mounted on TVIS with SPD Extension Assemblies**





**Figure 34. Drawing of BD-1 Mounted on TVIS with SPD Extension Assembly**



## 2.8 Treadmill 2 (T2)

### 2.8.1. T2 Description

Treadmill 2 (T2) is the second generation ISS treadmill intended for use by USOS crewmembers. T2 is a modified COTS Woodway Path treadmill. It was designed to allow walking and running exercises between 1.5 mph and 12.4 mph. T2 was also designed to minimize the transfer of dynamic forces caused by use of the treadmill to preserve the microgravity environment of ISS as well as minimize loads imparted to station structure.

T2 flew on 17A in the MPLM. Lifetime of T2 is expected to be 10 years. Bioastronautics provided the Treadmill, International Standard Payload Rack (ISPR), Avionics system, Contingency SLDs (aka Series Bungee System), and Ground Support Equipment (GSE). Boeing provided the vibration isolation system. ESA provided the subject loading device.

### 2.8.2. T2 Component List and Description

#### 2.8.2.1. T2 ORU

Treadmill 2 belt, belt housing and motor is a single ORU. The treadmill belt flew uninstalled on the 17A Flight. The motor was intended to fly with the belt, but on 17A and future flights, the motor box will fly separately because the installed configuration of the motor box did not pass launch vibration testing.

Once installed, the treadmill sits 4 inches above the rack face. The T2 rack is approximately 1400 lbs. without any components installed. With all components, ballasts, and handrails installed the rack is approximately 2230 lbs.

#### 2.8.2.2. T2 Vibration Isolation System

The T2 rack is isolated from the station structure via a passive vibration isolation system (VIS) that requires no ISS resources or data interfaces to perform its functions. The VIS component is comprised of Snubber cups and pins along with X, Y, Z and Upper Isolators designed to provide passive vibration isolation, resulting from the ISS crewmembers utilizing the treadmill, between the T2 Rack integrated assembly and the ISS Node 3 structure. In addition, the VIS provides a utility interface panel and umbilicals to facilitate the transfer of ISS resources to the T2 Rack integrated assembly, the transfer of Fire Detection System and Maintenance data and fan speed from the T2 Rack integrated assembly to the ISS, and the transfer of heat from the T2 Rack integrated assembly to the ISS Thermal Control System.

The VIS shall locate and control the position of the T2 Rack Integrated Assembly such that the combination of the ISPR Rack and VIS does not contact adjacent racks, standoff structures, or hardpoints and does not allow the ISPR rack to translate more than +/- 1.0 inches in the x and y directions and +/- 0.75 inches in the z direction from its nominal uploaded null-centered position under expected on-orbit environments and conditions.

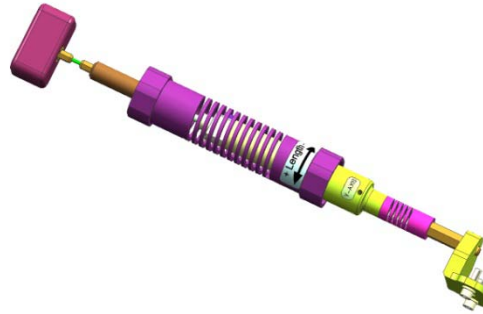
##### 2.8.2.2.1. Passive Rack Isolation System (PaRIS) Isolators

There are a total of eight modified PaRIS isolators that isolate the T2 rack from the station structure. The isolators were modified for assembly attachment points and interface requirements. Six isolators are installed on the bottom of the rack (2 in each direction x, y and z) and 2 isolators on the top of the rack. Each isolator contains a glass

dashpot, which are not visible because they are contained in metal housing. While the isolators themselves are the same, the attachment points are not. Thus x, y, z, and upper isolators are not interchangeable between the different axes. An isolator failure would be difficult to detect due to the concealed nature of the inner components. Isolators have a 3 year life span.



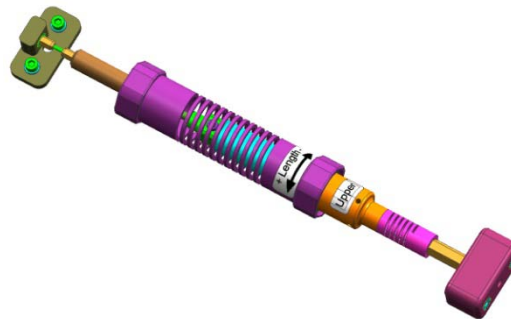
X-Axis Isolator



Y-Axis Isolator



Z-Axis Isolator



Upper Isolator

#### **2.8.2.2.2.3 T2 VIS Alignment Guides**

The Snubber Cup Alignment Guides provide a mechanical lock-down of the T2 Rack when the system is not in use in order to protect T2 and Node hardware from loads induced by high-G station events and inadvertent crew kick loads/rack push-off. A new design of the cups was installed during the Node 3 relocation so the VIS can be locked and unlocked in a single hand operation. Because of this, the Snubber Knobs no longer have to be actuated between “Normal” and “Alignment Guide R&R.” The permanent location of the Snubber Knobs is normal so the crew has applied gray tape to hold them in this configuration. Should the Snubber Knob slip out of the “Normal” position and into the “R&R” position, the sway space around the Snubber Pin is increased by +/- 0.25 inch. This is not a nominal configuration for exercise, and increases the risk of T2 bumping an adjacent rack and/or hyper-extension of the VIS isolators.

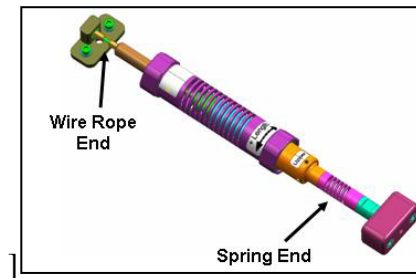
#### **2.8.2.2.3. T2 Snubber Assembly**

Each of the four T2 Snubber assemblies include a Snubber, Snubber Cup (lined with sorbothane to prevent metal-to-metal contact), Snubber Pin, and 3 thumbwheels/jam nuts

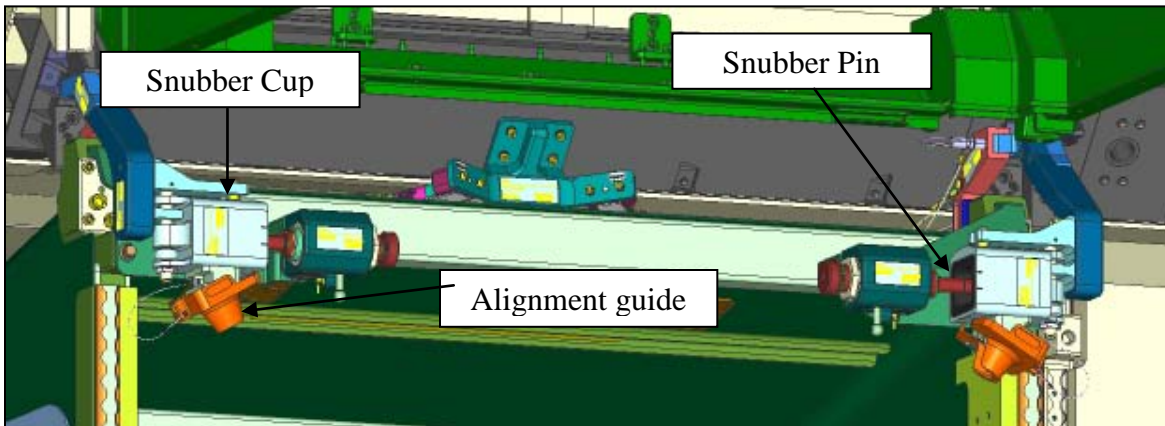
for each X (left-right),Y(in-out),Z direction (up-down). Snubbers are also used to align the rack. For alignment, the rack is secured in a known centered condition using the Spacer Bars (bottom of the rack) and Stabilizers (top of the rack). During alignment the thumbwheels are used to adjust the snubber pin so that it is centered within the snubber cup. Alignment in the Y,Z direction is considered achieved by positioning the snubber pin in the middle etch marks on the snubber cup. Alignment in the X direction is aided by positioning the etch mark on the snubber pin with the extended/long edge of the snubber cup. Thumbwheels are secured in position with jam nuts.

T2 rack centering occurs after alignment. Spacer Bars and Stabilizers are removed to allow the rack to float freely. Then as necessary, the X, Y, and Z isolators are adjusted such that the snubber pins align with the respective etchings on the Snubber Pin (X direction) and Snubber Cup (Y,Z direction).

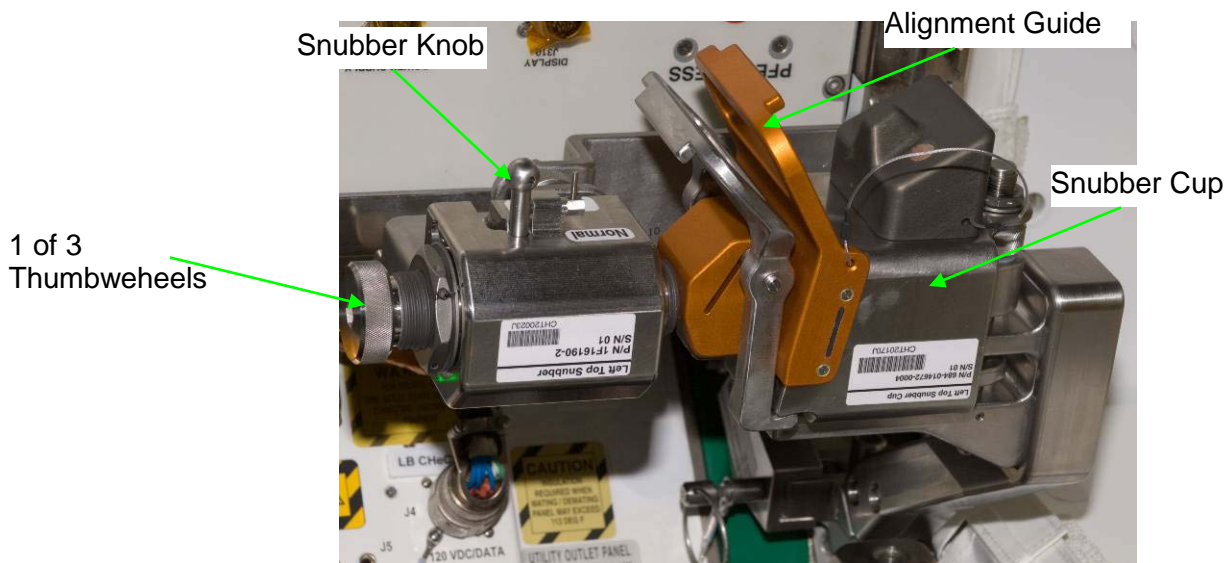
The T2 rack requires 1” clearance in the Y- and X-direction, 3/4” in Z-direction in the rack bay location for VIS sway space.



**Figure 1. T2 Isolator (all are not identical)**



**Figure 2. Top of Rack – Snubber Configuration.**



**Figure 3. Snubber, Snubber Cup, and Alignment Guide Locked**



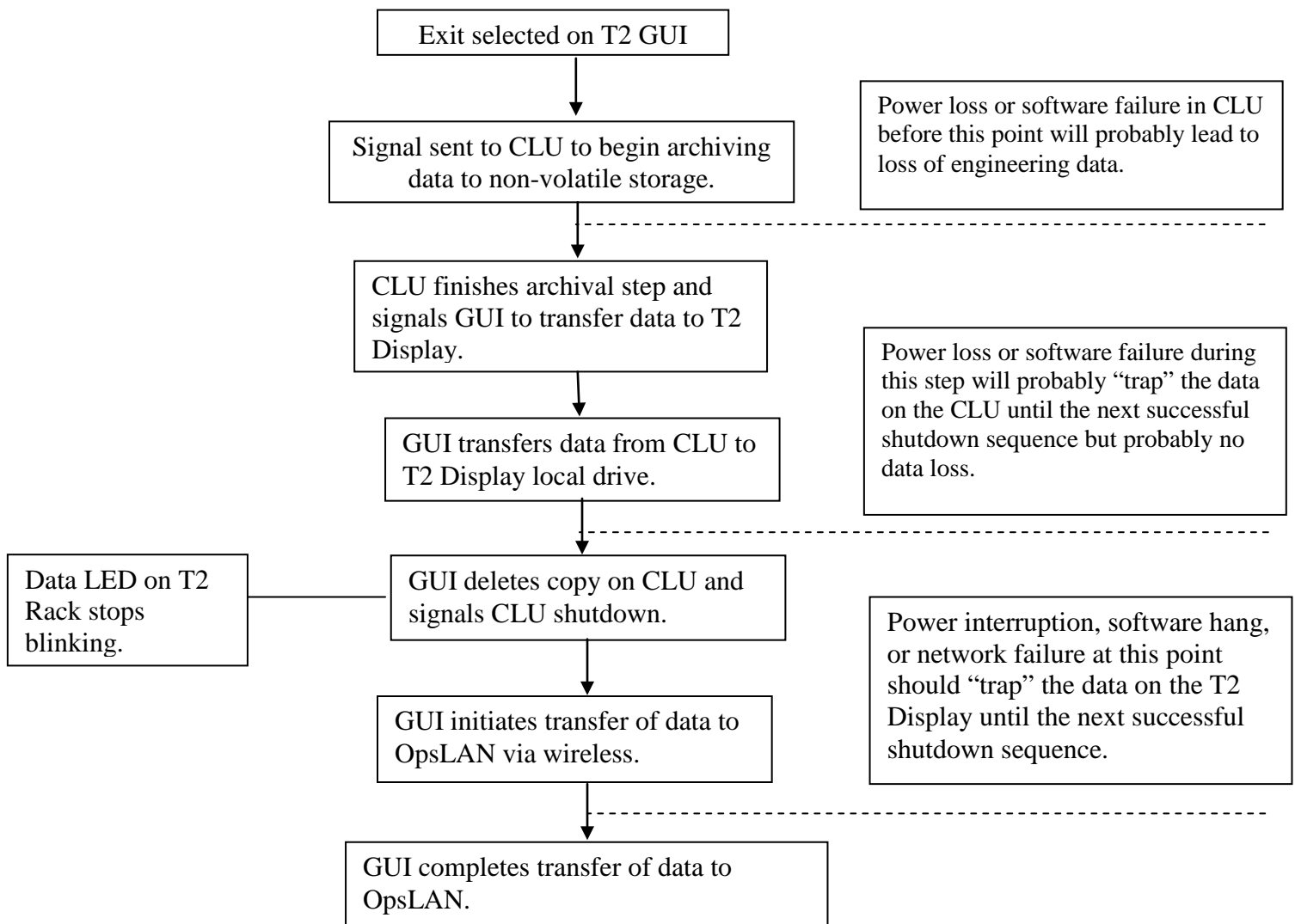
**Figure 4. Snubber, Snubber Cup, and Alignment Guide Unlocked**

**2.8.2.3. T2 Display**

The T2 Display provides a touch-screen crew interface for the crew and provides data transfer to the ISS LAN. The T2 Display is required during active or passive mode exercise. The T2 display’s use establishes connection with the Command Logic Unit (CLU). T2 prescriptions are nominally uplinked to the Server in a single file per crewmember. Protocols are nominally retrieved by the T2 Display via wireless transfer on power-up and marked as rcvd (Received) on the Server. Protocols are completed incrementally, but at start-up the crew can choose to perform the protocol or exercise in manual mode. Once the protocol has started, the stage the runner is completing can be adjusted manually, but when the stage expires (the time allotted to the specific stage), the next stage of the protocol will start automatically, so manual changes would need to be made again. Protocols are marked complete after 75% has been completed.

The software requires downlink of the exercise information immediately prior to uplink of new protocols because of the way the software was written. That is, each protocol is marked completed within the file that contains all protocols. Since this file is overwritten when new prescriptions are uplinked, it is necessary for the ground to mark which exercises were completed in the new protocols so the crewmember stays with the regimen prescribed by the ASCR. This feature will be fixed in the next version of the software hopefully during 2011.

Logging off the T2 exercise application will require a rack power cycle in order to re-establish connection between the Display and the Command Logic Unit (CLU) within the treadmill. If the power cycle does not happen, the Display cannot communicate with the treadmill because the CLU is powered off; therefore, engineering data will be lost. Figure 5 shows the data flow path when exiting the software.



**Figure 5. T2 Data Flow Path When Exiting Software**

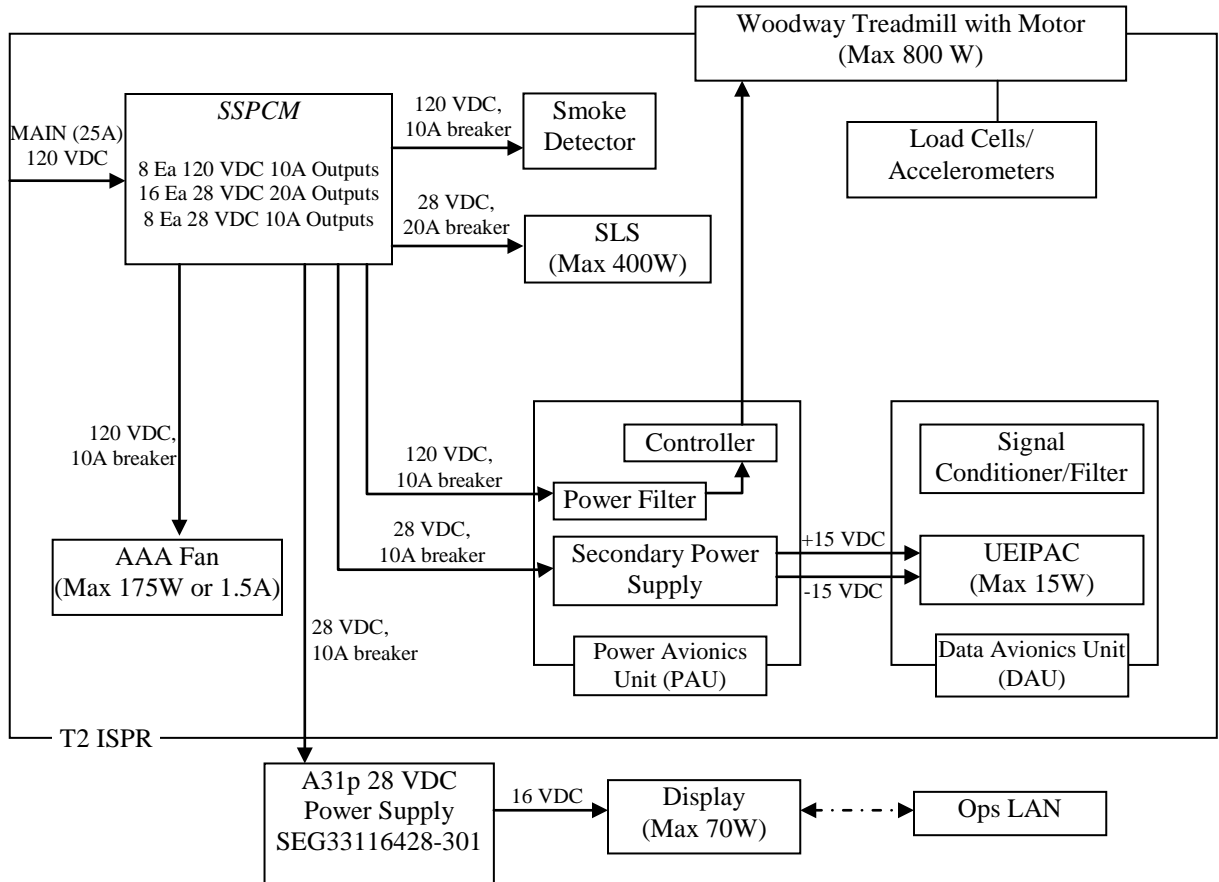
The Display is powered by an A31p 28V DC Power Supply (“Emerald Brick”). It cannot operate via battery power. The Display does have a CMOS battery.

Information on the T2 Software can be found in the **Software User Guide For the International Space Station (ISS) Second Treadmill (T2) System** (JSC-64745).

Data downlinked is typically one big .tgz file for each GMT which contains an engineering logs and all the T2 exercise data for each crewmember that exercised while T2 was powered on. The file is named something like 2920\_t2.tgz with the 292 being the GMT and the 0 referring to which power cycle we are on. If the crew power cycles again that same GMT, then you will get a second big tgz file with a new engineering log and the new T2 exercise data from the crewmembers that exercised after the power cycle. The file will then be named 2921\_t2.tgz. You can have up to 9 tgz files in one GMT since the files would essentially be named XXX0\_t2.tgz through XXX9\_t2.tgz. The engineering log contains the engineering health of the system while the data for the crewmembers is a .tgz file. When the .tgz file is opened, the data will appear by stages in the form of snapshot files. If a crewmember exercises in manual mode, only one data capture is taken at the beginning so only one snapshot file will be present.

**2.8.2.4. T2 power**

T2 Rack Power is provided by an SSPCM that receives 120VDC. Once rack power is established, all T2 rack components are powered. This includes the AAA, SD, Treadmill Motor, Data Avionics Unit (DAU), Power Avionics Unit (PAU), and the A31p 28 VDC Power Supply, which powers the T2 Display.



**Figure 6. T2 Power Flow**

**2.8.2.5. T2 Instrumentation**

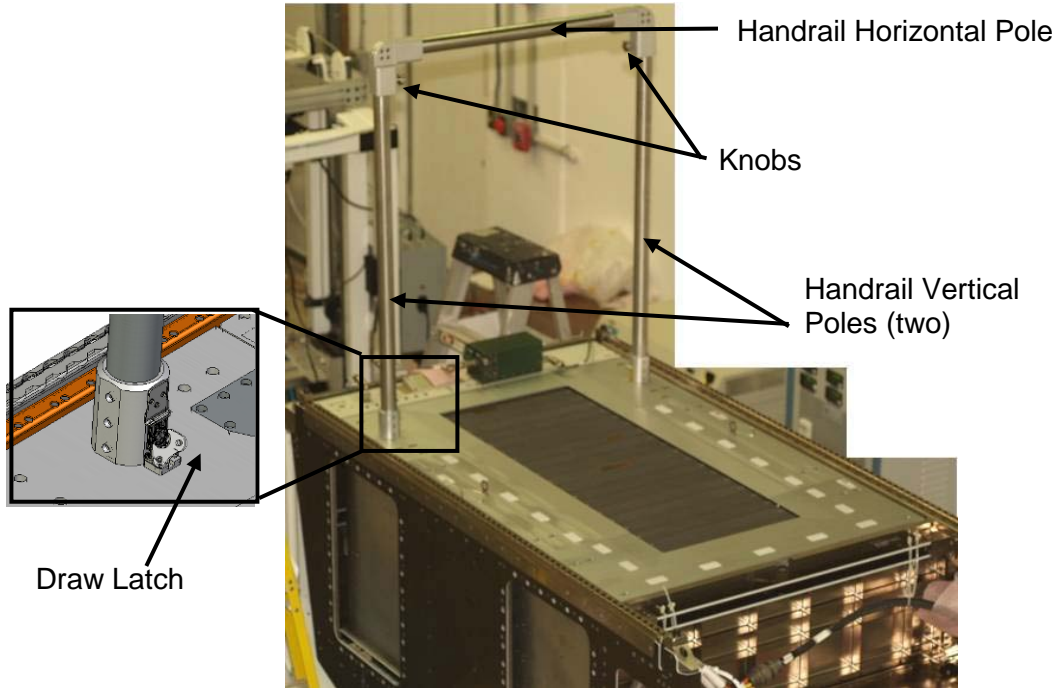
The Data Acquisition Unit (DAU) collects hardware information during sessions, which includes, but is not limited to, the following: motor temperatures, bearing temperatures, load cell data, accelerometers, subject load, subject pressure, and bus voltages and currents.

There are 4 load cells in the rack that measure footfall forces. Accelerometers are also embedded in the rack and measure rack acceleration response and detect perturbations of isolation.

**2.8.2.6. T2 Handrail**

There are three pieces that make up the handrail. The two vertical components can be installed without the horizontal piece--if this configuration is used, the pole endcaps must be installed on the vertical poles.





**Figure 6. T2 Handrail Components Installed.**

If the Handrail is not installed, Handrail Fillers are onboard to prevent FOD from entering the treadmill.



**Figure 7. T2 Handrail Filler**

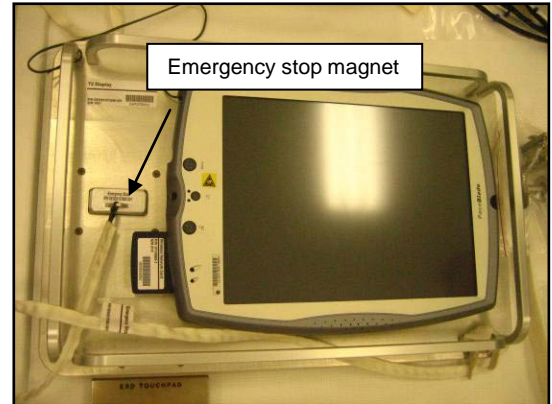
**2.8.2.7. Subject loading**

Delivery of the ESA provided Subject Loading System (SLS) is still TBD. Until the SLS is available, Series Bungee Systems (SBS) will be used. These are attached to the treadmill harness on one end, and on the other, attach to eyebolts located on the left and right closeout panels of the treadmill. Exercise sessions can be paused to adjust the load on the crewmember’s harness.

### **2.8.2.8. Emergency Stop Magnet**

The Emergency Stop magnet is located on the Display Panel. Pulling the magnet will pull power from the treadmill motor. The belt will slow down with natural resistance in the system once power is removed.

If the magnet is pulled, it will take 30 seconds for the “resume” button to pop-up for the crew to continue their exercise session due to a communication delay internal to the system.



**Figure 8. T2 Display launch configuration**

## ***2.8.3. Hardware Interfaces with Vehicle***

### **2.8.3.1. Internal Thermal Control System**

T2 is connected to the MTL loop of the ITCS. Cooling is required for the T2 DAU and the Treadmill itself. Both pieces of hardware are exposed to ducts from the AAA which provide direct cooling.

### **2.8.3.2. Power interface**

In Node 3, T2 rack components are powered via RPCM N31B4A C1 RPC 02.

### **2.8.3.3. Data interface**

T2 data is transferred to the SSC file server on the ISS LAN when a user exits out of the T2 exercise application (or the emergency stop button is pulled).

## ***2.8.4. Resupply Schedule***

Treadmill Harnesses are flown as needed for each crewmember. SBS Bungees are replaced every six months. The Alvania RL2 lubricant that is required for annual maintenance procedure is flown every year for one-time use.

## ***2.8.5. Data/Commanding Capabilities***

### **2.8.5.1. T2 Rack Telemetry**

The following parameters will come down via S-band:

- Smoke Detector Obscuration
- Smoke Detector Scatter
- Rack Power
- Treadmill 2 Rack AAA Fan Failure (Node 3)
- Treadmill 2 Rack Overtemp (Node 3)

Caution and Warning parameters exist for the following failures:

- FIRE – Treadmill 2 Smoke Detector
- Treadmill 2 Smoked Detector Active BIT Fail
- Treadmill 2 Smoked Detector Lens Contamination
- Treadmill 2 Smoked Detector Fail

Annunciation of the FIRE – Treadmill 2 Smoke Detector C&W will result in an automatic shutdown of the T2 Rack.

#### **2.8.5.2. HRM receiver:**

There is a receiver on the face of the T2 rack that collects heart rate data from the HRM2 transmitter.

#### **2.8.5.3. Modes of operation:**

**Prescription Mode:** Runner uses the uplinked protocol files. Currently all protocols are active mode. A software glitch (which will be fixed hopefully 2011) only allows one passive protocol to be prescribed so ASCRs are not prescribing them in the protocols. Rather, they are having crewmembers exercise in passive manual mode.

**Manual:** Runner overrides prescription mode. Manual mode sessions are 30 minutes in length.

**Active mode:** Motorized mode with variable speed (no protocol is used). Starting default speed in Active mode is 3 mph (4.8 km/h)

**Passive mode:** Unmotorized mode with variable resistance (no protocol is used). Starting default resistance in Passive mode is 6.7lbf (30N). The minimum resistance is 6.7lbf (30N), and the maximum resistance is 36.7 lbf (163.5N).

**Unpowered Passive:** The runner drives the belt (only resistance is constant rolling friction of the belt).

**2.8.6. Hazard concerns**

Below is a list of the T2 OCADs:

61287	D. [OPERATIONAL CONTROL] The crew is instructed to avoid reacting loads (pushing) against surrounding structures outside of the T2 System in order for the VIS to adequately isolate runner induced loads to the station. If the handrail is used in Node 2, the crew is instructed to remove the handrail once exercise is complete if the treadmill is not used for more than 1 hr. If the handrail is used in Node 3, the horizontal portion must be installed as well.
61290 revision 522	B. [OPERATIONAL CONTROL] The crew is instructed to wear gloves during application of the Alvania RL2 lubricant to the treadmill bearings. The crew will then clean-up any excess grease around the edges of the bearing with dry-wipes. Used dry-wipes, grease dispenser and gloves shall be disposed in a Ziploc bag and placed within an additional Ziploc bag for proper containment of the lubricant.
61291 revision 527	B. [OPERATIONAL CONTROL] The crew is instructed to wear hearing protection while running on T2. The crew is also instructed wear hearing protection if in the Node (Node 2 initially and then Node 3 for T2 relocation) during other crewmember’s treadmill exercise. If the crew chooses to listen to music while running on T2, it is required that a passive Hearing Protective Device (HPD) with insert speakers for music be used. Note that this OCAD may be updated after on-orbit acoustic measurements for T2 are made.
61292	A. [OPERATIONAL CONTROL] The crew is instructed to not be in the Node 2, Port 5 crew quarters (CQ) while the treadmill is being used in Node 2 during the passive or unpowered mode as the handrail may be deployed and interfere with emergency egress due to the horizontal portion of the handrail blocking the CQ.
61315	[OPERATIONAL CONTROL] The crew is instructed to avoid the surrounding gaps between the T2 rack and adjacent structures while another crewmember is running on T2 as there is a potential for pinch points and entrapment.
61226	[OPERATIONAL CONTROL] When the treadmill is not in operation, the alignment guides will be installed to cover access to the snubber cup.
61229	[OPERATIONAL CONTROL] The four snubber cup alignment guides will be removed prior to crew use of the treadmill.

# **3. Environmental Health System (EHS)**

- 3.1. Acoustics Countermeasures**
- 3.2. Microbiology and Water Quality**
- 3.3. Radiation Monitoring**
- 3.4. Toxicology**

## 3.1. Acoustics Countermeasures

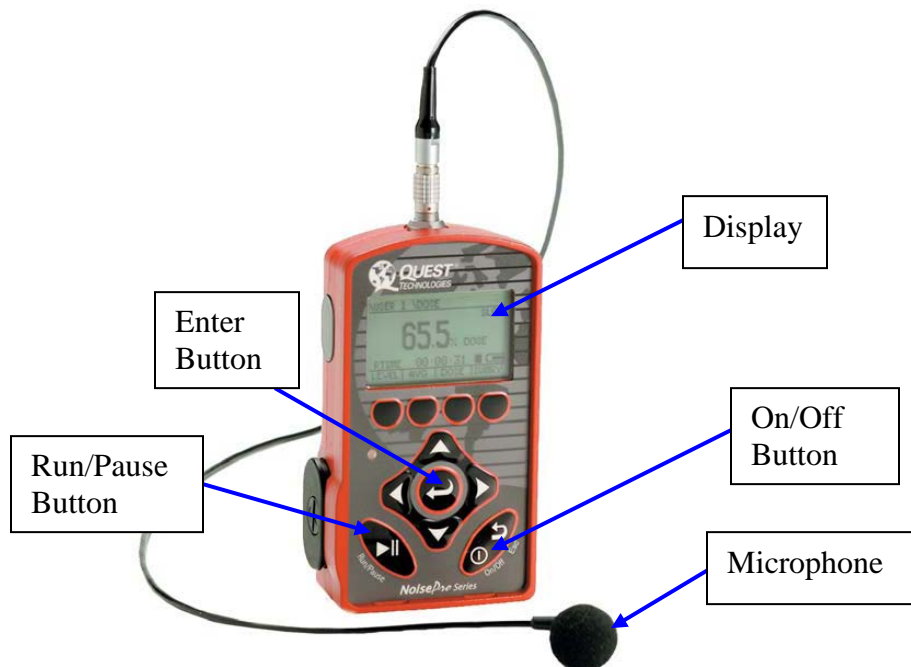
Acoustic countermeasures consist of Sound Measurement Hardware used to measure noise levels onboard the ISS and an assortment of Hearing Protection Hardware used for activities and personal use. These items were previously flown in the Sound Measurement Kit and the Active Noise Reduction (ANR) Headset Kit. They are now flown separately and on an as needed basis.

### 3.1.1 Sound Measurement Hardware

The Sound Measurement Hardware is used for on-orbit measurements onboard the ISS. They were previously packed together in a kit but due to transportation limitations the kit will no longer be flown and the hardware will be sent up separately on an as needed basis. These items may be stowed inside the previously used Sound Measurement Kit.

#### 3.1.1.1 Acoustic Dosimeter (Modified COTS)

The Acoustic Dosimeter is a Quest NoisePro DLX-1 dosimeter that is used to measure and monitor crew exposure to ambient noise as they perform nominal activities throughout the ISS. The monitoring will also be used to characterize the internal acoustic environment of ISS, to ensure that hardware acoustic levels have been met, and to assist in the implementation of effective countermeasures to reduce or eliminate crew exposure to high noise levels. The dosimeter can be used to give an instantaneous noise level reading, compute an average noise level over time, and determine the maximum noise level during dosimeter operation.



**Figure 1. Acoustic Dosimeter**

The Acoustic Dosimeter has a backlit 128 x 64 graphical Liquid Crystal Display. It is battery powered by two AA alkaline batteries, which will allow the unit to run for 70 hours when neither the display backlighting nor the optional vibrating belt clip is used. If one of the backlighting

options is selected or the vibrator alerts are triggered, then the battery lifetime is substantially decreased. When the instrument is on, the lower right corner displays a battery icon, indicating the remaining battery life. When battery power gets down to an estimated eight hours of run time, the battery icon is replaced by the word “LOBAT”.

The settings on the dosimeters are preprogrammed prior to flight, and are locked from inadvertent changes. Internal non-volatile memory allows for a maximum 48 hours of data storage. A Lithium button battery will maintain the clock and internal memory for 1-2 years. The dosimeter is capable of providing dBA values for each 1 minute interval during the selected sampling period. Data can be recalled on the display or downloaded via the Acoustic Dosimeter Data Receiver (Figure 3), an infrared serial interface.

The Acoustic Dosimeter is supplied with a protective cover that protects the entire face of the Acoustic Dosimeter. This cover utilizes hook and loop as hinge points and be attached to the face of the Acoustic Dosimeter with hook and loop (Figure 2).



**Figure 2. Protective Cover on Acoustic Dosimeter**





**Figure 3. Acoustic Dosimeter Data Receiver**

**The Acoustic Dosimeter can be used:**

- To obtain the A-weighted decibel (dBA) levels of crewmembers’ exposure over 24 hours.
- To determine the average noise level at a certain location over a 24 hour period.
- To obtain an instantaneous analysis of noise if the sound level meter malfunctions.
- To obtain a maximum value recorded by the microphone over a 24 hour period.

The dosimeter can measure several parameters. Below is a list of the parameters recorded for each measurement session:

- SPL – sound pressure level
- MAX – highest level sampled during the run time
- Dose % - percentage of the maximum allowable exposure to accumulated noise
- Lavg – average sound level measured over the run time
- Time – measurement run time, hours: minutes

The crew can utilize the Acoustic Dosimeter as they see fit to determine the actual noise levels at any time. This will indicate whether or not they should be using hearing protection.

**Acoustic Dosimeter Components List**

- Acoustic Dosimeter
- Microphone (clip-on)
- Acoustic Dosimeter Data Receiver

**Table 3.1.1.1-1 General Hardware Specifications**

<b>Kit and Component List</b>	<b>Mass M(E)</b>	<b>Volume M(E)</b>	<b>Dimensions M(E)</b>	<b>Nominal Stowage Location</b>	<b>Storage Temp °C (°F)</b>	<b>Operating Temp °C (°F)</b>	<b>Operating Pressure mmHg (psia)</b>
Acoustic Dosimeter	0.4 Kg (0.875 lbs)	331.8 cm <sup>3</sup> (20.25 in <sup>3</sup> )	6.9 cm x 12.7 cm x 3.8 cm (2.7” x 5” x 1.5”)	In the Sound Measurement Kit	-25 - 60°C (-13 - 140°F)	-10°C-50°C (14 - 122°F)	13.5-15.2 psia

**Table 3.1.1.1-2 Hardware-Specific Parameters**

Power Requirements	2.0-3.0V; 1.5V AA alkaline batteries (two)
Power Source	Battery
Measurement Parameters/ Analysis Capabilities	Operating Ranges: 40-140 dB
Indicators for Out-of-Range Parameters	O <sub>L</sub> - the signal was too large and an overload occurred. U <sub>R</sub> - the signal was too small to be separated from instrument noise.

### **3.1.1.1.1 Hardware Interfaces with Vehicle**

The Acoustic Dosimeter will be worn by crewmembers for periods of 24 hours at a time to measure typical exposures to noise on ISS. The device can be stored in a pocket or clipped to the crewmember's clothing. The microphone has a separate clip allowing placement on the collar or lapel so that it is in close proximity to the crewmember's ear.

The Acoustic Dosimeter will also be deployed at specific locations via Velcro inside the ISS for 24 hours to collect data on noise levels in static locations onboard.

### **3.1.1.1.2 Resupply Schedule**

- All 3 dosimeters will be re-supplied every 2 years, prior to when the calibration life expires.
- Dosimeters are resupplied to ISS without batteries.
- Calibration of dosimeters is performed by the vendor after return.
- Post Shuttle retirement Dosimeters will no longer be returned. Units will be trashed on a Progress flight after they have passed their calibration life.

### **3.1.1.1.3 Data/ Commanding Capabilities**

The data can be transferred via the Acoustic Dosimeter Data Receiver, an infrared serial interface to a T61p SSC.

### 3.1.1.2 Sound Level Meter (Modified COTS)

The B&K 2260 Investigator™ Sound Level Meter is a versatile, handheld, battery-operated, two-channel sound analyzer comprising hardware and embedded operating-system software. It is the ideal platform for high-quality, real-time sound analyses. Like a personal computer, it is driven by application software for various tasks.

The Sound Level Meter is a Type 1 meter with real-time 1/1- and 1/3-octave frequency analysis and broadband statistical distributions. For storage, overview and post-flight processing, the data can be transferred to a PC using the Noise Explorer™ software where data can be displayed graphically or as tables. It is used to measure and monitor the sound in the habitable areas of the ISS.

The Sound Level Meter is used for:

- Comprehensive sound measurements
- Detailed octave and 1/3-octave band analysis
- Appraisal of noise reduction efforts
- Gathering field data for further analysis
- Research and Development



Figure 1. Sound Level Meter

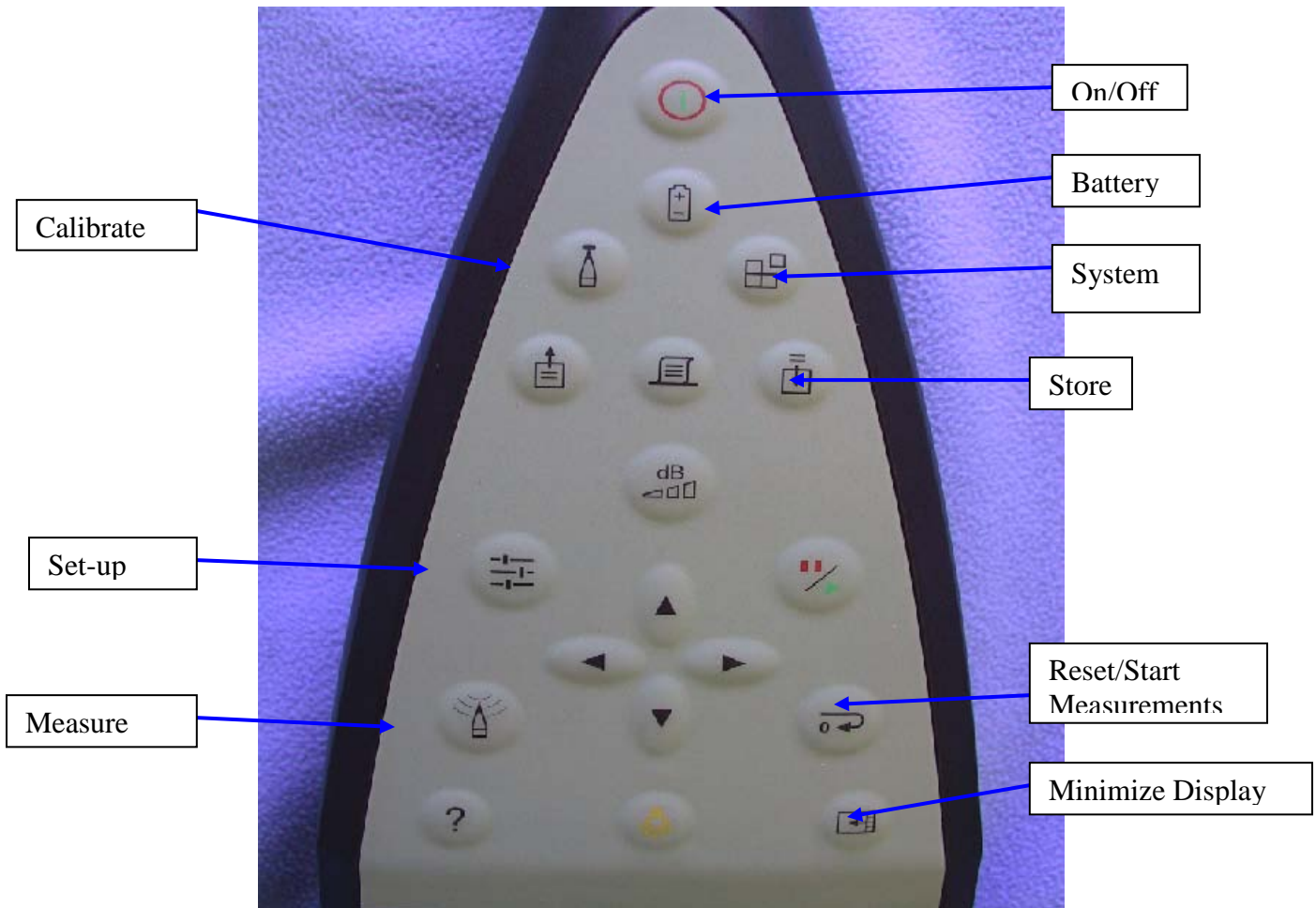


Figure 2. SLM Front Panel Pushbuttons

#### 3.1.1.2.1 Sound Level Meter Components

- Sound Level Meter
- Windscreen
- RS-232 Cable

The Sound Level Meter has a back-up battery for running the clock, even when the analyzer is switched off or the main batteries are removed. The back-up battery is automatically charged when there are batteries in the analyzer. It is fully charged upon delivery from the factory and runs the clock for about 3 months. If the back-up battery is flat, the next time fresh batteries are inserted, it will automatically switch on and boot up. However, the date and time will need to be re-entered.

**Table 3.1.1.2.1-1 General Hardware Specifications**

Kit and Component List	Mass M(E)	Volume M(E)	Dimensions M(E)	Nominal Stowage Location	Storage Temp °C (°F)	Operating Temp °C (°F)	Operating Pressure mmHg (psia)
Sound Level Meter	1.2 Kg (2.65 lbs)	1809.6 cm <sup>3</sup> (110.4 in <sup>3</sup> )	29 cm x 12 cm x 5.2 cm (11.4" x 4.7" x 2")	In the Sound Measurement Kit	-10 – 50° C (14-122° F)	-10 - 50° C (14 -122° F) (For a ±0.5 dB error margin)	No sealed compartments; no pressure issues

**Table 3.1.1.1.2.1-2 Hardware-Specific Parameters**

Power Requirements	6 C-cell alkaline batteries provided from the ACK after approx. 8 hrs. usage (4 sampling sessions). New and old batteries should not be installed in combination in the Sound Level Meter. Total voltage of all 6 batteries should be between 6.2V and 15V.
Measurement Parameters/ Analysis Capabilities	Spectral Sound (acoustic pressures) measurements
Indicators for Out-of-Range Parameters	Performs internal autocal (included in procedures)

**3.1.1.2.2 Hardware Interfaces with Vehicle**

The Sound Level Meter never interfaces with the vehicle, only the crewmembers.

**3.1.1.2.3 Resupply Schedule**

The Sound Level Meter is resupplied every 2 years. Sound Level Meter calibration is performed during the first usage of the Sound Level Meter.

**3.1.1.2.4 Data/ Commanding Capabilities**

The Sound Level Meter stores data internally, which is downloaded to an SSC via an RS-232 cable found in the Sound Measurement Kit and a T61p USB to Serial Cable. There are no commanding capabilities.

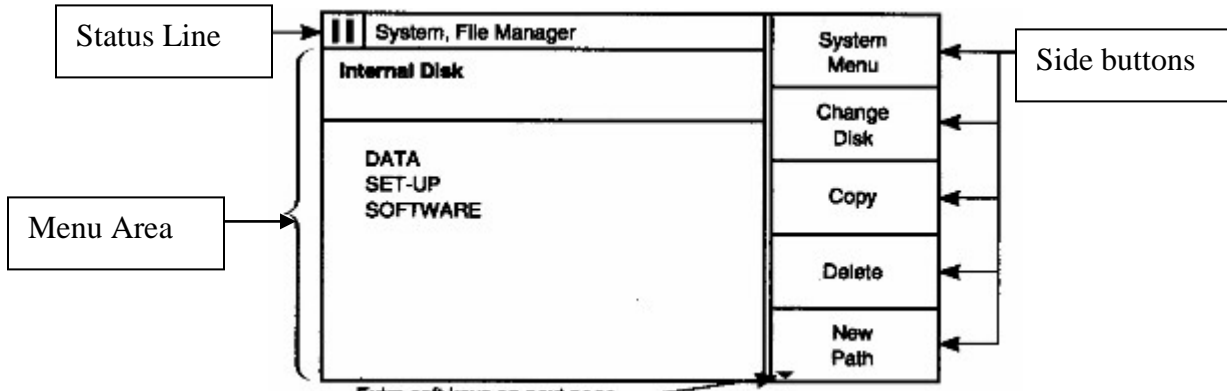
**3.1.1.2.5 Hazard Concerns**


N/A

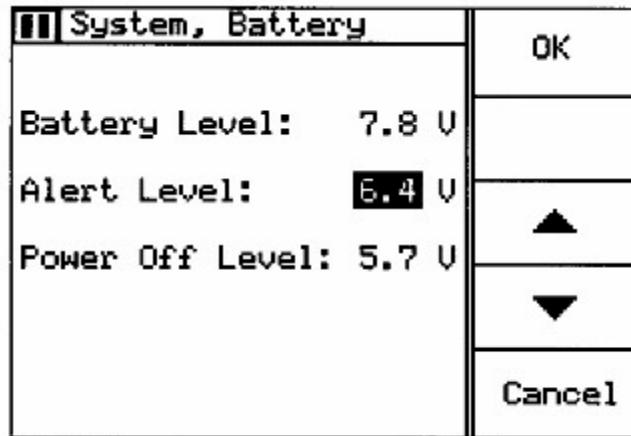
**3.1.1.2.6 Displays**


The Sound Level Meter has many displays. The displays can be accessed with front panel pushbuttons and side buttons. After pressing one front panel pushbutton, several displays can be accessed by pushing different side buttons.

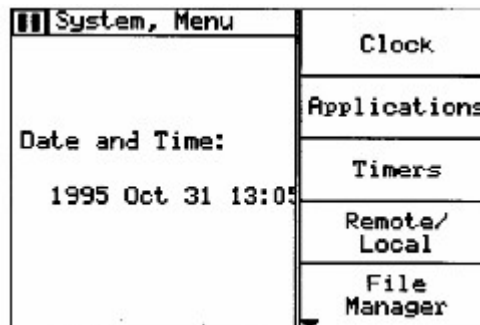
General Menu Structure:



Battery  : Displays the battery voltage screen to check the status of the batteries.

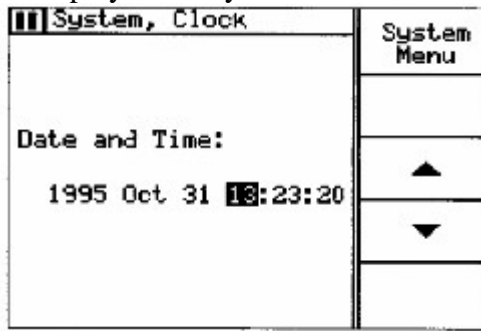


System  : Displays the system menu for configuring the analyzer.



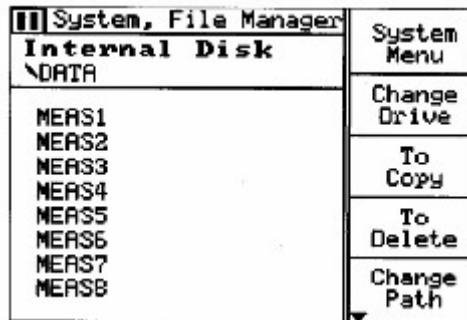


Press Clock (side button): This display allows you to set the measurement activity date and time.




Press System Menu (side button) to return to System display.

Press File Manager (side button).

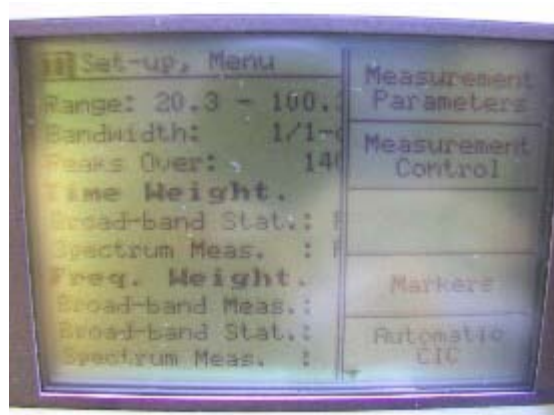


The Sound Level Meter from the factory is set with MEAS1 → directories. The Acoustics engineer deleted this directory to avoid crew confusion with saving data in the wrong directory.

Set-up  : Displays the set-up menu for changing the analyzer's set-up parameters.



Press Set-up Menu (side button): This takes you to a display for changing measurement parameters and control.



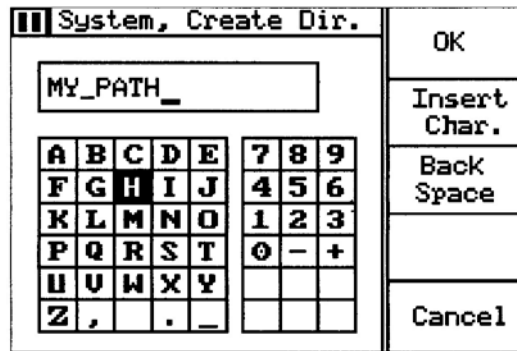
Press Measurement Control: This display shows the time required to take each measurement.

<b>II</b>	<b>Set-up, Meas. Ctrl.</b>	<b>Set-up, Menu</b>
<b>Mode:</b>	<b>Automatic</b>	
<b>Pre-set Time:</b>	<b>00:00:15</b>	▲
		▼

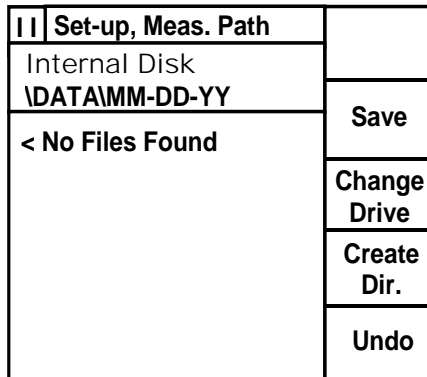
Press Set-Up, Menu (side button) and press Measurement Path (side button): This display allows you to create a new directory.


<b>II</b>	<b>Set-up, Meas. Path</b>	
Internal Disk <b>\DATA\</b>		
<b>&lt; MM-DD-YY &gt;</b>		<b>Save</b>
		<b>Change Drive</b>
		<b>Create Dir.</b>
		<b>Undo</b>

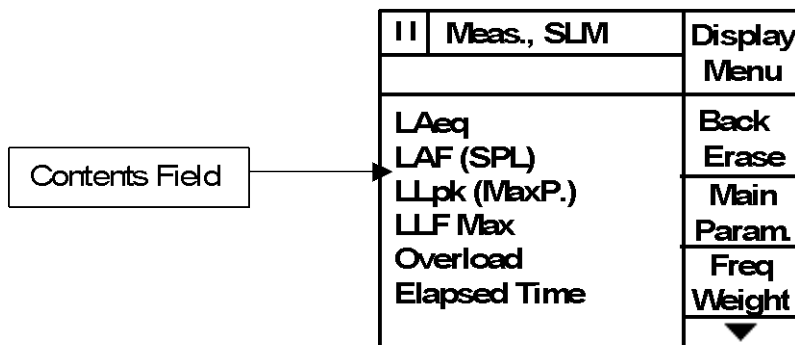
Press Create Dir (side button).



Once directory mm-dd-yy is created, using the up and down arrows to highlight the directory that you created, press the right arrow to see the display below.



Measure  : Displays the installed application's display menu for displaying measurement data.




If Laeq or Lleq is not displayed on the top line, press down arrow and see display below.

Meas., SLM	▲ Edit Display
L <sub>Aeq</sub>	Zoom Bar
L <sub>AF</sub> (SPL)	Main Param
L <sub>Cpk</sub> (MaxP.)	Freq Weight
L <sub>CF95.0</sub>	
Overload	
Elapsed Time	

Press Edit Display (side button) to see display below.


Meas., Edit Display	OK
L Leq	Edit Field
L <sub>AS</sub> (SPL)	
L <sub>Apk</sub> (MaxP.)	
L <sub>AFMax</sub>	
Overload	
Elapsed Time	Cancel

L<sub>Aeq</sub> or L<sub>Leq</sub> (1<sup>st</sup> line) can be edited by pressing Edit Field (side button).


Store  : Displays the store menu for storing data on the analyzer's internal disk.

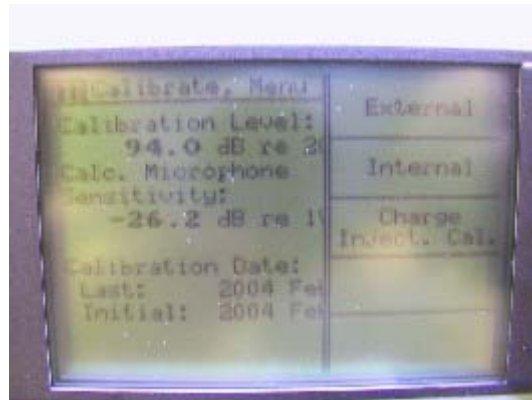
Internal Disk Field →	Meas., Store	OK
	Internal Disk	Change Path
	\DATA\MM-DD-YY	
	Store Measurement in	▲
	Data File: ####.S1B	▼
		Cancel

If folder name (mm-dd-yy) is incorrect, press change path (side button). Use left arrow to scroll until the internal disk field only shows \DATA. Then use the up and down arrow to find the correct date (mm-dd-yy).

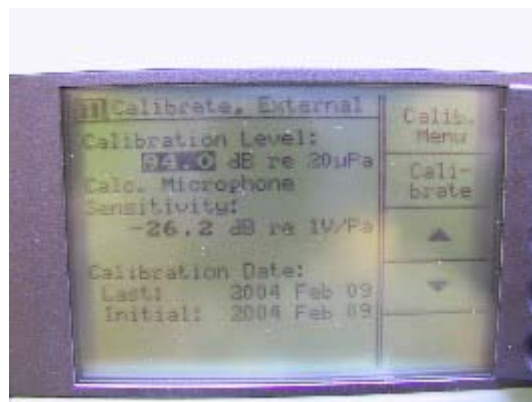
Reset/Start  : Deletes the current measurement data, sets the analyzer's internal buffer to zero and, restarts the measurement.



Calibrate  : Displays the calibration menu for calibrating the analyzer.



Press External (side button).



Pressing Calib. Menu (side button) will take you back to calibration display.  
 Press Internal (side button).



Press Charge Inject. Cal. (side button)



### 3.1.2 Hearing Protection Hardware

The Hearing Protection Hardware serves multiple functions including an On-Orbit Hearing Assessment and for use as personal hearing protection. There are 4 different kinds of earplugs and Active Noise Reduction Headphones. These items are flown separate or as part of the IMAK.

#### 3.1.2.1 Bose Headphones (COTS)

ANR Bose Headphones are Commercial Off-The-Shelf equipment. The commercial name for the headphone is the Bose® Quiet Comfort® 2 Headphone. The primary purpose for these headphones is to be used during an On-Orbit Hearing Assessment (O-OHA). The ANR Bose headphones are battery-powered, active noise cancelling headphones featuring two over-the-ear phones with replaceable cushions, connected by an adjustable headband. The left and right earcups rotate and pivot on their mounting points, allowing adjustment for maximum user comfort.



**Figure 1. Bose Headphones**

The small microphones in each earcup actively monitor what you hear, including unwanted outside sound. The difference between the unwanted sound and the desired sound is then electronically processed, creating a correction signal that acts to negate the unwanted noise. The speaker within each earcup is then fed the correction signal. This signal, combined with the passive noise reduction of the headset itself, dramatically reduces the outside noise that reaches the ears.

Input capability for audio devices (e.g. iPod, laptop) is provided via the Audio Cable. One end of the Audio cable inserts into the opening on the left earcup of the headset and the other end of the Audio cable is a standard 1/8-inch stereo mini-plug that inserts into the audio source (Figure 6). On the audio cable are “Hi” and “Lo” settings that are used to adjust the output volume of different audio sources (Figure 7). “Lo” is typically used for devices that use A/C power. “Hi” is typically used for battery-powered audio devices. The Hi and Lo settings have no effect on noise reduction. Volume adjustments must be made on the device connected to the audio adapter. If the headphones are going to be used for noise reduction only, no cable connections are required.



There is an OCAD against the battery inside the Bose Headphones that states the single AAA battery cannot remain in the Headphones for more than six months. It was determined that the Headphones are being used on a routine basis and batteries do not remain in the Headphones for that long. If the Headphones are to be stowed from use the battery must be removed.

**Bose Headphones Components List:**

- Audio Cable
- Bose Headphones Ear Pad



**Figure 2. Audio Cable connected to Headset**



**Figure 3 - Hi/Lo Switch on Audio Cable**

Although it varies by usage, one alkaline battery provides an average of 35 hours of operation. With the headphones turned on, the battery light indicator will flash when there are

approximately 5 hours of battery life remaining. The battery compartment can be accessed from the top of the right earcup (Figure 4-5).



**Figures 4-5. Headphone Battery Compartment (Closed and Open)**

#### **3.1.2.1.2 Hardware Interfaces with Vehicle**

The Bose Headphones have no interface with the ISS.

#### **3.1.2.1.3 Resupply Schedule**

The Bose Headphones will be resupplied on an “as needed” basis.

#### **3.1.2.1.4 Data/ Commanding Capabilities**

N/A

#### **3.1.2.1.5 Hazard Concerns**

N/A

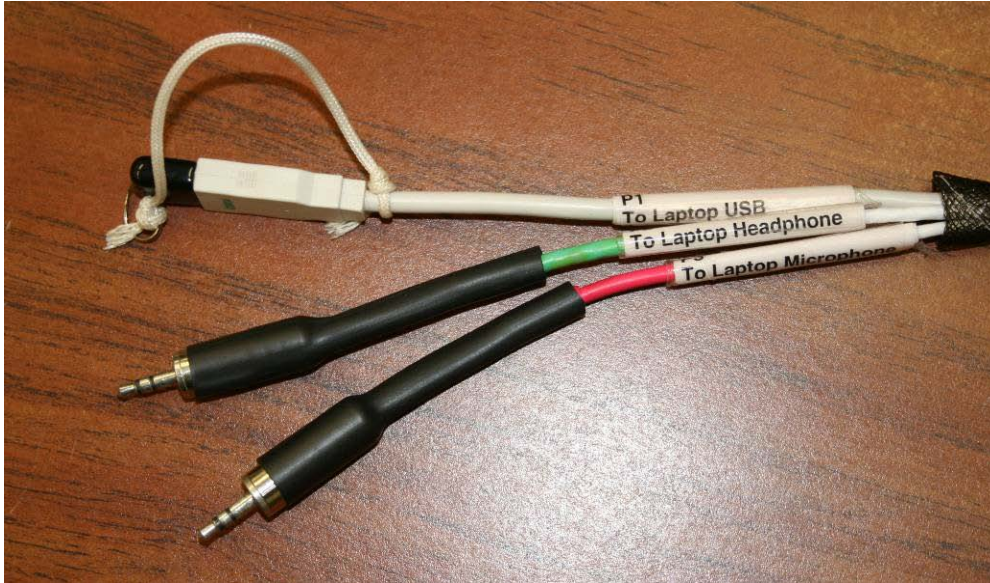
#### **3.1.2.2 Bose Headphones Integrated Cable**

The Bose Headphones Integrated Cable is an integrated cable that allows the Bose Headphones to make IP telephone calls with the T61p SSC's. It can only be used with a pair of Bose Headphones and a T61p SSC. It is currently not certified to be used in the Russian segments or A31p SSC's.



**Figure 6. Bose Headphones Integrated Cable installed on a pair of Bose Headphones**

The cable consists of an audio and microphone jack, USB dongle, microphone boom with microphone, push to talk box, headphone cover, and battery simulator. The green audio and pink microphone plugs install into the headphones and microphone jack on the SSC. The USB dongle powers the cable and can plug into any USB port.



**Figure 7. Microphone, audio, and USB plug-ins.**

#### **3.1.2.2.1 Hardware Interfaces with Vehicle**

The Bose Headphones Integrated Cable have no interface with the ISS.

#### **3.1.2.2.2 Resupply Schedule**

The Bose Headphones Integrated Cable will be resupplied on an “as needed” basis.

#### **3.1.2.2.3 Data/ Commanding Capabilities**

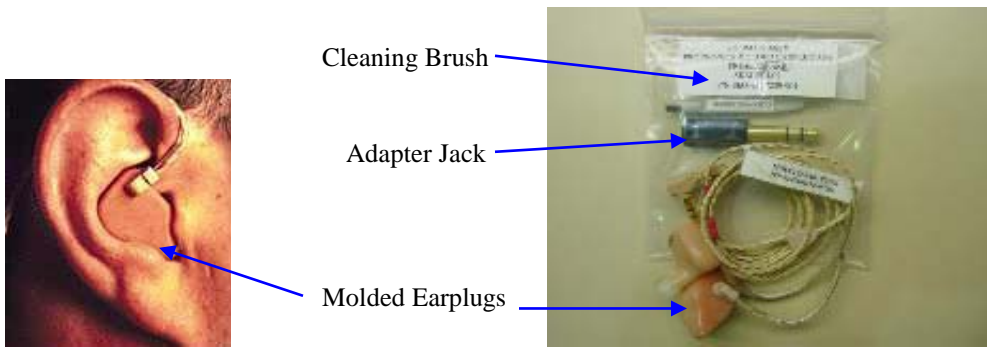
N/A

#### **3.1.2.2.4 Hazard Concerns**

N/A

#### **3.1.2.3 Molded Earplug Subpack, Prophonics (COTS)**

- Subpack Assy, Prophonics Custom Molded Ear Plug Set (2)
- Prophonics Custom Molded Ear Plug Set (2 pairs per crewmember)
- Adapter Jack (2)
- Cleaning Brush (2)



**Figure 8. Prophonics Custom Molded Earplug**

These earplugs have adapter jacks connected to them, which allows the crewmember the ability to plug them into their CD players. These earplugs are also used for the On-Orbit Hearing Assessment (O-OHA).

**3.1.2.4 Molded Earplug Subpack, Etymotics (COTS)**

- Etymotic Custom Molded Earplug Set (2 pairs per crewmember)
- 9dB Etymotic Filter Subpack Assembly \*
- 15dB Etymotic Filter Subpack Assembly \*
- 25dB Etymotic Filter Subpack Assembly \*

\* The quantity of filters flown shall be determined by crew preference. If the crew does not provide a preference for the number of filters during the fit check, then the quantity in each filter subpack shall default to 2 sets per crewmember of each filter. (3 crewmembers x 2 sets w/ 2 earplugs per set)



**Figure 9. Etymotics Custom Molded Earplug**

The Etymotic earplugs are packed such that they already have a filter inserted in each ear mold based on each crewmember’s preference. The crewmember may switch out the filters by squeezing the silicon earplugs and popping the filters out, then replacing with the desired filter.

The earplugs are marked with either a red dot, signifying the right ear, or a blue dot, signifying the left ear. The earplugs are not tethered to each other.



### 3.1.2.5 Earplug Subpack (COTS)

1. Quiet Earplug Subpack (20 pairs) – disposable (C)
2. Decidamp Earplug Subpack (40 pairs) – disposable (C)



**Figure 10. Howard Leight Quiet Ear Plug**



**Figure 11. North Decidamp Ear Plug**

The Decidamp Ear Plugs are constructed of non-irritating PVC foam. They are disposable after a few uses and do not need to be thrown away after each use. The Quiet Ear Plugs are reusable. A single pair could be washed and used for many weeks unless torn or soiled excessively. The Quiet Ear Plugs have a cord to hold the two ear plugs together, making removing and refitting more convenient. The Quiet Ear Plugs require no rolling, unlike the Decidamp Ear Plugs that must be rolled and inserted into the ear canal, which allows for the foam to expand and contour to the shape of the ear canal.

Crewmembers may use either disposable or custom-molded earplugs in concordance with the Active Noise Reduction (ANR) Bose headsets. Each crewmember will decide, at his/her discretion, which hearing protection device will be worn. These earplugs are not only used at crewmembers' discretion, but also during new module ingress. During training, it is recommended that the crewmembers change out their disposable earplugs twice per week. These earplugs are resupplied as needed during the increment

## 3.2. Microbiology and Water Quality

### 3.2.1. EHS Water Kit

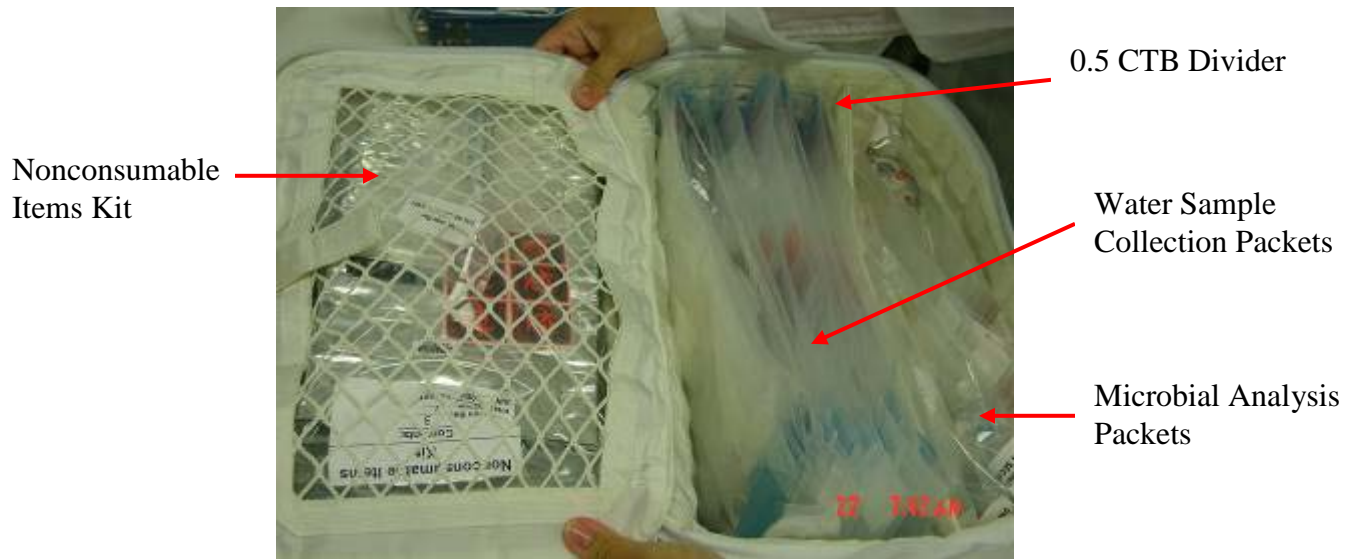
#### 3.2.1.1. EHS Water Kit Description

The EHS Water Kit was designed to replace the Water Microbiology Kit, Water Sample Collection Kit, and Microbiology Water Analysis Kit. It includes contents for water collection from the Russian and US water ports, bacteria enumeration, and coliform detection. The contents are grouped into three different components: Water Sample Collection Packet, Microbial Analysis Packet, and Nonconsumables Items Kit. Each kit consists of three Water Sample Collection Packets and one Nonconsumables Items Kit. The quantity of Microbial Analysis Packets will vary depending on sampling schedule. Each 0.5 CTB will contain two to three EHS Water Kits. The Water Kits are delivered to ISS and during unpacking, the outer large ziplock bag (EHS Water Kit) is removed and discarded. All of the contents are packed into an existing half CTB with other Water Sample Collection Packets or a new half CTB is created on-orbit if an existing half CTB is already full.



**Figure 1. 0.5 CTB containing EHS Water Kits**





**Figure 2. Contents of the 0.5 CTB**

### **3.2.1.2. Water Sample Collection Packet Description**

The contents of this Packet consist of various sizes of sample bags, Ziploc bags, potable water samplers, and disinfectant wipes. The contents in each Packet vary depending on sampling schedule. Refer to the CHeCS Consumables Tracker for contents of each Packet. The Packets will be identified by serial number and expiration date for each activity. Once the kit is opened and partially used, all contents, except for the SRV-K Adapters and CBO-3B Adapters, may be discarded as common trash. The Adapters are to be returned for refurbishment. An unused kit may not be discarded as common trash. It requires an approved WMR before it can be discarded.

The Water Collection Bags are used for water collection and processing. They are made of FEP, with polypropylene female luer lock ports. One-liter sized bags are used to collect post-flight samples. The Micro Sample, In-flight Analysis Bags (300 ml) are used to collect the sample for in-flight analysis. These bags contain thioneutralizers, chemicals used to neutralize silver contained in the Russian segment potable water supply and iodine contained in the U.S. potable water supply. When injected into the In-Flight Bags, the thioneutralizers are a clear liquid but over time they may crystallize and have a yellow tint that may get as dark as brown. It is acceptable to proceed with water collection even with the presence of these droplets or crystals. The TOCA Sample Analysis Bag is used to collect water from the PWD, then installed in the TOCA for analysis.

The Disinfectant Wipes are used to clean the ISS water port adapter prior to collection of water. The wipes are cellulose fiber towelettes soaked in a 1:250 solution of benzalkonium chloride in water. Each wipe is packaged in a sealed foil and paper pouch.

There are three types of adapters used on ISS for water collection. The SRV-K Adapter is used to allow a US water bag to be filled from the hot and warm ISS SRV-K water port. They consist of a Teflon adapter that mates to the Hot/warm dispenser probe as appropriate and a stainless steel male luer lock fitting that mates with collection bags. These samplers have been sealed in a

Teflon bag, and sterilized prior to flight and should remain sterile until use. The CBO-3B Adapter is used for collection from the SVO-ZV dispenser probe. The third type is the PWD Adapter, which is used for collection from the PWD dispenser at the Rehydration Station. These adapters are not interchangeable among the different ports.



Outer Ziplock  
(discarded during  
on-orbit unpacking)

**Figure 3. Water Sample Collection Packet**

**Table 3.2.1.2-1 List of Part Numbers/Volumes in Water Sample Collection Packet**

Op Nom	P/N	Bag Volume
Water Sample Collection Packet	SEG46121614-602	N/A
Potable Water Collection Packet SRV-K	SEG46119988-315	300 mL
Small Waste Water Bag	SEG46119988-612	
SRV-K Adapter	SEM46110793-308	
Disinfectant Wipe	D35100	
Potable Water Collection Packet SVO-ZV	SEG46119988-612	300 mL
Small Waste Water Bag		
CBO-3B Adapter		
Disinfectant Wipe		
Potable Water Collection Packet PWD	SEG46119988-316	300 mL
Small Waste Water Bag		
PWD Adapter		
Disinfectant Wipe		
Micro Sample In-Flight Analysis Packet	SEG46119988-312	300mL
Micro Sample In-Flight Analysis Bag	SEG46119988-610	
TOCA Analysis Packet	SEG46121617-301	210 mL
TOCA Sample Analysis Bag	SEG461121617-601	
TOCA Bag Clip	SEG46121616-602	
Post-Flight Analysis Packet	SEG46119988-313	1000 mL
Post-Flight Analysis Bag	SEG46119988-611	



**Figure 4. Contents of a Potable Water Collection Packet SRV-K (gray)**



Figure 5. Potable Water Collection Packet (SVO-ZV) (brown)

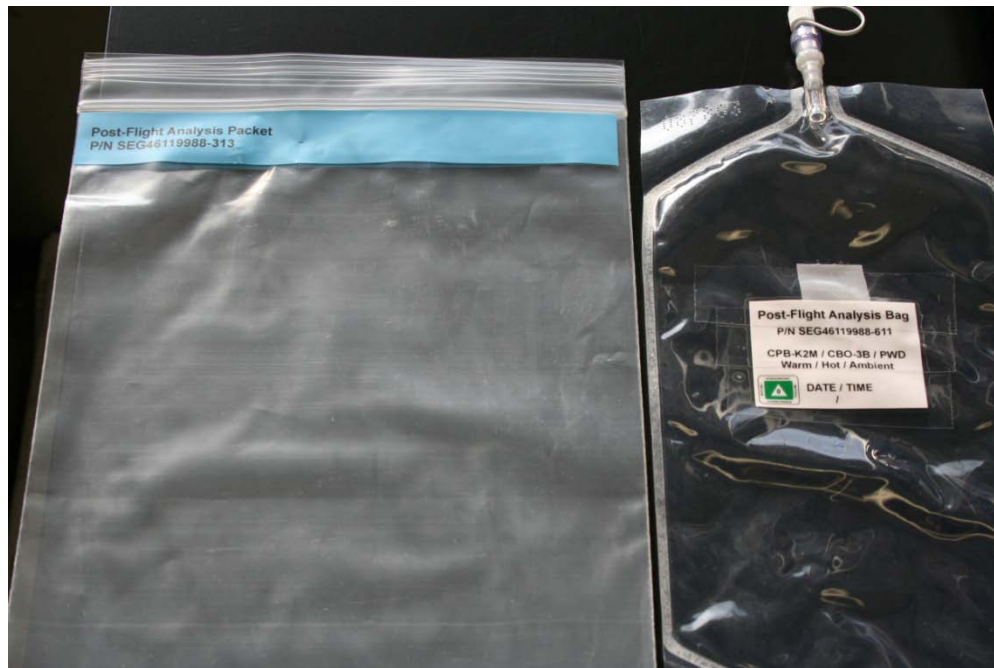


Figure 6. PWD Collection Packet (lavender)





**Figure 7. Micro Sample In-Flight Analysis Packet (orange) – will be changing to black label starting with ULF3**



**Figure 8. Post-Flight Analysis Packet (blue)**

### **3.2.1.3. Microbial Analysis Packet Description**

The contents of the Microbial Analysis Packet consist of the Coliform Detection Packet, Microbial Capture Device, filters, syringes, and disinfectant wipes. Each packet contains all necessary materials for processing water from one port. The packets have serial numbers, however; as the contents of each packet are identical, it is only necessary to verify the Expiration

date associated with each packet. Once the hardware is used, it can be discarded as common trash.

The syringe filters (0.45 micron and 0.22 micron) are used to sterilize air drawn in from the cabin and across the filter pad during Microbial Capture Device processing.

Microbial Capture Devices are constructed of two polystyrene press-fitted sections that encase a 0.22 micron filter and pad. Two female luer lock fittings made of K-resin are glued to the polystyrene item using methylene chloride. Two male luer lock polyethylene caps with Polyvinyl Chloride tethers are used to seal the inlet and outlet ports. The inlet cap is colored blue and the outlet is red. A label is located on the side of the filter for recording in-flight information.

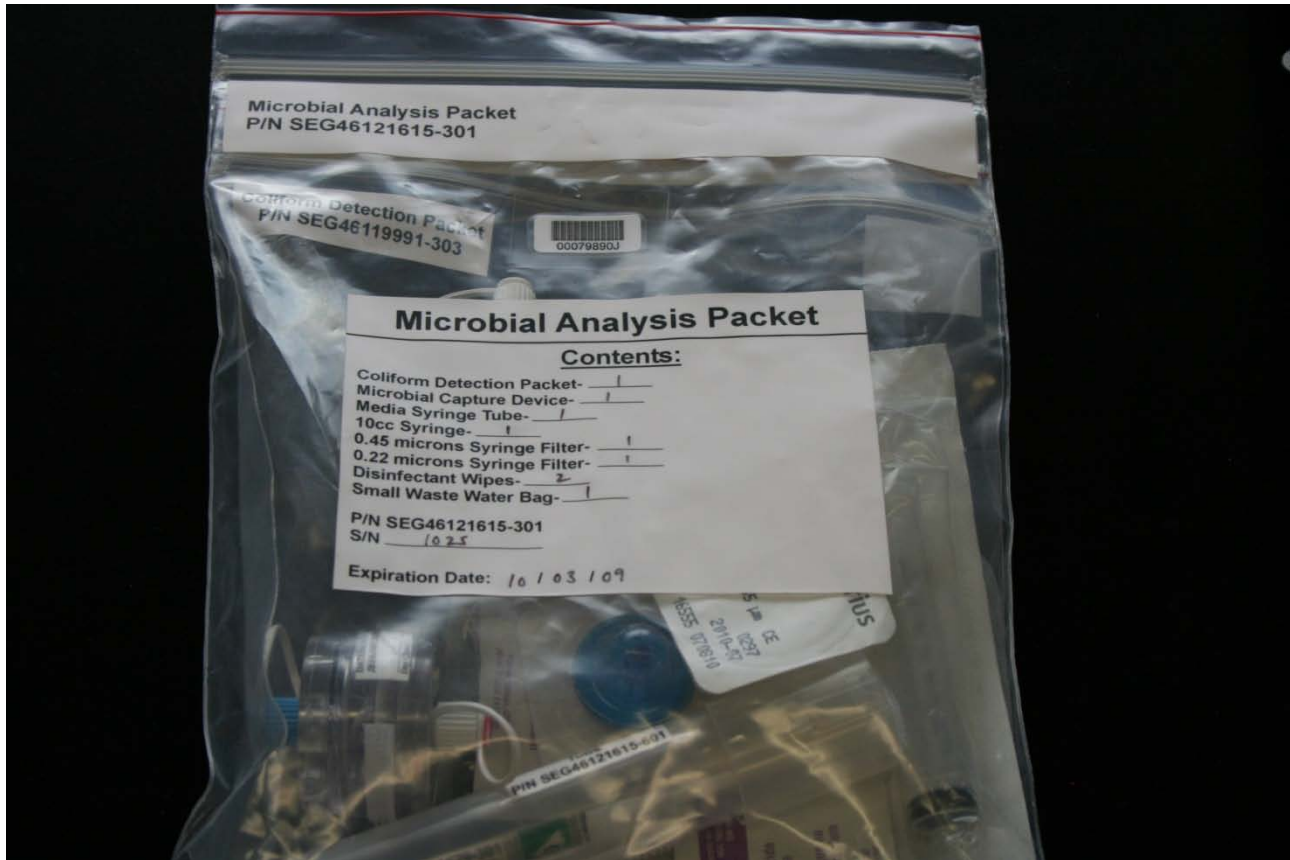
The media syringes contain nutrient growth media, which promote growth of bacteria and fungi. The media is injected into the Microbial Capture Device after processing has been completed. The R3A (total count) media contains: glucose, Sodium pyruvate, Potassium phosphate, dibasic, anhydrous, Magnesium sulfate heptahydrate, MTT (Thiazoloyl Blue dye), Soluble starch, Yeast extract, Proteose peptone #3, Bacto Casamino Acids. The media syringes are nominally clear however the media may sometimes turn purple due to a chemical reaction occurring between the dye in the media and oxygen. Media syringes that have turned purple at/near the tip only (<50% of the syringe) are still good for use. Media that is purple (clear or cloudy) over more than 50% of the syringe should not be used (purple and cloudy = contamination; purple and clear = heat exposure which damages the media).

The 10cc syringe is used to withdraw water from the Micro Sample, In-flight Analysis Bag and then water is injected through the Microbial Capture Device.

The Coliform Detection Bag is an off-the-shelf technology that is easy to execute. Dry growth media is inserted into the sample bags prior to delivery. When water is added to this growth media and the sample is incubated between 28 °C to 37 °C for 44 hours ( $\pm$  4 hours), it produces a color change. A yellow color change signifies a negative result. A positive result, signified by a magenta color, indicates the presence of coliform bacteria. This test is highly sensitive such that it detects and identifies simultaneously one coliform and/or *E. coli* in 100 ml of water sample. Under exposure to UV light, fluorescence indicates presence of *E. coli*. A UV light source is not available at this time on board, but is planned in the future.

The Coliform Detection Bag has a label with the part number, lot number, and expiration date. The label also has 'Hot/Warm/SVO-ZV and Date/Time' written on it for the Crew to circle and label each sample appropriately. On the bag is also a label indicating a tox level 0.

The cap is not tethered, but has Velcro attached to it. The male Luer Loc on the bag will connect with the female Luer Loc on the Micro Sample In-flight Analysis Bag. Powder inside the bag should be tan and free-flowing. If powder is dark and/or clumpy, the bag should not be used and should be discarded.



**Figure 9. Microbial Analysis Packet**

**Table 3.2.1.3-1 List of Part Numbers in Microbial Analysis Packet**

<b>Op Nom</b>	<b>P/N</b>
Microbial Analysis Packet	SEG46121615-301
Coliform Detection Packet	SEG46119991-303
Coliform Detection Bag	
Microbial Capture Device	KLSK270349-303
10 cc Syringe	14-823-2A
0.45 micron syringe filter	NC9926188
0.22 microns syringe Filter	09-719A
Disinfectant Wipe	D35100
Small Waste Water Bag	SEG46119988-612
MCD Storage Bag	90242XX
Media Syringe Tube	SEG46121615-601
Media Syringe	SEG46121629-301





Figure 10. Contents of Microbial Analysis Packet



Figure 11. 0.45 µm Filter (yellow)



Figure 12. 0.22 µm Filter (blue)



**Figure 13. Microbial Capture Device (MCD)**



**Figure 14. Growth on MCD**



**Figure 15. MCD Storage Bag**



**Figure 16. Media Syringe Tube and Syringe**



**Figure 17. 10cc Syringe**



Figure 18. Small Waste Water Bag

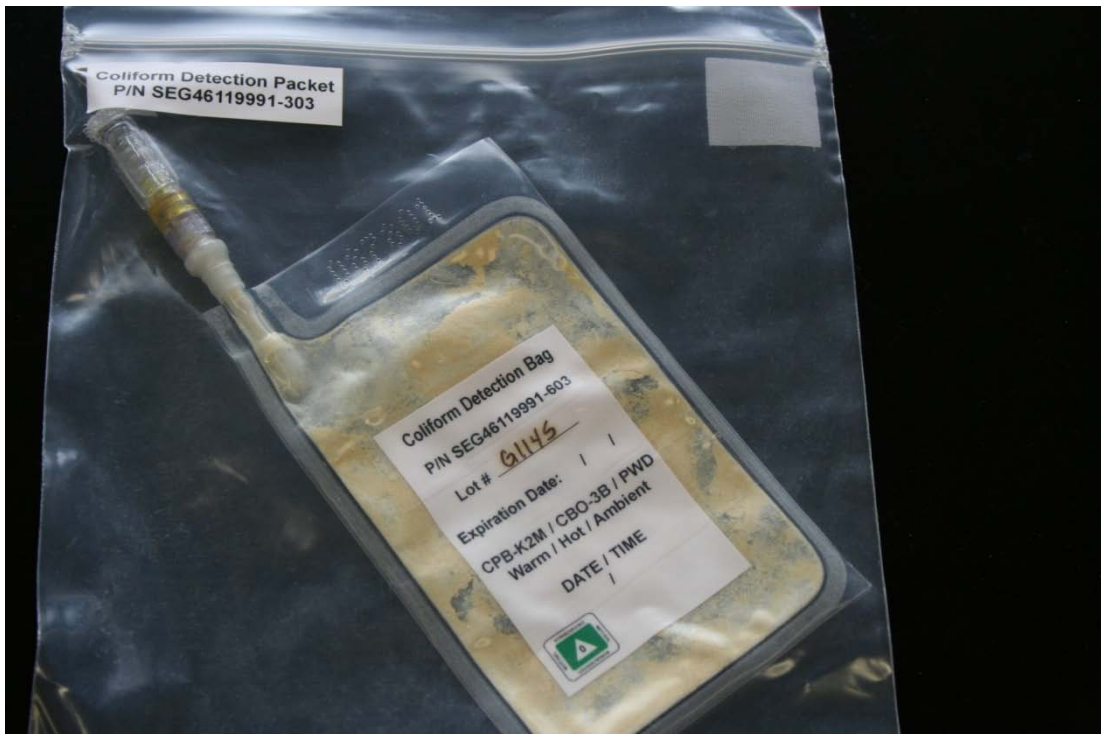


Figure 19. Coliform Detection Packet and Bag





**Figure 20. Yellow (negative result – Biosafety level 1)**



**Figure 21. Magenta (positive result - Biosafety level 2)**

#### **3.2.1.4. Nonconsumables Items Kit Description**

The contents of this kit consist of Mylar Incubation Bags with temperature strip, 30cc Syringes, and Biohazard Labels. The Incubation Bags and 30cc Syringes are reusable. The Incubation Bag is used to incubate both Coliform Detection Bags and Microbial Capture Devices. All Coliform Detection Bags and Microbial Capture Devices from each sample activity will fit into one Incubation Bag. The Biohazard Labels are used to mark Post-Flight Analysis Bags if a positive (magenta) Coliform results.



**Figure 22. Nonconsumables Items Kit**

**Table 3.2.1.4-1 List of Part Numbers in Nonconsumables Items Kit**

Op Nom	P/N
Nonconsumables Items Kit	SEG46121616-301
Incubation Bag	SEG46119993-304
30cc Syringe	SEG46121619-301
Biohazard Labels	SDD39124182-002



**Figure 23. Nonconsumables Items Kit**



**Figure 24. 30cc Syringe in the Nonconsumables Items Kit**



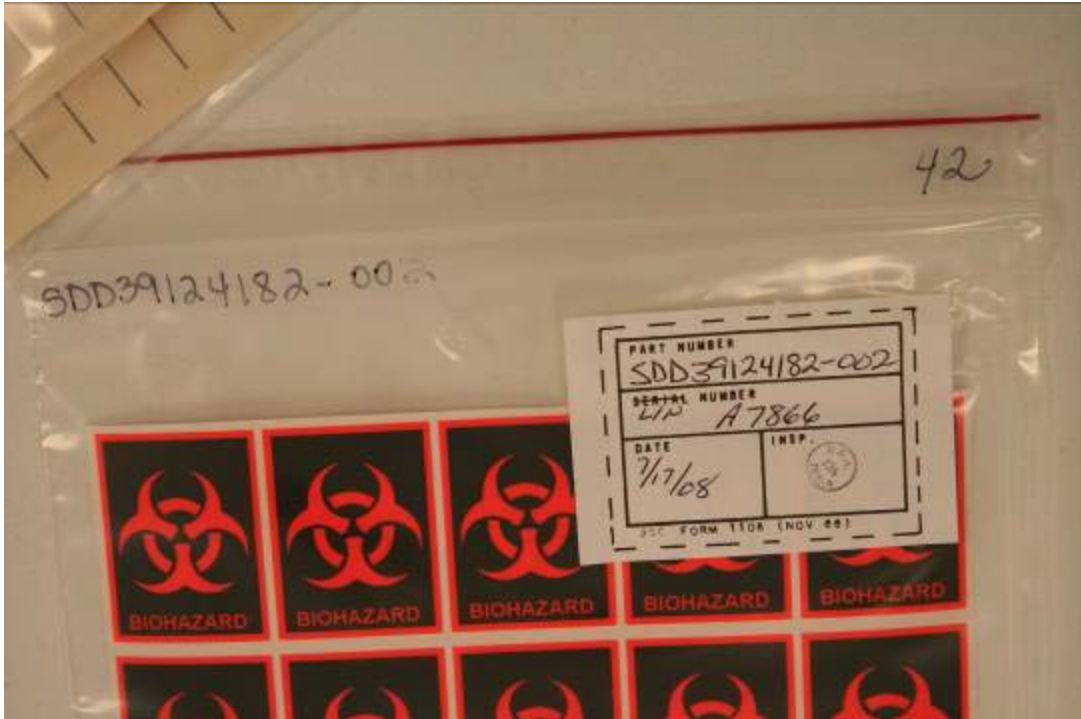


Figure 25. Biohazard Labels



Figure 26. Mylar Incubation Bag

### **3.2.1.5. Hardware Interfaces with Vehicle**

The Potable Water Samplers SVO-ZV and SRV-K interface with the Russian water ports.

### **3.2.1.6. Resupply Schedule**

Consumables are resupplied on as-needed basis.

### **3.2.1.7. Data/Commanding Capabilities**

N/A

### **3.2.1.8. Hazard Concerns**

The Micro Sample, In-Flight Analysis Bags contain a small amount of neutralizer, Sodium Thiosulfate and Sodium Glycolate. These chemicals are designated as tox level 1 substances, and the bags are marked accordingly. After water is added to these chemicals per the procedure, they are then designated as a level 0 hazard or non-hazardous.

In the event of rapid decompression, the Teflon water sample bags may leak, releasing potable water samples (tox level 0).

The Coliform Detection Bags before sample addition are considered to be tox level 0. Negative results will be a Biosafety Level 1, and will be double-contained. Positive results will be a Biosafety Level 2, and will be triple-contained. Containment levels are designated in the procedure.

### 3.2.2. *Microbial Air Sampler*

#### 3.2.2.1. Microbial Air Sampler Description

The Microbial Air Sampler is used for the collection of cabin air atmosphere for evaluation of the microbial load. The Microbial Air Sampler contains Alkaline Manganese Dioxide Batteries (8), which are not rechargeable.

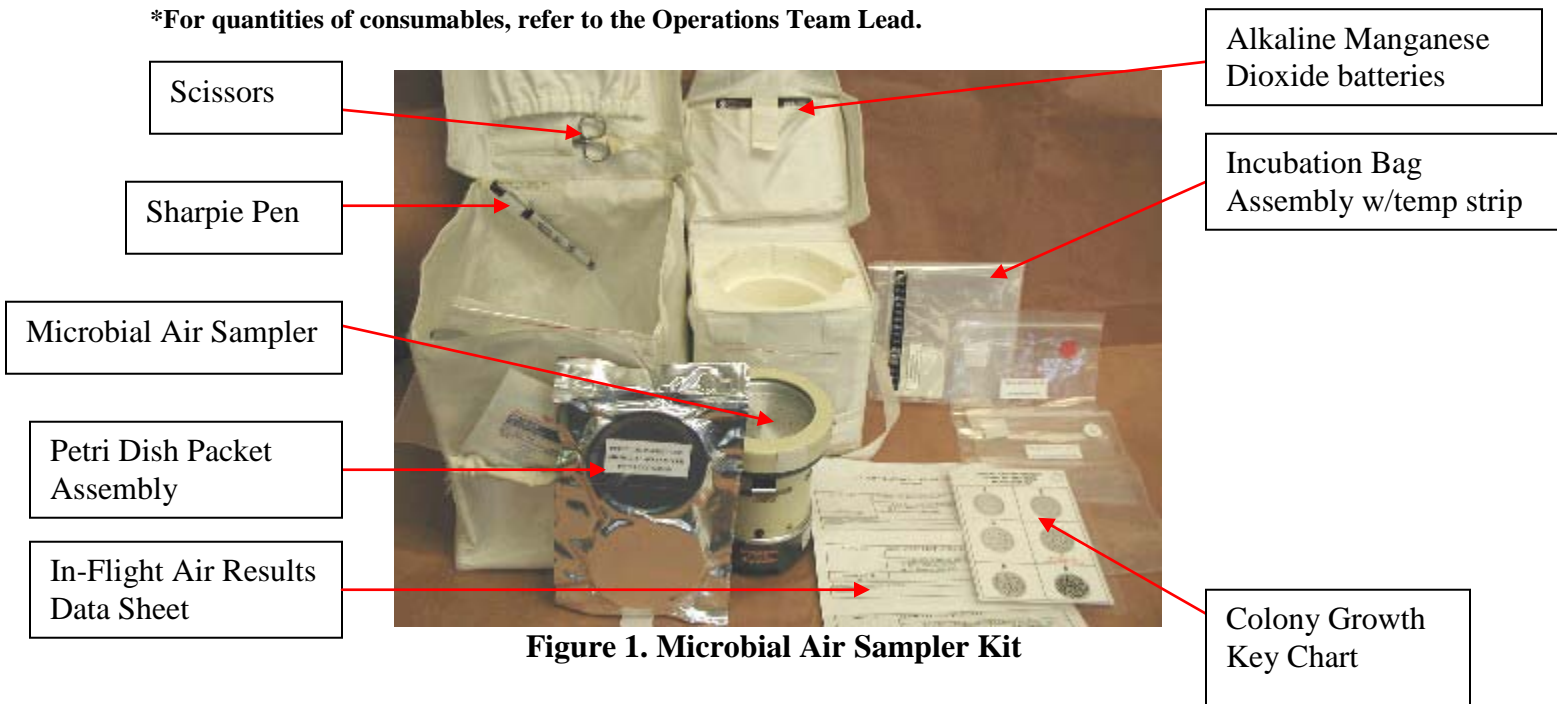
#### 3.2.2.2. Microbial Air Sampler Kit Components List and Description

Microbial Air Sampler Kit Components\*:

- a. Microbial Air Sampler
- b. Pouch Assembly
- c. Transfer Case
- d. Foam Assembly
- e. Sharpie Pen
- f. Alkaline Manganese Dioxide Batteries
- g. Petri Dish Packet Assembly (1 Bacterial and 1 Fungal Media Plate/Packet) (C)
- h. Incubation Bag Assembly (C)
- i. Disinfectant Wipes (C)
- j. Plastic Bag (6x6") (C)
- k. Plastic Bag (4x3") (C)
- l. Scissors
- m. Colony Growth Key Chart and Data Sheet
- n. Gauze (C)

\*‘C’ stands for consumables and are considered to be common trash items.

\*For quantities of consumables, refer to the Operations Team Lead.



**Figure 1. Microbial Air Sampler Kit**



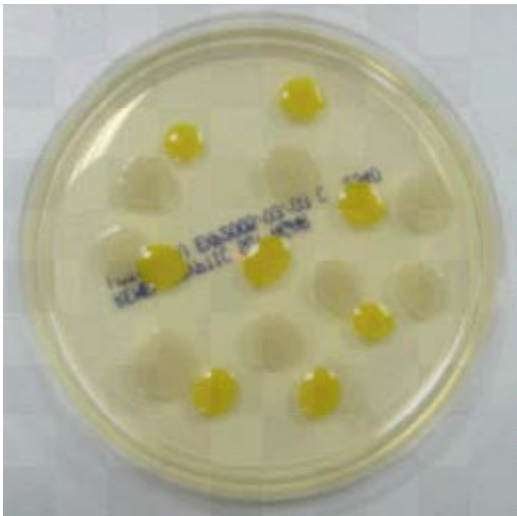
Petri Dish Packet Assembly

Fungal Media Plate (red dot)

Bacterial Media Plate (white dot)

**Figure 2. Petri Dish Packet Assembly**

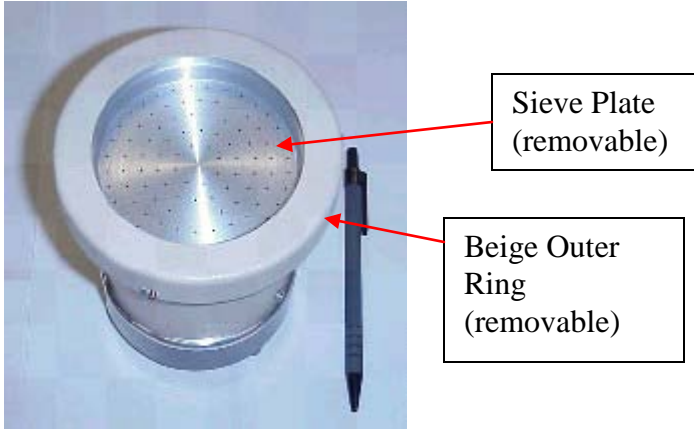
Inoculated Media Plates after incubation:



**Figure 3. Bacterial Colonies (smooth)**



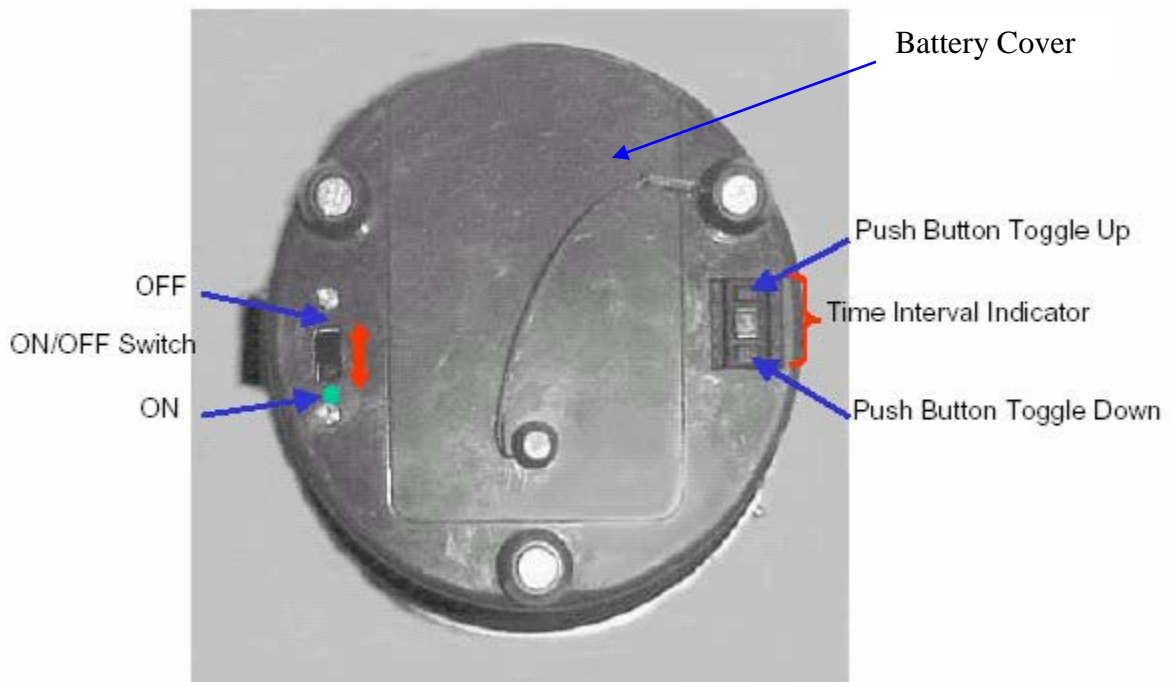
**Figure 4. Fungal Colonies (fuzzy)**



Sieve Plate  
(removable)

Beige Outer  
Ring  
(removable)

**Figure 5. Microbial Air Sampler Top**



Battery Cover

Push Button Toggle Up

Time Interval Indicator

Push Button Toggle Down

OFF  
ON/OFF Switch  
ON

**Figure 6. Microbial Air Sampler Bottom**



**Figures 7-8. Microbial Air Sampler PUSH ON and PUSH OFF Sliding Valve (Rocker switch)**





**Figure 9. In-Flight Air Results Data Sheet and Colony Growth Key Chart (will not be resupplied)  
(Also in the procedure)**

**Table 3.2.2.2-1 General Hardware Specifications**

Kit and Component List	Mass M(E)	Volume M(E)	Dimensions M(E)	Nominal Stowage Location	Storage Temp °C (°F)	Operating Temp °C (°F)	Operating Pressure mmHg (psia)
Microbial Air Sampler Kit	2.3 kg (5.0 lbs)	13300.2 cm <sup>3</sup> (811.6 in <sup>3</sup> )	29.2 x 25.4 x 19.1 cm (11.5" x 10" x 7.5")	LAB1O5_G2	4 – 35°C (39 – 95°F)	20 – 35°C (68 – 95°F)	
MAS unit				MAS Kit at LAB1O5_G2			

**Table 3.2.2.2-2 Hardware-Specific Parameters**

Power Source	Battery; 8 AAA Alkaline Manganese Dioxide
Measurement Parameters/ Analysis Capabilities	Bacterial and Fungal levels will be measured. Acceptability limits are listed in the ISS MORD, JSC-50260.

**3.2.2.3. Hardware Interfaces with Vehicle**

Velcro may be used logistically to secure the Microbial Air Sampler for media plate loading.



#### **3.2.2.4. Resupply Schedule**

The Microbial Air Sampler Kit will no longer be resupplied. Only the Petri Dishes, Plastic 6x6 Bags, and Incubation Bag will be resupplied. They are resupplied on an as needed basis.

#### **3.2.2.5. Data/Commanding Capabilities**

After all results for each sample have been collected, the data can either be called down to MCC-H or entered into crew notes.

#### **3.2.2.6. Hazard Concerns**

N/A

### 3.2.3. Surface Sampler Packet 'Ziploc'

#### 3.2.3.1. Surface Sampler Packet 'Ziploc' Description

The Surface Sampler Packet 'Ziploc' provides hardware for taking surface samples for in-flight assessment of bacterial and fungal bioload on International Space Station (ISS) surfaces. The Ziploc is just a generic Ziploc cut at Bench Review to provide a means for containing all Surface Sampler Packets and Incubation Bag together. The Ziploc is labeled 'Surface Sampling Hardware'. Fourteen Surface Sampler Packets plus one Incubation Bag is manifested every 3 months.



Figure 1. Surface Sampler Packet 'Ziploc'



**Figure 2. Contents of one Surface Sampler Packet**

Inoculated Media Slides after incubation:



**Figure 3. Bacterial Colonies (smooth)**



**Figure 4. Fungal Colonies (fuzzy)**

**3.2.3.2. Surface Sampling Hardware Ziploc Component List and Description**

- Surface Sampler Packet Assembly\*
  - Each packet contains:
    - a) Fungal media slide (1) (C)

- b) Bacterial media slide (1) (C)
- c) Swab tube (1) (C)
- d) Containment bag assembly (red dot and white dot, 1 each) (C)
- e) Disinfectant wipe (1) (C)
- Other Item
  - f) Incubation Bag with temperature strip

\* 'C' stands for consumables and are considered to be common trash items.

**Table 3.2.3.2-1 General Hardware Specifications**

Kit and Component List	Storage Temp °C (°F)	Operating Temp °C (°F)
Media slide	4-35°C (39-95°F)	20-35°C (68-95) °F ideal for incubation period

**Table 3.2.3.2-2 Hardware-Specific Parameters**

Measurement Parameters/ Analysis Capabilities	Operating Ranges: bacteria is detected up to 4000 Colony Forming Units (CFU) per 100cm <sup>2</sup> fungi is detected up to 400 CFU per 100cm <sup>2</sup>
--	--

The Surface Sampler Packet Assembly contains everything necessary to collect surface samples and contain them for incubation. They are aluminized Mylar shrink-wrapped packets. The fungal media slide (red dot) contains Emmon’s Saboraud Dextrose Agar with Chloramphenicol (SDA). SDA has a pH of 6.9 and is composed of Pancreatic digest of casein, Peptic digest of animal tissue, Dextrose, Agar, Cloramphenicol (50.0 mg/l), and Distilled Water.

The bacterial media slide (white dot) contains Trypticase Soy Agar (TSA). TSA has a pH of 7.3 and is composed of Pancreatic digest of casein, Papaic digest of soy meal, Sodium chloride, Agar, and Distilled Water.

The swab inside the swab tube is intended to be used for sampling of non-flat surfaces of the ISS. It contains 0.5% sterile phosphate buffer; the buffer provides moisture for the swab so that the microbes on the surface to be sampled will adhere to the swab.

The two containment bag assemblies with either a white dot or a red dot are used to enclose the media slide for incubation and disposal. The bags are sized to hold one contact slide each and have a Ziploc seal at one end.

The disinfectant wipe contains 1:250 benzalkonium chloride and is used to wipe the sampled area of the module after sampling is completed.

**3.2.3.3. Hardware Interfaces with Vehicle**

The Surface Sampler Packet interface with the vehicle via Velcro. The Agar in each slide contacts the surface of the vehicle being sampled.

#### **3.2.3.4. Resupply Schedule**

The Surface Sampler Packets are currently resupplied on an as-needed basis, but usually 14 Packets are delivered on every shuttle flight or Progress flight. No maintenance is required.

#### **3.2.3.5. Data/Commanding Capabilities**

After all results for each sample have been collected, the data will be called down to MCC-H or entered in crew notes.

#### **3.2.3.6. Hazard Concerns**

Both the Emmon's Sabouraud and Trypticase Soy Agar were reviewed by SD2/JSC toxicologists and determined to be a tox level 0 (non-toxic).

After a sample has been taken and the bacterial colonies have incubated, the colonies are considered a biohazard for safety purposes and are controlled as a critical hazard. Thus, these samples should be doubly contained.

### **3.2.4. Total Organic Carbon Analyzer (TOCA)**

#### **3.2.4.1. Total Organic Carbon Analyzer Description**

TOCA is next generation hardware. The primary function is to serve as a safety control for the Regenerative ECLSS Water Processor (potable water) because Regen ECLSS potable water must be monitored for total organic carbon (TOC) before it is deemed as potable for crew consumption. TOCA is a tool used as a 3<sup>rd</sup> redundant control to detect out of specification potable water by measuring Total Organic Carbon (TOC) levels. TOC concentrations are a general indication of overall water quality by indicating the potential presence of hazardous chemicals. Some organic compounds can have acute or chronic health effects although many are benign. All water purification systems include processes to remove organic carbon. Low TOC indicates that the Water Processor Assembly (WPA) is functioning properly. It is designated as criticality 1SR.

1SR - Redundant components designed to provide safety or protection capability against a potentially hazardous condition or event, all of which if failed could cause the system to fail to detect, or operate when needed during the existence of a hazardous condition that could lead to loss of flight or ground personnel or Station; or redundant components within a safety or hazard monitoring system, all of which if failed could cause the system to fail to detect, or operate when needed during the existence of a hazardous condition that could lead to loss of flight or ground personnel or Station.

TOCA's secondary function is to analyze water from the SRV-K and SVO-ZV systems. The first unit is not planned for use to analyze water from these systems.

#### **3.2.4.2. High Level Concept**

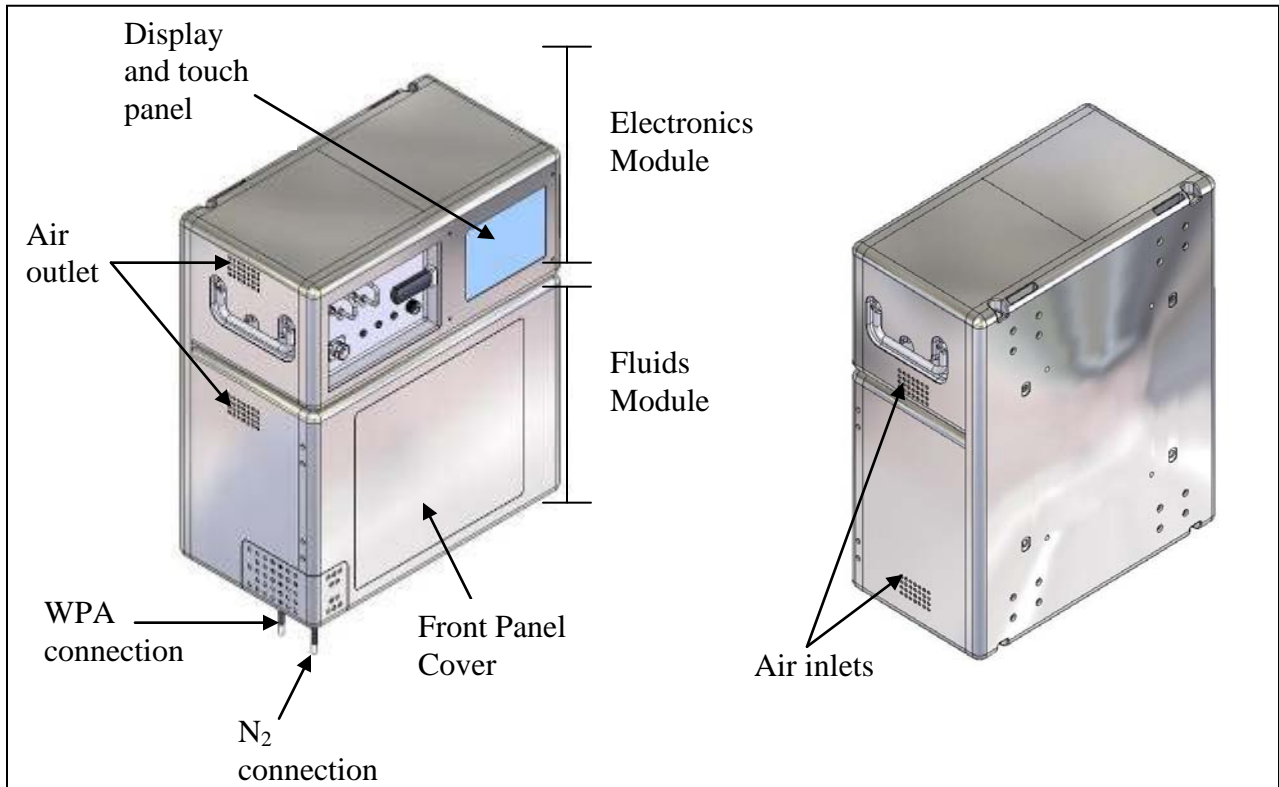
Total carbon enters the TOCA via a water sample either through the TOCA Water Sample Hose or from a TOCA Sample Analysis Bag used to collect water from various sources. "Total carbon" is total inorganic carbon (TIC) plus total organic carbon (TOC). TIC interferes with the direct measurement of TOC and must be removed prior to TOC measurement. TOCA converts and removes TIC by pH shift with a slightly acidic buffer which forces inorganic carbon species to CO<sub>2</sub> gas. TOCA oxidizes organic carbon species remaining in the sample water to CO<sub>2</sub> gas. The TOCA produced CO<sub>2</sub> gas is measured using an infrared CO<sub>2</sub> detector called Non Dispersive Infrared (NDIR) detection. The CO<sub>2</sub> measurement is converted into the concentration of TOC (micrograms/L or ppb). TOCA performs a minimum of three automated replicate measurements and calculates the average and relative standard deviation of the replicates for each TOC sample or calibration standard. Replicate samples are required for calculating precision.

#### **3.2.4.3. TOCA Process States**

- General steps include:
- Flush
- Purge gas loop (Gas Purge)
- pH shift and convert and remove TIC (React TIC)
- Detect CO<sub>2</sub> from TIC (Detect TIC)
- Oxidize TOC (React TOC)



- Detect CO<sub>2</sub> from TOC (Detect TOC)
- Analyze and report (calculate TIC, TOC, and %RSD)



**Figure 1. Total Organic Carbon Analyzer**

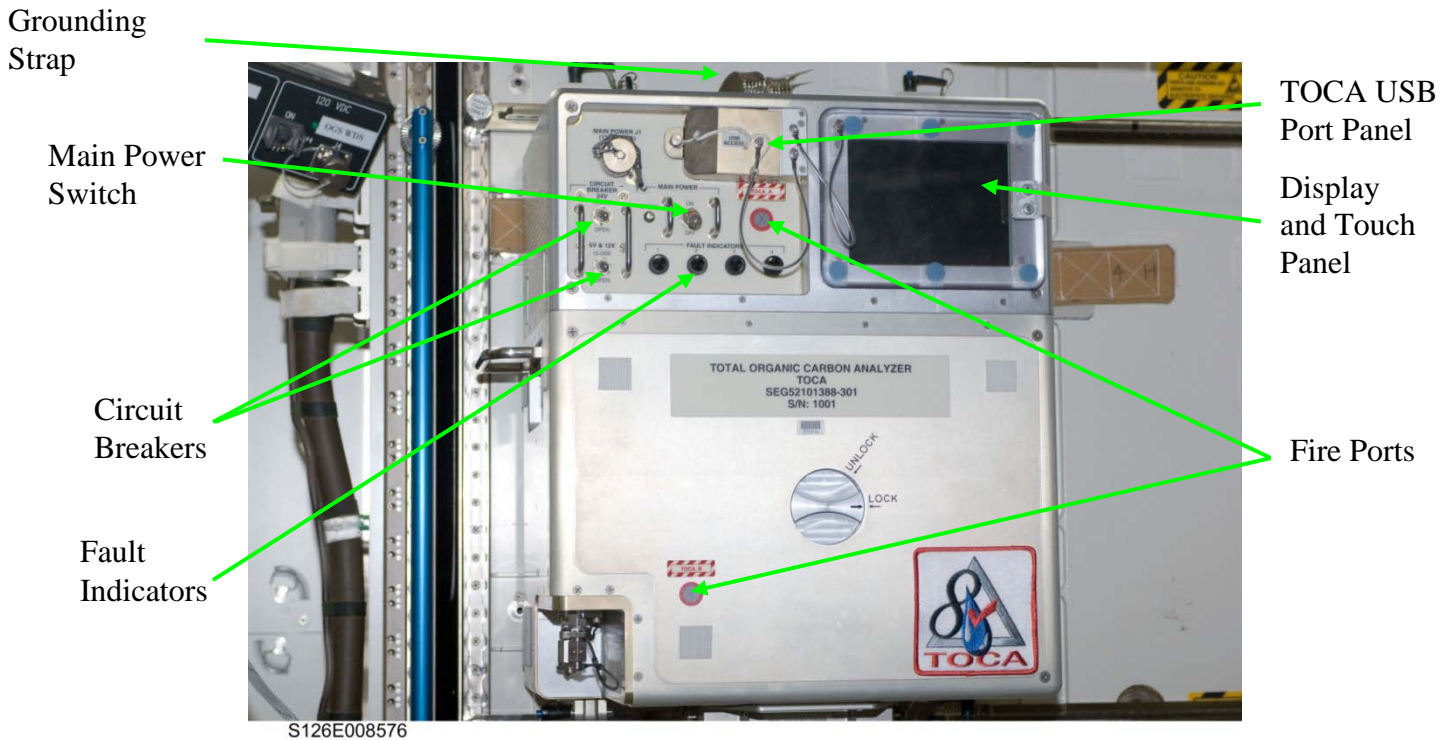


Figure 2. TOCA On-orbit Unit on WRS 2 Rackface

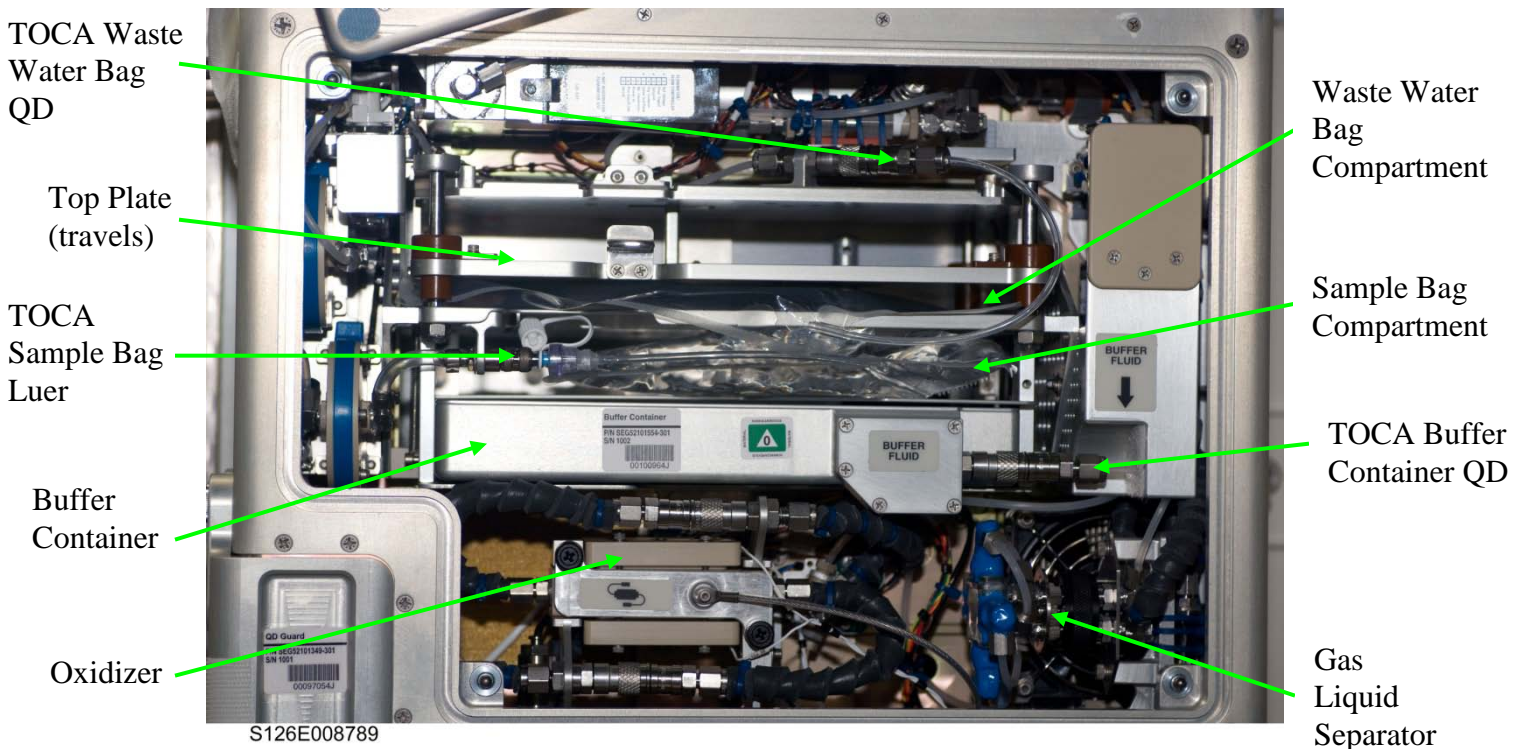


Figure 3. TOCA Fluids Module Interior

3.2.4.4. Front Panel Crew Interfaces

- Main Power – Manual switch, applies or removes power from the TOCA

- Circuit Breaker 24V – Manual breaker with remote trip; enables or disables 24VDC and TEC power supply
- Circuit Breaker 5V & 12V – Manual breaker with remote trip; enables or disables 15VDC and 12VDC power supply
- Main Power J1 – 120 VDC power in from UOP
- Status LED – when illuminated indicates that the 5VDC power supply is on

#### **3.2.4.5. TOCA Components List and Description**

- TOCA Components:
  - a) Total Organic Carbon Analyzer
  - b) Orbital Replacement Units (ORUs)
    - i. Buffer Container
    - ii. Waste Water Bag
    - iii. Gas Liquid Separator
    - iv. Oxidizer
    - v. TOCA Sample Analysis Bag
    - vi. Fluid Fitting Guard
    - vii. TOCA Power Cable
    - viii. TOCA Grounding Strap
    - ix. TOCA Mounting Fixture
    - x. TOCA Water Sample Hose
    - xi. NOD3 TOCA N2 Hose
    - xii. TOCA USB Drive
    - xiii. Calibration Check Packet
    - xiv. High TOC Calibration Packet
    - xv. Low TOC/TIC Calibration Packet
    - xvi. TOCA Compact Flash Card
  
- 0.5 CTB S/N 1237 contents – generic CTB not owned by CHeCS:
  - a) Calibration Check Packet
  - b) High TOC Calibration Packet
  - c) Low TOC/TIC Calibration Packet
  - d) Cable Straps
  - e) Oxidizer
  - f) TOCA Waste Water Bag (1000 mL)
  - g) Timer/Stopwatch
  - h) Gas Liquid Separator
  - i) Buffer Container
  - j) TOCA Media Kit (contains 2 spare USB Drives and 1 Compact Disk)
  - k) TOCA Analysis Packet
  - l) TOCA Fluidic Maintenance Kit
    - i. Long Flangless Nut
    - ii. Small Ferrule
    - iii. 1/4-28 Elbow fitting
    - iv. 1/4-28 Tee
    - v. 1/4-28 Cross

- vi. 1/4-28 Blind Plug
- vii. 10-32 Elbow
- viii. 10-32 Coupling
- ix. 10-32 Straight Fitting
- x. 10-32 Screw Plug
- xi. Small O-ring
- xii. Large O-ring
- xiii. 4" Cable Tie
- xiv. Kynar 1/8" Tubing
- xv. 6-32 x 3/8 Socket Head Screw
- xvi. #6 Flat Washer
- xvii. Tube Insulation
- xviii. 10-32 male to female adapter
- xix. 10-32 to NPT Adapter Fitting
- xx. Nanoport fitting
- xxi. Nanoport gasket
- xxii. 7/64 ball end hex drive
- xxiii. 5/16 wrench
- xxiv. Tube cutter
- m) TOCA Gas Module Kit
  - i. Catalyst Jumper Tube
  - ii. Relief Valve Plug
  - iii. Relief Valve Replacement
  - iv. TOCA Dryer
  - v. TOCA Catalyst

**Table 3.2.4.5-1 General Hardware Specifications**

Kit and Component List	Mass M(E)	Volume M(E)	Dimensions M(E)	Nominal Stowage Location	Storage Temp °C (°F)	Operating Temp °C (°F)	Operating Pressure (psia)
TOCA unit	75.5 lbs	4038 in3	21.72 x 16.34 x 11.38 inches	WRS 2 Rackface		65F – 85F	13.9-14.9 psi Non-operating pressure: 9.7-16.0 psi

**Table 3.2.4.5-2 Hardware-Specific Parameters for TOCA**

Power Requirements	120 VDC
Power Source	UOP 3 J4
Analytical Range	TOC: 250-25,000 ppb for ISS Potable Water Source containing up to 35,000 ppb TIC.
Accuracy	+/- 25% 1000 – 25,000 ppb for ISS Potable Water Source containing up to 15,000 ppb
Reproducibility	Relative Standard Deviation +/- 25% for TOC range of 1000 – 25,000 micrograms/L

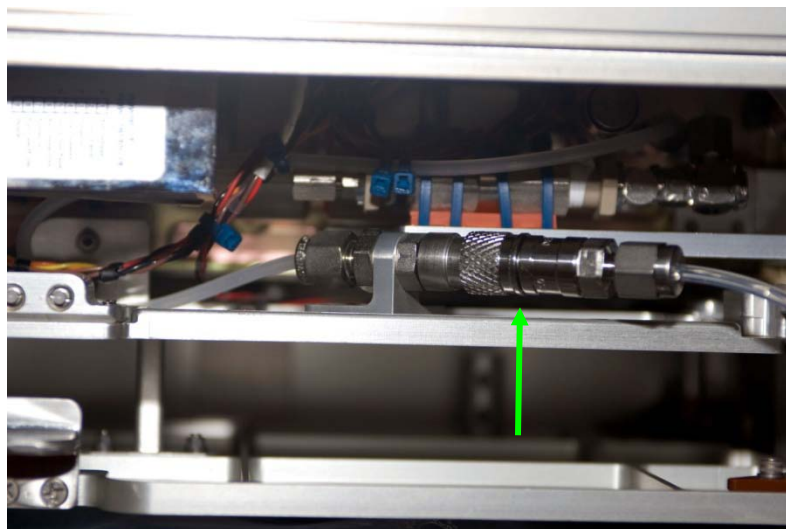
Operating Ranges	Cabin Temperature: 65-85F Nitrogen requirement: 75-135 psia
Indications for Out-of-Range Parameters	Unit will shut down, fault indicators on the front panel of the electronic box will change to black and white, or there will be alert messages on the display.

**TOCA Waste Water Bag Description**

The waste container provides a storage location for the flush water and post processed sample water that is produced with each sample analysis. The waste container is sized to store the sample volume associated with no less than six sample analyses or 900 mls. The toxicity of the wastewater is considered Toxicity 0 – non-hazard, per memo TOX-NK-2006-016. As with the acidic buffer dispenser, the waste container is considered an ORU for on-orbit maintenance, and may be trashed after use. If reclamation of waste water is desired, the waste water is safe to reclaim, but goggles must be worn if sodium phosphate crystals are accumulated after evacuation of the liquid.



**Figure 4. TOCA Waste Water Bag**



**Figure 5. Waste Water Bag QD Connection**



**TOCA Data Storage**

Data will be stored on an internal Compact Flash and a removable SanDisk Cruzer® Micro USB Flash Drive USB. The USB Drive can store 1 GB of data, which is approximately 200 analyses. The Compact Flash can store 8 GB, which is approximately 1000 analyses. There are two spare Drives on-orbit; however, they do not have the correct folder structure and require reformatting prior to use. The Compact Flash Card can store 8 GB of data. The Compact Flash Card is installed on the ground before delivery and should never have to be changed out; however, there is one spare Card on-orbit for contingencies. Data will be transferred from the TOCA to a particular SSC (with KFX) via the USB drive, then downlinked to the ground. From this particular SSC, the entire TOCA data folder for the sampling session desired will be downlinked in the following form:

Activity	File Extension	Location
TOCA	Folder	\data\Sample ##- <b>ddmmmyy</b> -hhmmss\

Where **ddmmmyy** should be replaced with the date of the run that is to be downlinked. The data is then placed in the MER drop box for distribution.



**Figures 6-7. TOCA Flash Drive and Compact Flash Card, respectively**

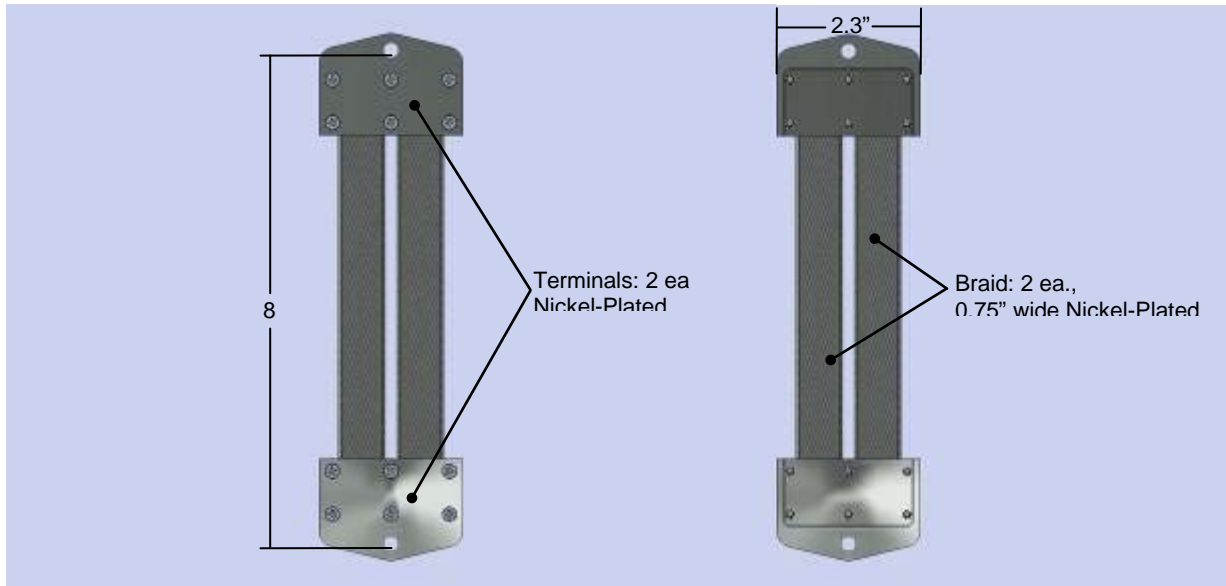
**TOCA Grounding Strap**

There are two grounding straps installed on the TOCA. The one below is attached to the EDV Attachment Bracket. Since the handrail extenders are not conductive, this grounding strap serves no purpose in grounding the TOCA as the EDV attachment Brackets are attached to the handrail extenders. A second ground strap is attached directly to the rack from the TOCA and this serves as the grounding mechanism.

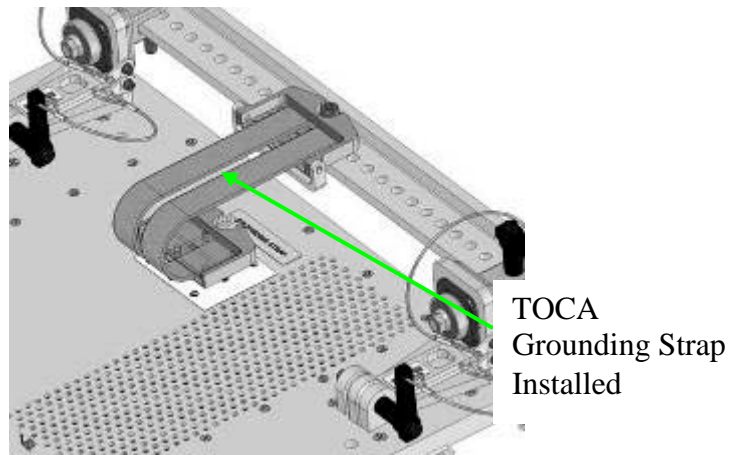




**Figure 8. TOCA Grounding Strap**



**Figure 9. Schematic of TOCA Grounding Strap**



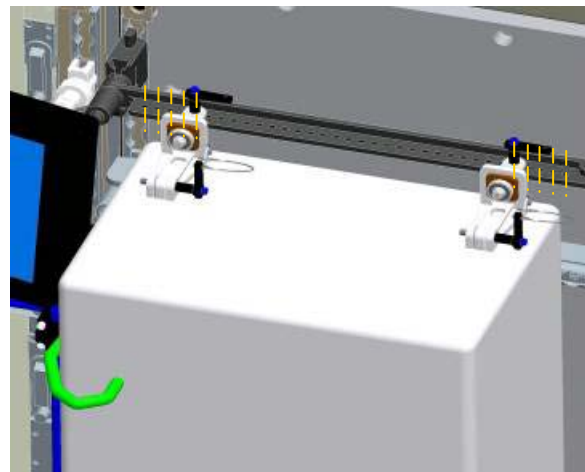
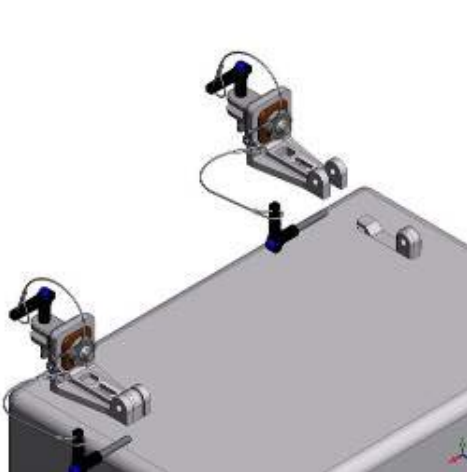
**Figure 10. TOCA Grounding Strap Installed**

**TOCA Mounting Fixture Description**

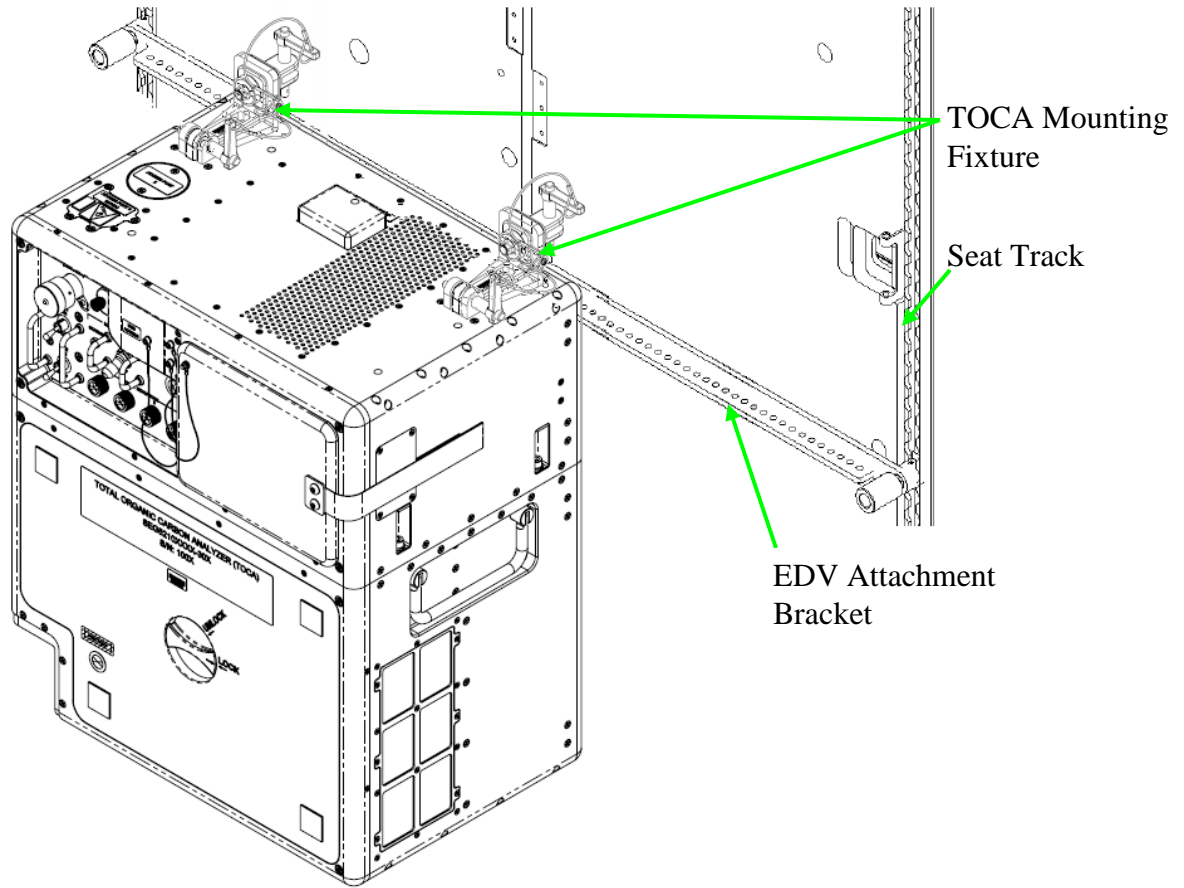
The mounting fixtures (4) are attached to the TOCA via pip pins. They allow the TOCA to attach to the EDV Attachment Brackets.



**Figures 11-12. Mounting Fixtures**



**Figures 13-14. Mounting Fixtures installed**



**Figure 15. TOCA Installed on the WRS2 Rack**

**Fluid Fitting Guard**

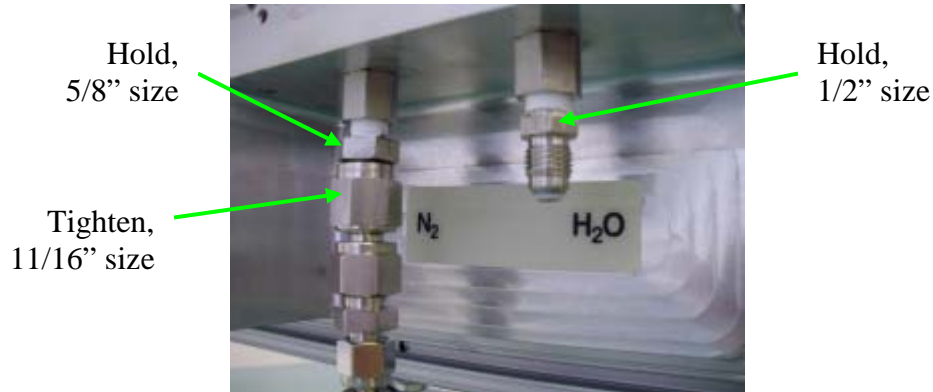
The Fluid Fitting Guard is used to protect the water and nitrogen connections on the TOCA.



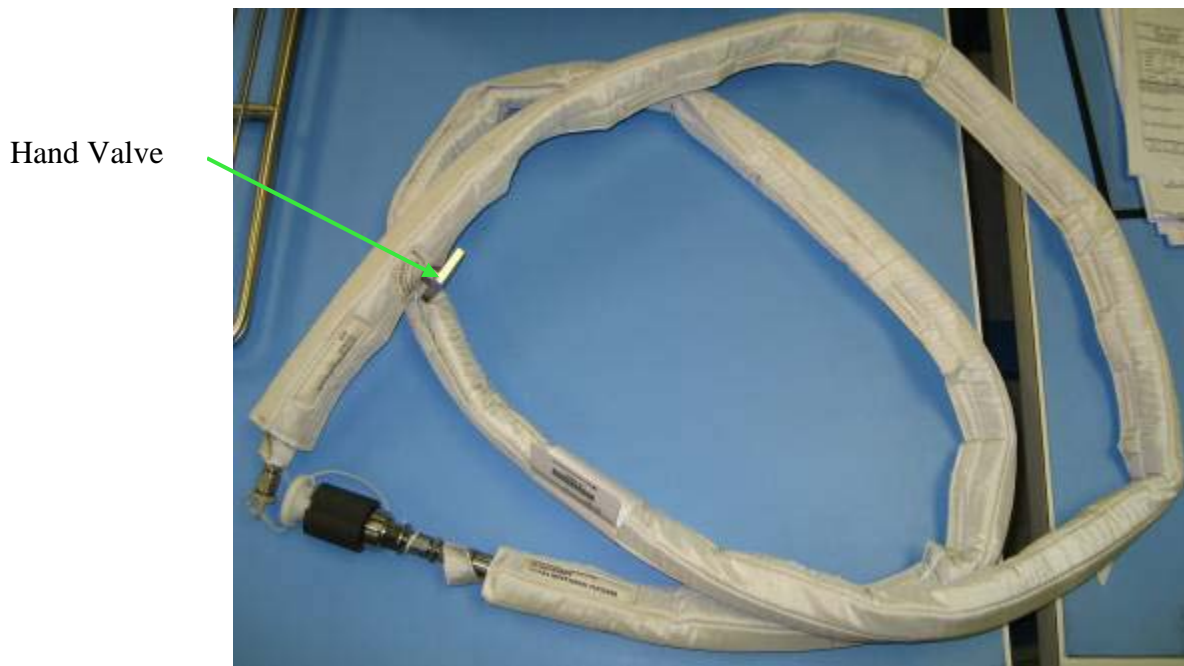
**Figure 16. Fluid Fitting Guard**

**TOCA Nitrogen and Water Connection**

The NOD3 TOCA N<sub>2</sub> Hose and TOCA Water Sample Hose should never be disconnected once they are installed. TOCA uses N<sub>2</sub> at a rate of 325 +/- 50 mL/min. The maximum N<sub>2</sub> design pressure is 200 psia.

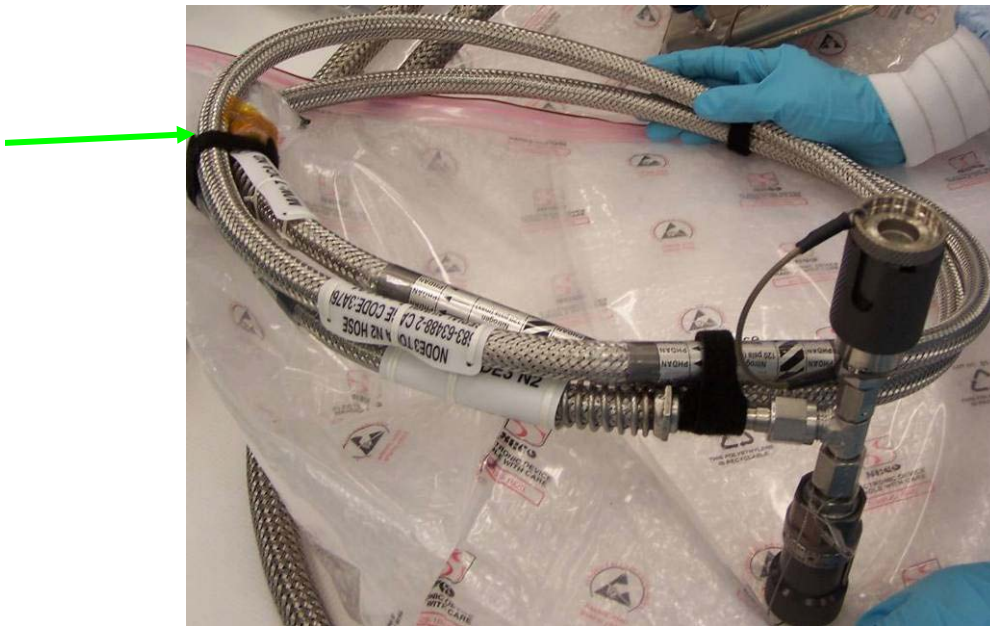


**Figure 17. N<sub>2</sub> and Water Sample Hose Connections**



**Figure 18. TOCA Water Sample Hose**

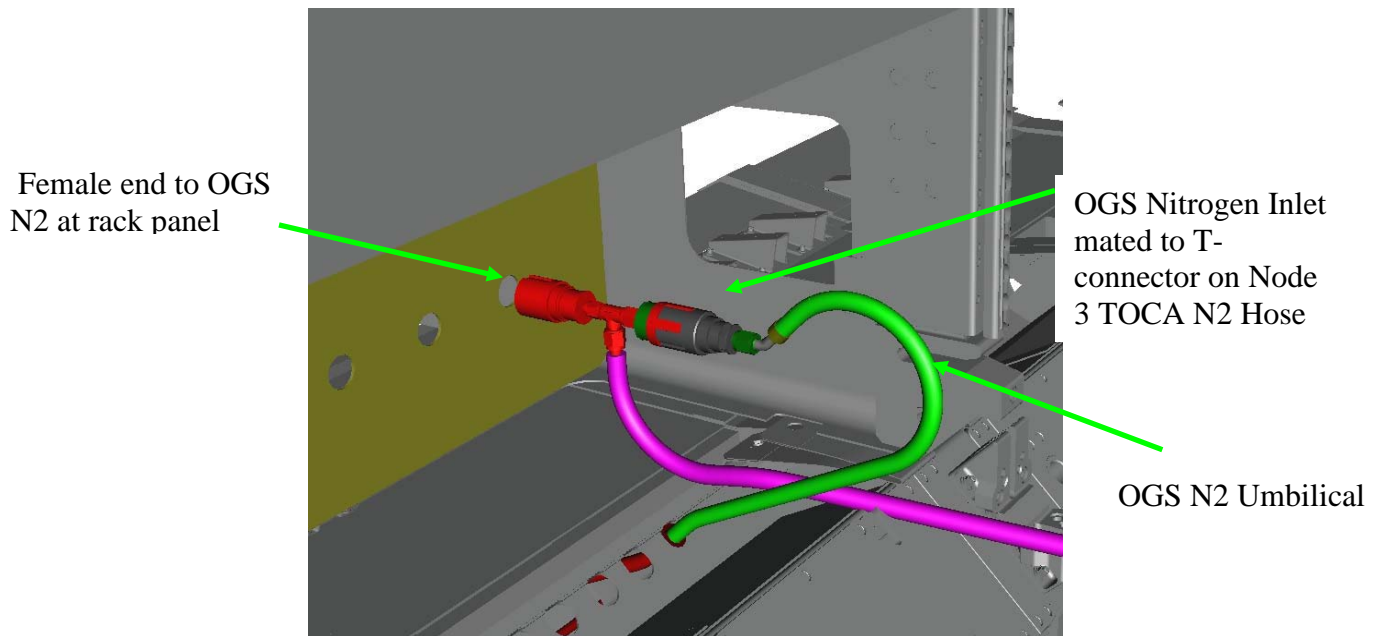
To TOCA



**Figure 19. NOD3 TOCA N2 Hose**

**GN<sub>2</sub> QD connection at the Z panel**

The NOD3 TOCA N2 Hose connects to the GN<sub>2</sub> QD at the OGS Rack Interface Panel. This Hose may sometimes be disconnected; therefore, crew is instructed in the procedure to verify its connection prior to starting an analysis.



**Figure 20. Node 3 TOCA N2 Hose mated with OGS N2 umbilical**

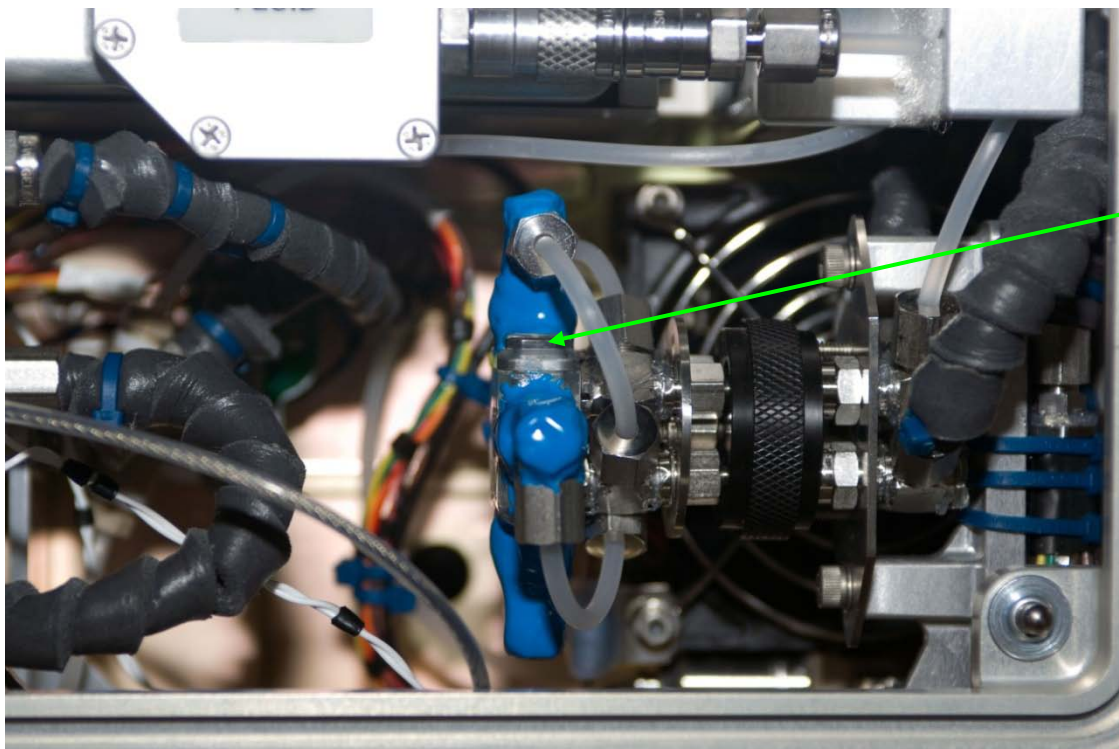


**Gas Liquid Separator (GLS)**

The Gas Liquid Separator (GLS) is a 1” x 1” x 0.25” device that separates gas from the water sample volume. The GLS utilizes a hollow-fiber membrane and a differential pressure to transfer the gas across the membrane. As the sample passes over the tubing, the gases diffuse across the membrane due the difference in CO<sub>2</sub> partial pressure across the membrane leaving an almost fully aqueous sample stream. The diffused gas then flows to the gas loop where its CO<sub>2</sub> content is measured and then expelled. The GLS is installed during TOCA installation and spares are maintained on-orbit.



**Figures 21-22. Gas Liquid Separator, Location to be Installed**



Gas  
Liquid  
Separator

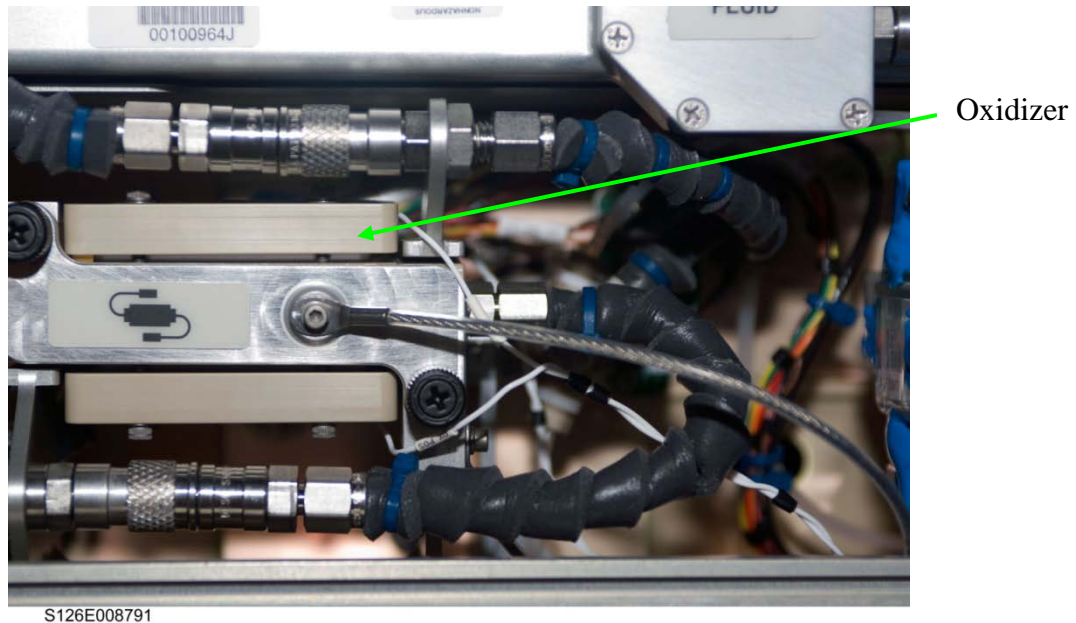
S126E008792

**Figure 23. Gas Liquid Separator Installed**



### **Oxidizer**

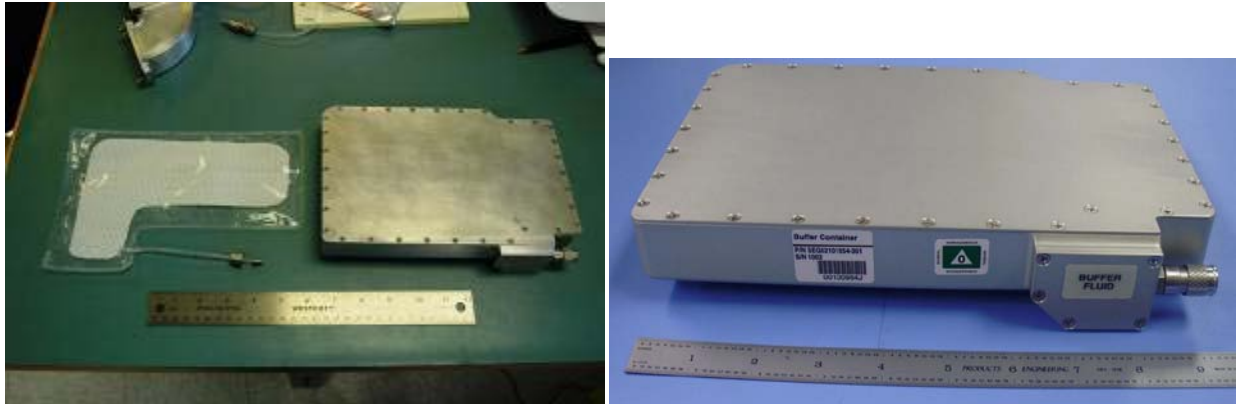
The oxidizer reactor converts organic carbons to CO<sub>2</sub> by using electrolysis to split water molecules into O<sub>2</sub> and H<sub>2</sub>. The O<sub>2</sub> is then available to oxidize the organic carbon into CO<sub>2</sub>, and H<sub>2</sub> is a by-product of the process. The electrolysis process occurs when sample fluid flows between 2 (anode and cathode) Boron-Doped-Diamond (BDD) coated electrodes. This method of oxidation does not require oxidizing reagents, heat, or UV light. It has no moving parts and only requires inputs of electrical current and sample water flow. The oxidation reactor operates at a constant DC current of 460mA, a voltage of 14-16 VDC, and requires a flow rate of at least 190 mL/min. The Oxidizer reactor typically adds 4-5 watts of heat to the water sample.



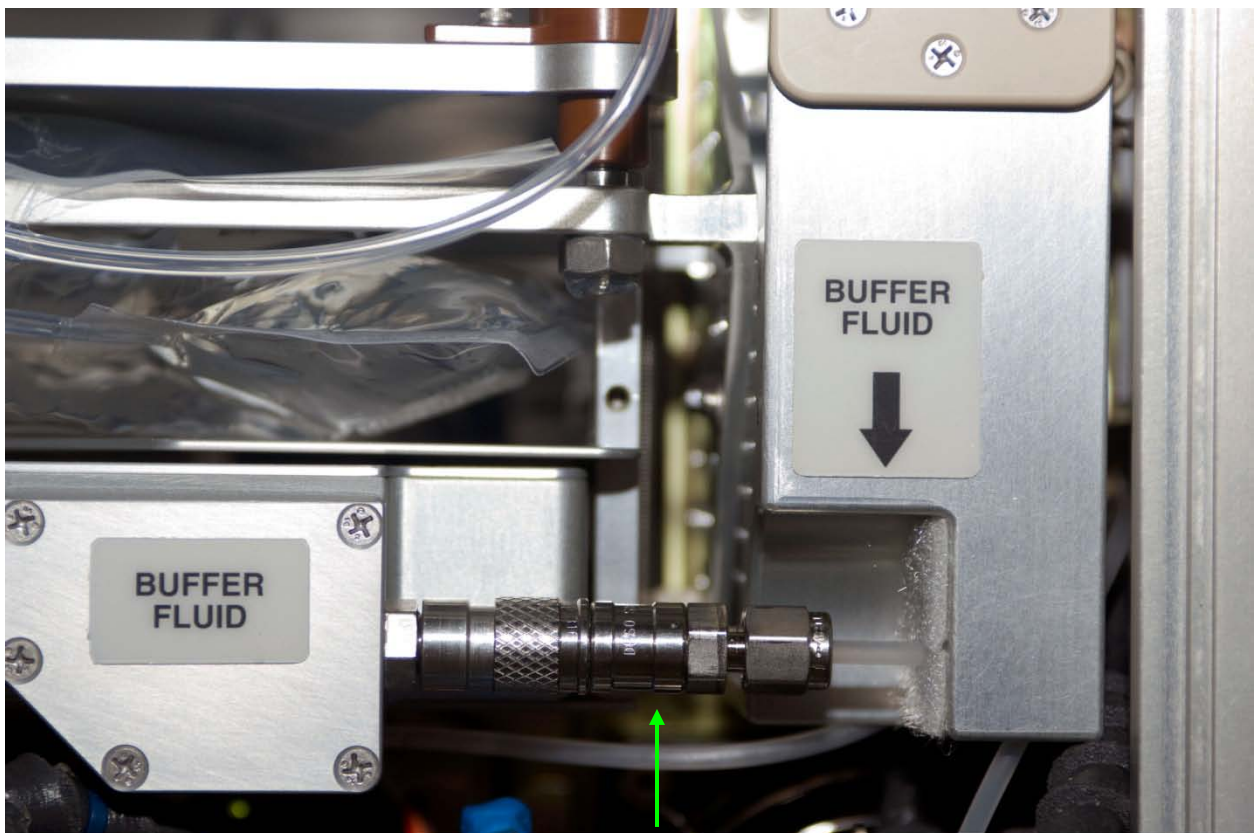
**Figure 24. Oxidizer**

### **Buffer Container**

The Buffer Container is an aluminum casing that encloses a 500 mL bag. One is installed during TOCA installation and there is one spare on-orbit. The acidic buffer container provides a reservoir from which the acidic buffer is drawn and introduced into the sample. The acidic buffer produces a pH shift that allows the conversion of inorganic carbons in the sample volume to CO<sub>2</sub> gas, which can then be measured. The acidic buffer used in the TOCA consists of an aqueous sodium phosphate buffer. The acidic buffer solution consists of ~99% 0.5M NaH<sub>2</sub>PO<sub>4</sub> and ~1% 0.5M Na<sub>2</sub>HPO<sub>4</sub> titrated to a pH of 5.2. The solution has been assessed by JSC Toxicology as Toxicity 0 – non-hazard material (reference memo TOX-NK-2006-16). The acidic buffer container is opened to the sample loop and the VCA draws the buffer solution into the sample to achieve a mix of 1 part buffer to 8 (TBR) parts sample solution. The acidic buffer is a TOCA consumable and is considered an Orbital Replaceable Unit (ORU) for on-orbit maintenance. The acidic buffer container consists of a 500 mL soft-sided flexible bag which is enclosed within a sealed aluminum container that is purged with Nitrogen in order to eliminate volatile organics.



**Figures 25-26. Buffer Container**



S126E008793

**Figure 27. Buffer Container QD Connection**



**Figures 28-29. Incorrect and Correct QD Connections, Respectively**

**Power Cable**



**Figure 30. TOCA Power Cable**

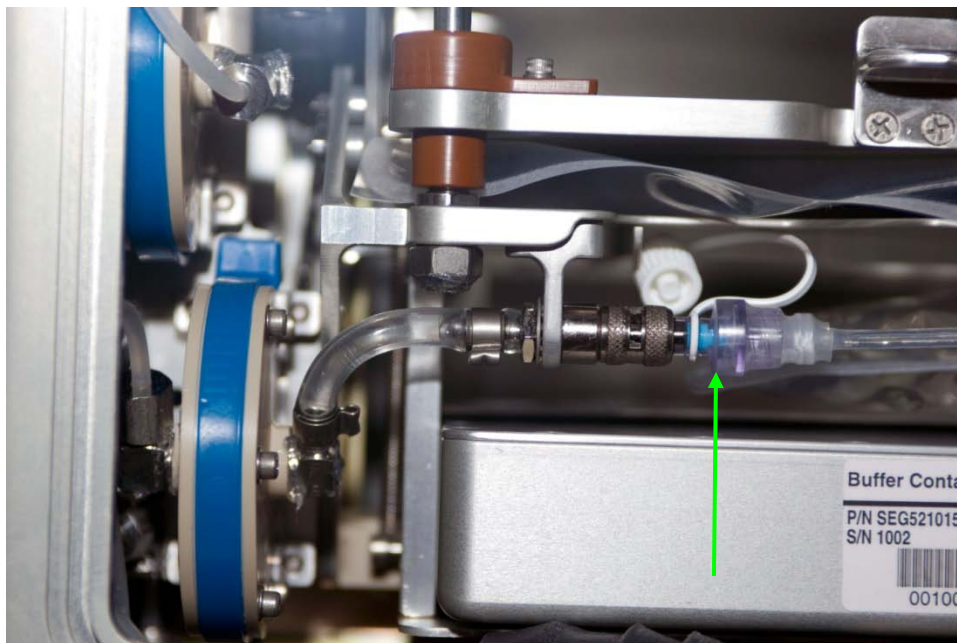


**Sample Analysis Bag**

Each sample collected will be 200 mL of water. The TOCA only requires 150 +/- 10 mL of water for analysis. The extra 50 mL of water is collected to allow some water to be separated from the volume to be analyzed when installing the clip.



**Figure 31. Filled TOCA Bag**



S126E008796

**Figure 32. TOCA Sample Analysis Bag Luer**

## Calibration Packets



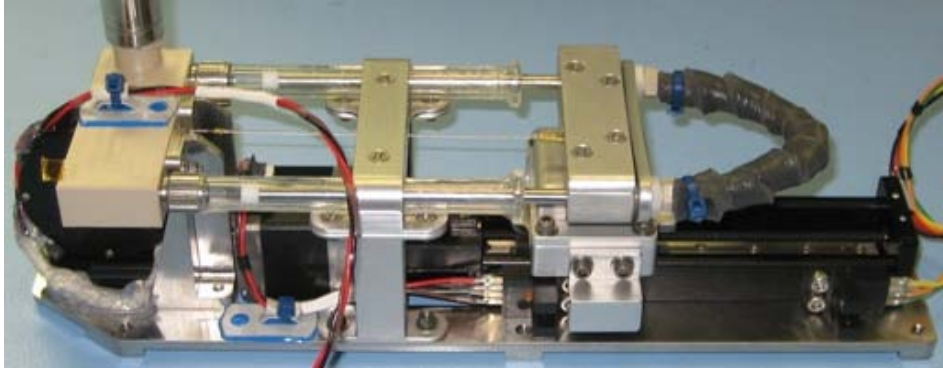
**Figure 33. High TOC Calibration Packet**



**Figure 34. Low TOC/TIC Calibration Packet**

**Volume Compensation Assembly (VCA)**

The VCA provides a variable volume ranging from 0 to 2 mL and controls water loop pressure. The primary function is to account for sample loop volume changes due to CO<sub>2</sub> production, free gas introduced via the sample inlet, temperature effects, and acidic buffer volume that is introduced during the react TIC operating stage. It is also used to maintain a controlled pressure on the sample loop when CO<sub>2</sub>, H<sub>2</sub>, and O<sub>2</sub> are removed from the sample.

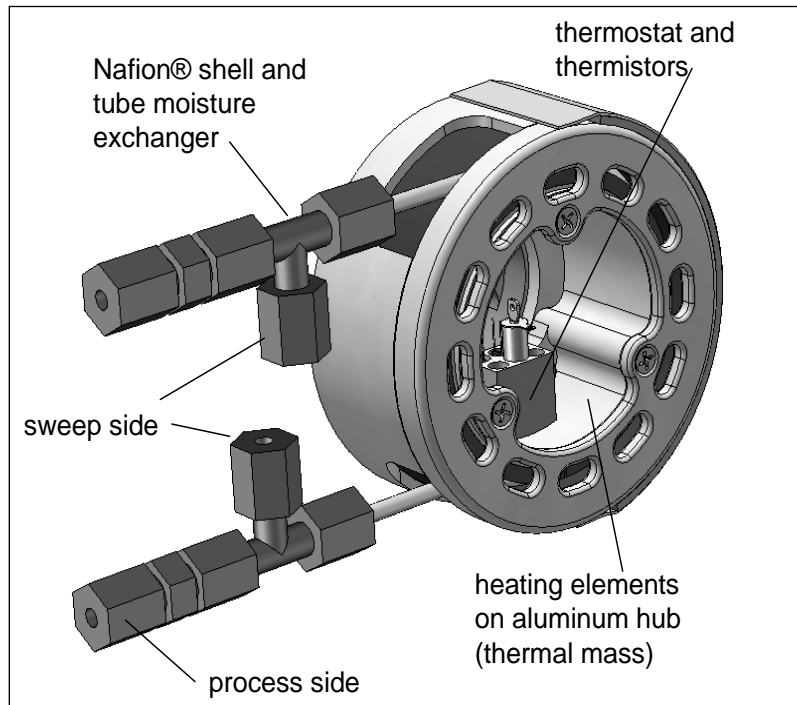


**Figure 35. Volume Compensation Assembly**



**Moisture Exchanger**

The Moisture Exchanger removes water vapor from the gas loop. Mitigates condensation within gas loop or interference with CO2 detector. Consists of a Nafion® polymer tube surrounded by an outer tube. A dry sweep gas flowing over the exterior surface of the Nafion® tubing continuously extracts water vapor from the CO2/sweep gas stream inside the Nafion® tubing. The sweep gas along with the water vapor is then vented to the ISS cabin. The container is also heated to 50°C to ensure tube temperature remains above process or sweep side dew point temperature to prevent the formation of condensate.



**Figure 36. TOCA Dryer Diagram**



**Figure 37. TOCA Dryer**

### TOCA Repair/Maintenance Kits



**Figure 38. TOCA Gas Module Repair Kit**



**Figure 39. Interior of Gas Module Repair Kit**



**Figure 40. TOCA Maintenance Kit**



**Figure 41. Contents of TOCA Maintenance Kit**



**Figure 42. TOCA Maintenance Kit Contents**



### Screen Shots of Displays

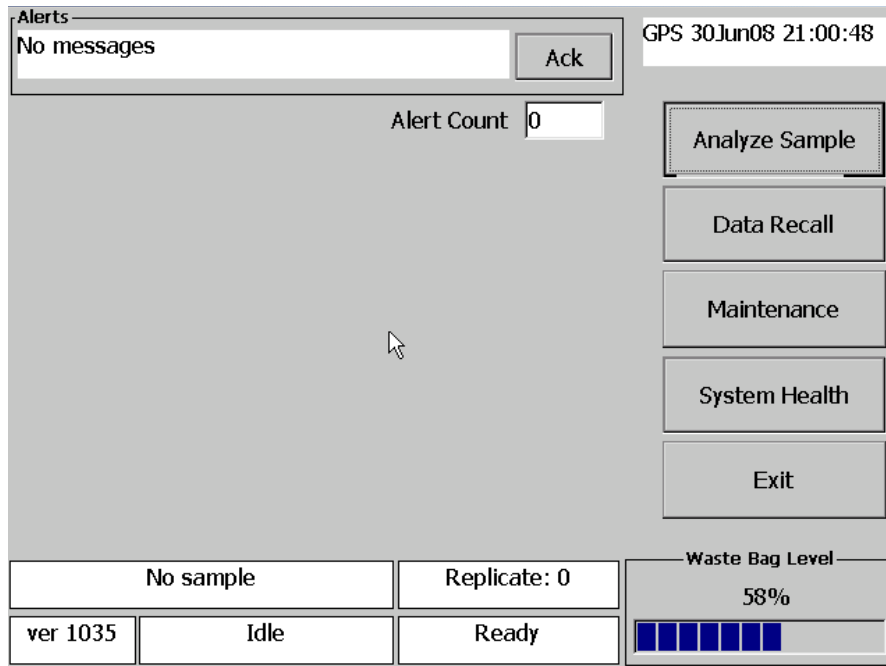


Figure 43. Screen Shot of Main Screen

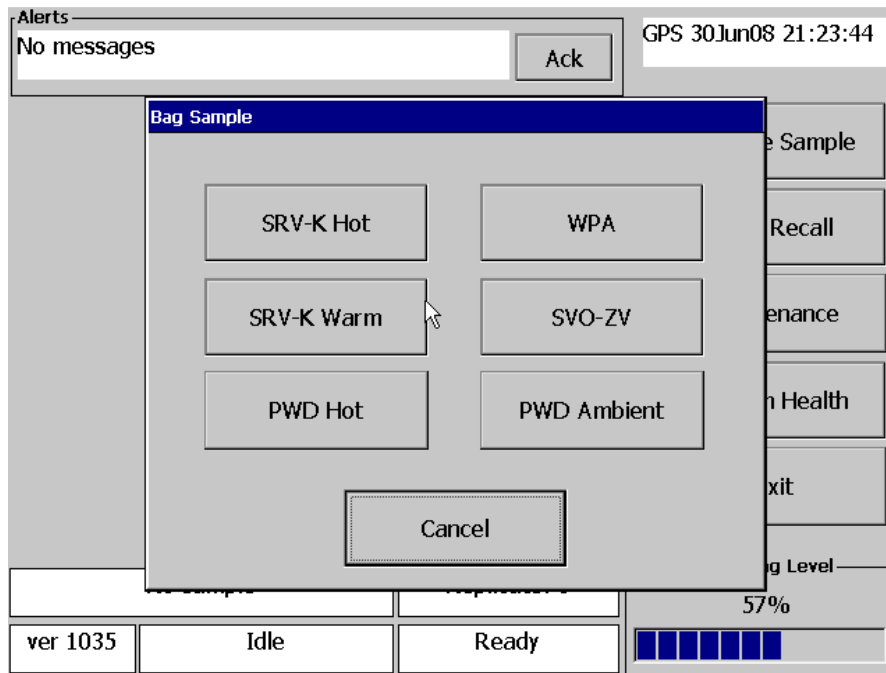


Figure 44. Bag Sample Type Screen

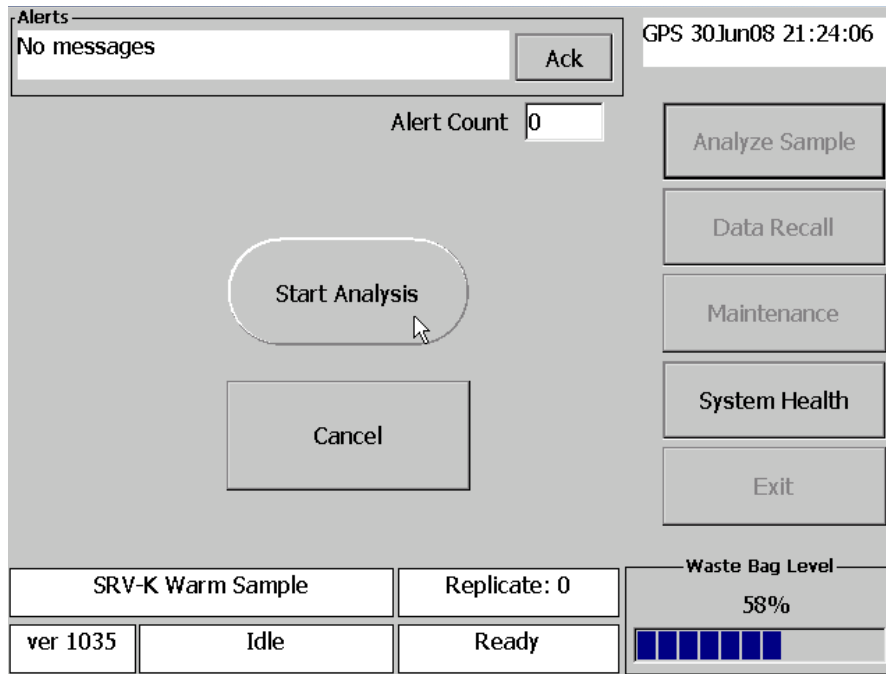


Figure 45. Start Analysis Screen

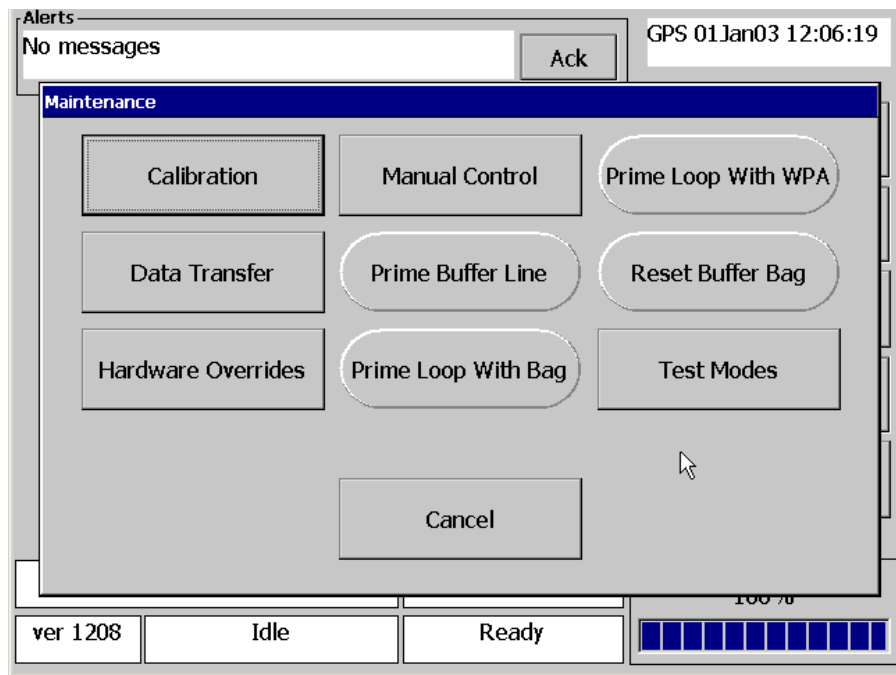


Figure 46. Maintenance Screen



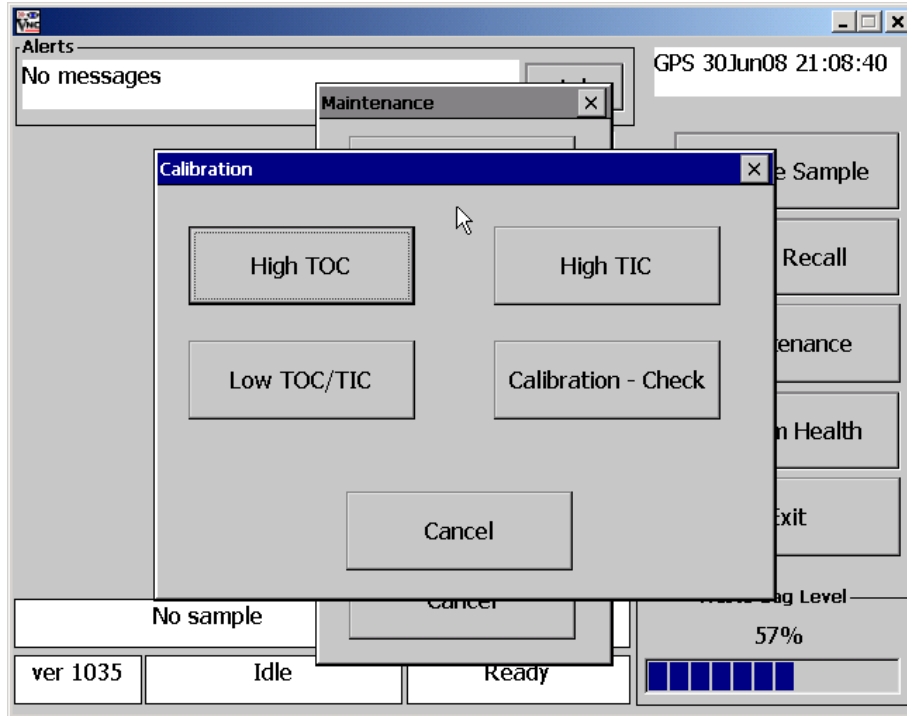


Figure 47. Calibration Type Screen

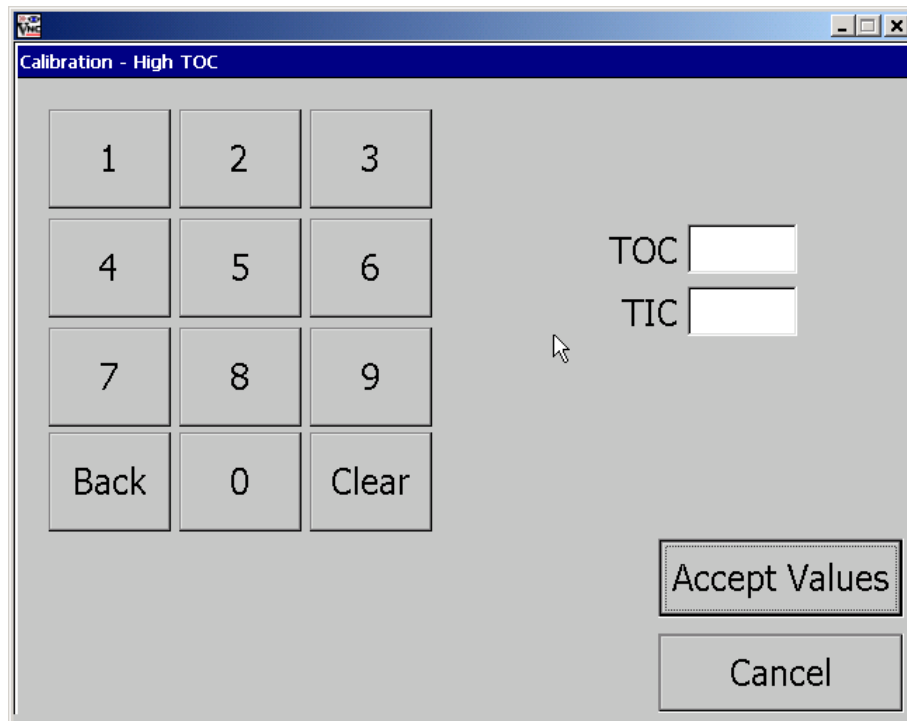


Figure 48. Known TOC and TIC Screen

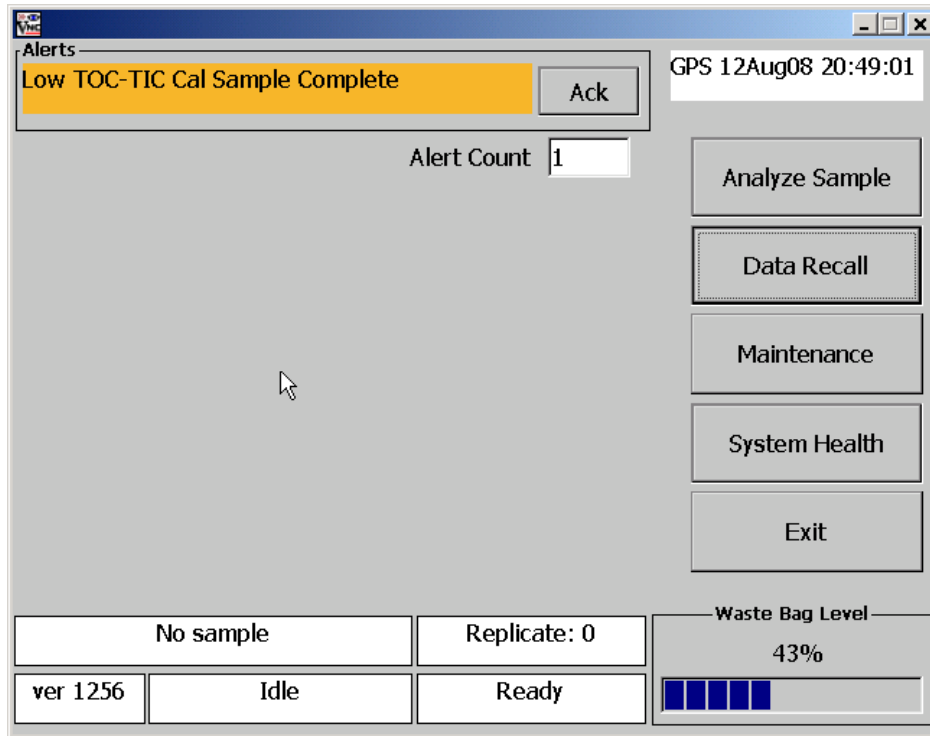


Figure 49. Low TOC-TIC Calibration Complete Screen

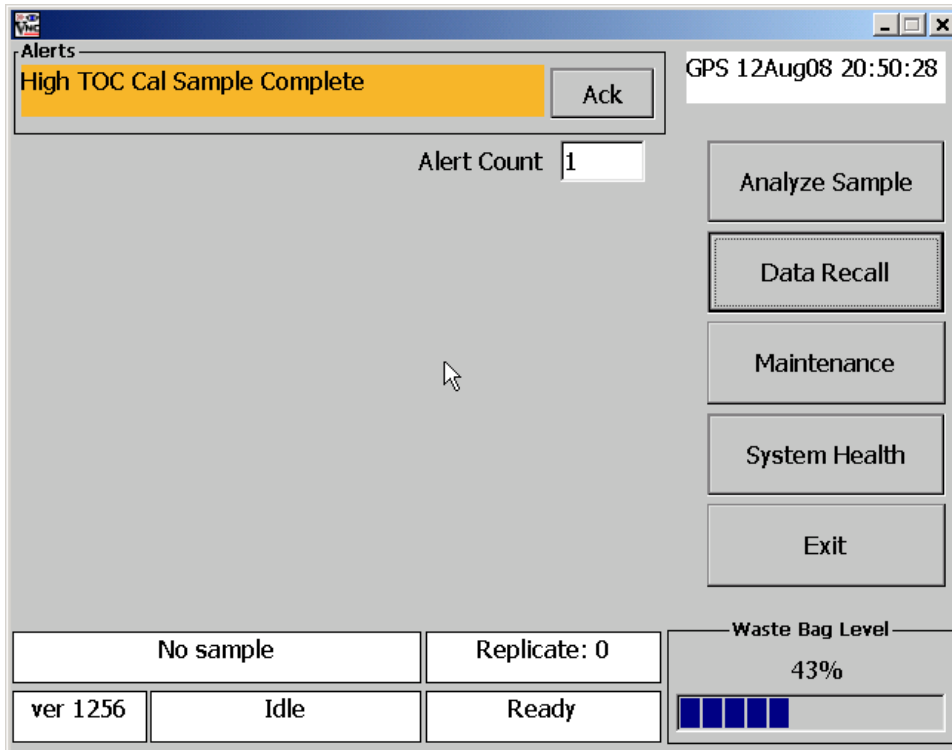
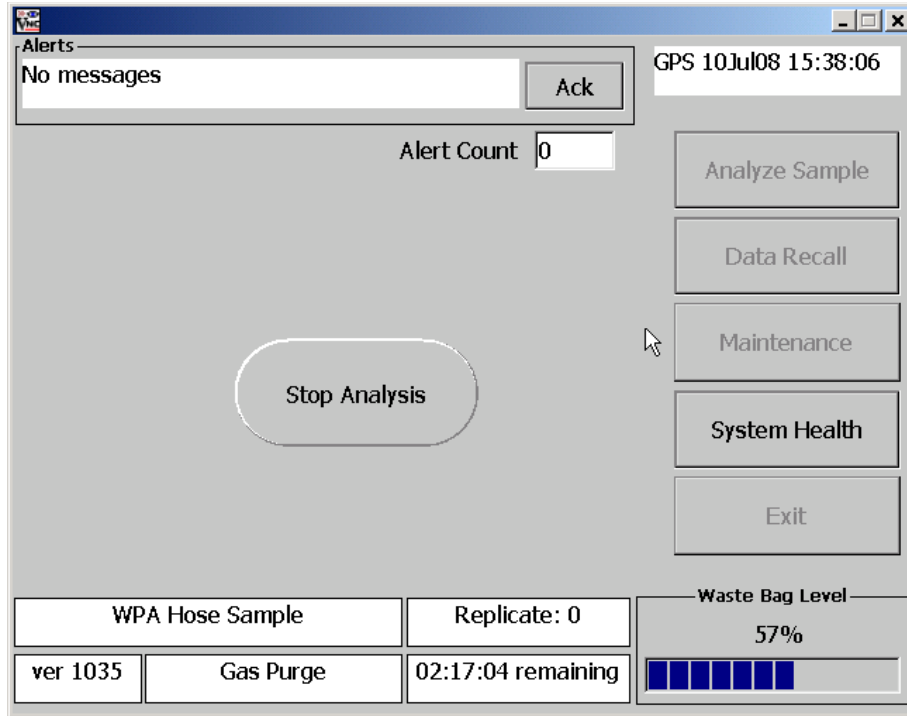
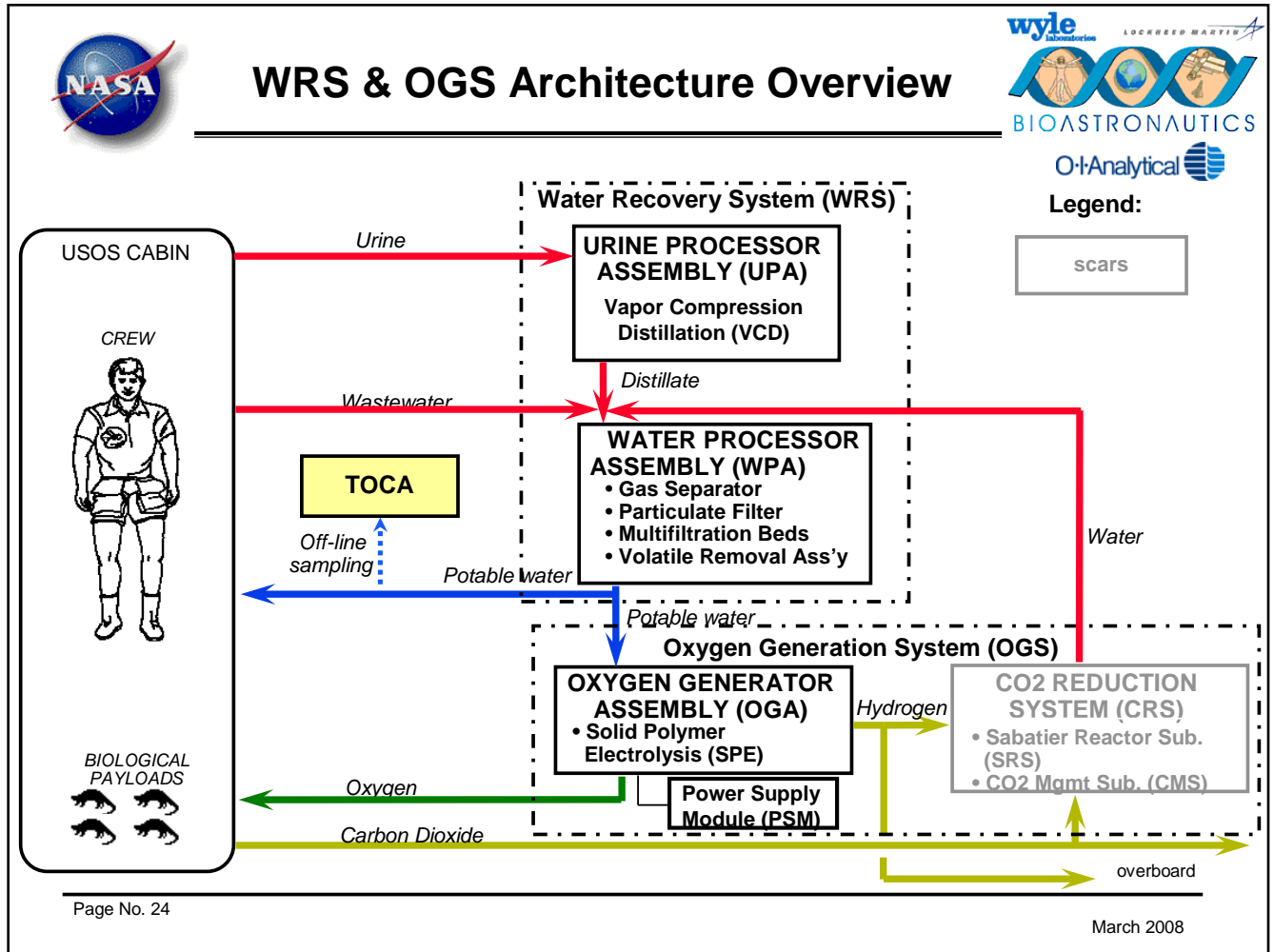


Figure 50. High TOC Calibration Complete Screen



**Figure 51. Stop Analysis Screen**

**TOCA Schematics**



**Figure 52. WRS & OGS Architecture**

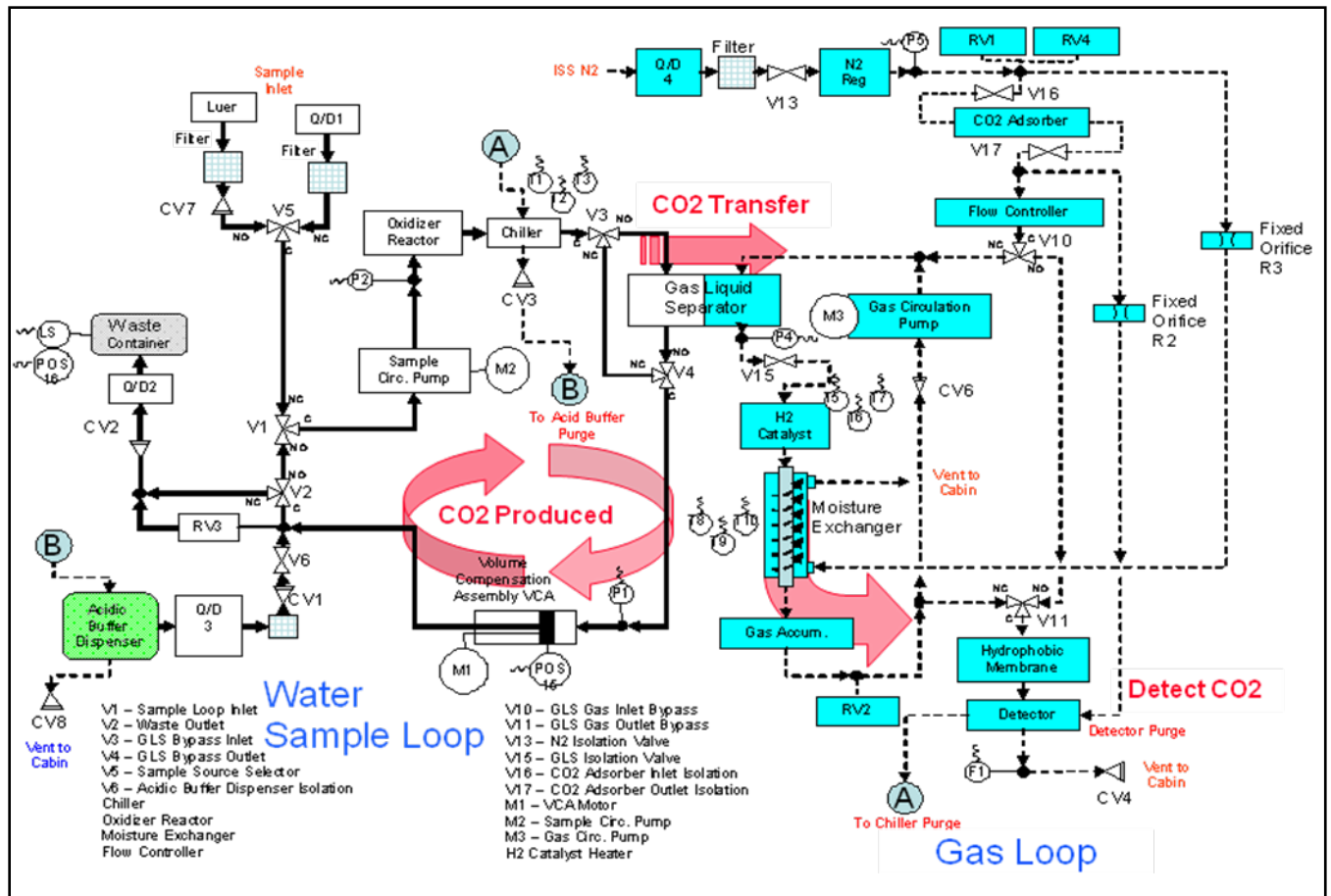


Figure 53. TOCA Schematic

### 3.2.4.6 TOCA Process States

Normal Sequence		
Bag Sample	Secs	
Power Up	240	Rep 0
Gas Purge	60	
Gas Purge 2	15	
Gas Purge	45	
Pos Vca 0	10	
Add Buffer 0	30	
React TOC 0	120	
Detect TOC 0	240	
Position VCA	25	
Line Flush	11	
Debubble	60	Rep 1
Chiller Cool	335	
Detector Health	65	
Flush Bypass	5	
Position VCA	20	
Flush	11	
Debubble	60	
Position VCA	30	
Flush	11	
Debubble	60	
Gas Purge	60	
Gas Purge 2	15	
Gas Purge	45	
Position VCA	25	
Add Buffer	35	
React TIC	60	
Detect TIC	960	
React TOC	120	
Detect TOC	240	
Analyze	5	
Gas Shutdown	10	

Repeat 2x for  
Rep 2 & 3  
(excluding Flush  
Bypass state)

Normal Sequence		
WPA Hose Sample	Secs	
Power Up	240	Rep 0
<b>Set Flush Time</b>	5	
Gas Purge	60	
Gas Purge 2	15	
Gas Purge	45	
Pos Vca 0	10	
Add Buffer 0	30	
React TOC 0	120	
Detect TOC 0	240	
Position VCA	25	
Line Flush	11	Rep 1
Debubble	60	
Chiller Cool	335	
Detector Health	65	
Flush Bypass	5	
Position VCA	20	
Flush	11	
Debubble	60	
Position VCA	30	
Flush	11	
Debubble	60	
Gas Purge	60	
Gas Purge 2	15	
Gas Purge	45	
Position VCA	25	
Add Buffer	35	
React TIC	60	
Detect TIC	960	
React TOC	120	
Detect TOC	240	
Analyze	5	
Gas Shutdown	10	



### 3.2.4.7. Shutdown Description

The TOCA is able to cause a shutdown of the box under a variety of conditions. The shutdown may be caused by an over current on a circuit breaker, a computer initiated shutdown, or an analog circuit initiated shutdown.

There are two circuit breakers on the front panel with a remote trip capability. This remote trip is used to turn off the power from the secondary supplies (5VDC, 12VDC, 24VDC, and Chiller Power Supply). Should only SW3 (24VDC and Chiller Power) be tripped, the display, fans, and computer will continue to function. When SW2 is opened, the 5VDC and 12VDC power is opened. The opening of SW2 also causes a solid state relay to open and remove the 120VDC from the primary side of the DC/DC converters and heaters. Hazardous voltages may still be present inside the TOCA and therefore the power cable must be disconnected or input voltage positively safed before any servicing is attempted.

In the event that an analog or computer initiated shutdown occurs, a binary message will be displayed using unpowered, latching indicators. If a circuit breaker is tripped due to an over current on the circuit breaker, there may not be a fault indicator message.

In the event power quality issues on the power lines such as load shedding, large amplitude transients from other equipment turning off, etc, the TOCA may turn off without a fault indicator being displayed.



**Figure 54. Example Fault Indication after an automatic shutdown**

Fault 1 is considered the most significant bit (MSB). The message in Figure 54 can be interpreted from the below table (Figure 55) to be an Error 13, low ambient pressure.

Error	Fault 1	Fault 2	Fault 3	Fault 4	Event
0					No Error/Check Breakers
1					Catalyst Over Temp T5, T6, T7
2					Gas Pump Over Current Liquid Pump Over Current
3					Reserved/Invalid
4					Oxidizer Overcurrent
5					Watchdog Timer
6					Reserved/Invalid
7					CPU Shutdown
8					Valve Overcurrent
9					Enclosure Over Temperature T11, T12, T15
10					Reserved/Invalid
11					Reserved/Invalid
12					IR Source Over Current
13					Low Ambient Pressure
14					Reserved/Invalid
15					Dryer Over Temperature T8, T9, T10

**Figure 55. Fault Indicator Error Table**

**Table 3.2.4.7-1 Possible TOCA Failure Causes**

Fault Indicator #	Possible Cause
1 & 15	<ul style="list-style-type: none"> <li>• Computer inability to control heaters</li> <li>• Sensor failure</li> </ul>
2 & 8	<ul style="list-style-type: none"> <li>• Fluid leak</li> <li>• Failed device</li> <li>• Shorted wire</li> <li>• Faulty Sensor</li> </ul>
4	<ul style="list-style-type: none"> <li>• Faulty sensor</li> <li>• Short inside the oxidizer</li> </ul>
5	<ul style="list-style-type: none"> <li>• Software was exited for another operation</li> <li>• Software locked up due to radiation hit or other event</li> </ul>
3, 6, 10, 11, & 14	<ul style="list-style-type: none"> <li>• These error messages are invalid.</li> </ul>
7	<ul style="list-style-type: none"> <li>• Various potential causes</li> </ul>
9	<ul style="list-style-type: none"> <li>• Device failure causing excessive heating</li> </ul>

	<ul style="list-style-type: none"> <li>• Sensor failure</li> </ul>
12	<ul style="list-style-type: none"> <li>• Short on in the power cable going to the detector</li> <li>• Fluid in the purge side of the IR filament</li> <li>• Fluid near the IR source outside the detector</li> <li>• Sensor Failure</li> </ul>
13	<ul style="list-style-type: none"> <li>• Reduced Cabin Pressure</li> <li>• Incorrect power on sequence: If the main power switch SW1 is rapidly turned from on to off and then back on again it <i>may</i> be possible to defeat a circuit used to prevent a transient condition on power up. This <i>may</i> cause this error to appear</li> </ul>

**3.2.4.8. TOCA Sensor Functions**

**Table 3.2.4.8-1 TOCA Sensor Functions**

Sensor ID	ID Long Name	Engineering Unit	Description
DP	Delta Pressure	PSIG	This derived data is calculated as the difference between P2 and P1
Elec Fan Speed	Electronics Fan Speed	RPS	The speed of the electronics module fan in revolutions per second
F1	Detector Flow Rate	mL/min	The rate at which gas is flowing at the detector in milliliters per minute
F2	Liquid Loop Flow Rate	mL/min	The rate at which water is flowing in the liquid loop calculated based on the delta pressure.
Fluid Fan Speed	Fluids Module Fan Speed	RPS	The speed of the fluids module fan in revolutions per second.
Gas Pump Curr	Gas Pump Current	mAmps	The current draw at the gas pump.
Ox Current	Oxidizer Current	Amps	The current draw at the oxidizer.
Ox Voltage	Oxidizer Voltage	Volts	The voltage at the oxidizer. The amount of acidic buffer in the liquid loop influences this voltage by adjusting the conductivity of the sample water. A lower voltage indicates a higher concentration of buffer in the loop.
P1	VCA Pressure	PSIG	The gauge pressure of the liquid loop at the Volume Compensation Assembly (VCA)
P2	Sample Pump Pressure	PSIG	The gauge pressure of the liquid loop at the liquid loop pump.
P4	Catalyst Pressure	PSIG	The gauge pressure of the gas loop at the catalyst.
P5	Nitrogen Inlet Pressure	PSIG	The gauge pressure at the nitrogen inlet to the gas side of the TOCA.
Sample Pump Curr	Liquid Pump Current	mAmps	The current draw of the liquid pump.

T1-T2-T3	Chiller Temperatures	deg C	The temperature of the water flowing through the chiller. This is measure in 3 different locations within the chiller.
T5-T6-T7	Catalyst Heater Temps	deg C	The temperature of the catalyst heater measured in 3 different locations on the catalyst body.
T8-T9-T10	Nafion Heater Temps	deg C	The temperature of the nafion heater measured in 3 different locations.
T11-T12-T15	Ambient Box Temps	deg C	T11 is the temperature at the electronics fan outlet....T12 is the temperature at the fluids fan inlet...T15 is the temperature at the outlet of the fluids module.
T14	Chiller Cold Plate Temp	deg C	The temperature directly on the cold plate of the chiller.
Vca Pos	VCA Position	Volts	The current position of the VCA plunger in volts.

**3.2.4.9. TOCA Software Message List**

**Table 3.2.4.9-1 TOCA Software Messages**

<b>Alert Message</b>	<b>Description</b>
Analysis Terminated	The software has terminated the analysis due to an error. Consult additional alert messages and analysis data for the termination's cause.
Cal Check Sample Percent Error: %XX	This alert is displayed after a complete analysis of a calibration check solution. This is the percent error for TOC from what was entered during analysis setup.
Can't open diagnostic log file	The software is unable to open the diagnostic log file and write the results of the latest startup diagnostics.
Can't open run time file	The TOCA software is unable to open the file run_time.txt which tracks the total number of hours of operation for the TOCA.
Can't open state machine log	The software is unable to open the state machine log
Can't open toca_crc.ini	The file containing the CRC values for the TOCA executable, main .ini, and all fault table files cannot be opened.
Can't open: XXXXXX	The software attempted and failed to open file 'XXXX'
CF Disk space at X%	Indicates that the amount of used space on the CF disk has reached a configurable percentage that indicates it is reaching the end of its disk space.
Chiller Cold Plate Near 0 deg C	The thermistor on the chiller cold plate (T14) indicates that the cold plate is nearing freezing which can freeze the liquid loop and cause an increase in pressure.
CO2 Max Out of Range	Parameter is outside configured bounds...check data for exact value
CO2 Min Out of Range	Parameter is outside configured bounds...check data for exact value
CO2 Ratio Avg Out of Range	Parameter is outside configured bounds...check data for exact value

CO2 Ratio Max High	Parameter is outside configured bounds...check data for exact value
CO2 Ratio Min Low	Parameter is outside configured bounds...check data for exact value
Co2 Rect Avg Term Equal 0	This would lead to a divide by zero in calculation of detector health values.
CRC error: 'XXXXXXXX'	A file did not pass its CRC check as part of the startup diagnostics. Check the diagnostic log for the calculated CRC value.
Detect Data Ready Timeout	A timeout expired while waiting for the data ready signal from the detector.
Detector baseline values zero	The baseline values for one or both detector channels is zero which would cause a divide by zero in calculation of signal data from the detector. One possibility is that the Chiller Cool state did not execute.
Device Fault, State: XXX, Status: 0XXXXXXXX	A device (valve, pump, etc.) is in the incorrect state for a given state in the analysis. The 'Status' indicates calculated bit pattern representing which devices are on and off. This 'Status' differs from what was loaded from the device fault table for the 'State' and thus the analysis will be terminated.
Empty waste container...switch tripped	The waste bag volume has increased to the point that the waste switch has been engaged. The waste bag must be emptied in order to continue operating the TOCA.
Error calculating stats	An error occurred during calculation of the TOC, TIC etc.
Fault: <parameter> below/above <value> in <state>	A fault has occurred and the alert message indicates the parameter that failed, whether it was below or above a value, and in what state the failure occurred.
No resources to start SM	The TOCA computer does not have enough resources to start the State machine process.
P5 holding pressure at shutdown	Valve 13 (nitrogen supply valve) has been closed but P5 is still indicating pressure from the supply after a 5 second hold waiting for pressure to drop off.
Ref Max Out of Range	Parameter is outside configured bounds...check data for exact value
Ref Min Out of Range	Parameter is outside configured bounds...check data for exact value
Ref Ratio Avg Out of Range	Parameter is outside configured bounds...check data for exact value
Ref Ratio Max High	Parameter is outside configured bounds...check data for exact value
Ref Ratio Min Low	Parameter is outside configured bounds...check data for exact value
Ref Rect Avg Term Equal 0	This would lead to a divide by zero in calculation of detector health values.
Replace buffer container	The number of draws on the buffer container has exceeded the configured maximum value. The buffer container must be replaced and the software counter reset before continuing to operate the TOCA.
Supply Fail: 0XXXXXX	This indicates one or more of the power supplies was determined to be out of a configurable range during the startup diagnostics. This bit field indicates which supply failed the diagnostic check.
TIC concentration over limit of X	The calculated TIC concentration is above the allowed maximum value for TIC. The maximum value is a configurable value in the software.
TOC Below Detect Limit of XX	The amount of TOC detected is below the minimum that the instrument can

	detect. This minimum value is a configurable value in the software.
TOC Concentration Exceeds: XX ug/L	The amount of TOC detected exceeds the maximum allowed value for TOC. This maximum value is a configurable value in the software.
TOCA recalibrated	Nominal message that should occur after successful analysis completion of a calibration solution.
Too little buffer drawn in Add Buffer	The VCA position does not indicate a full buffer draw in the Add Buffer state.
Unable to pressurize liquid loop	The software made 4 attempts to draw extra solution after VCA closure and has now aborted the analysis when unable to stabilize pressure on the liquid loop with the VCA.
USB Disk Full	The USB disk has no more space available.
USB Disk space at X%	Indicates that the amount of used space on the USB disk has reached a configurable percentage that indicates it is reaching the end of its disk space.
USB Disk access failed...insert USB drive	The USB disk is not in the TOCA.
USB Disk update folder not found	The update folder on the USB disk is not found.
Valve Fail: 0xXXXXXXXX	This indicates one or more of the TOCA valves failed to open or close. This bit field indicates which valve(s) failed the diagnostic check.
Valve X Close Fail	A check of the valve state failed to indicate that the valve had closed.
Valve X Open Fail	A check of the valve state failed to indicate that the valve had opened.
VCA not fully closed in Pos VCA	The VCA did not move beyond a configured position when closing during the Position VCA state. Review the health data to determine how far the VCA actually moved.
Zero Steps in State Add Acid	The number of steps for the VCA to move is zero in the Add Buffer state.

**3.2.4.10. Hardware Interfaces with Vehicle**

The TOCA unit is mounted on the WRS2 rack face in NOD3. The TOCA power cable is connected to UOP3 J4. The NOD3 TOCA N<sub>2</sub> Hose is connected at OGS GN2 umbilical source. The TOCA Water Sample Hose is connected to the Potable Water Container QD at the WRS1 Rack Interface Panel.

**Table 3.2.4.10-1 TOCA Connections to Vehicle**

Developer	Part Number	OpNom
Boeing	683-63488-2	Node 3 TOCA N2 Hose
Wyle	SEG52101727-301	TOCA Water Sample Hose
Wyle	SEG52101306-301	TOCA Power Cable

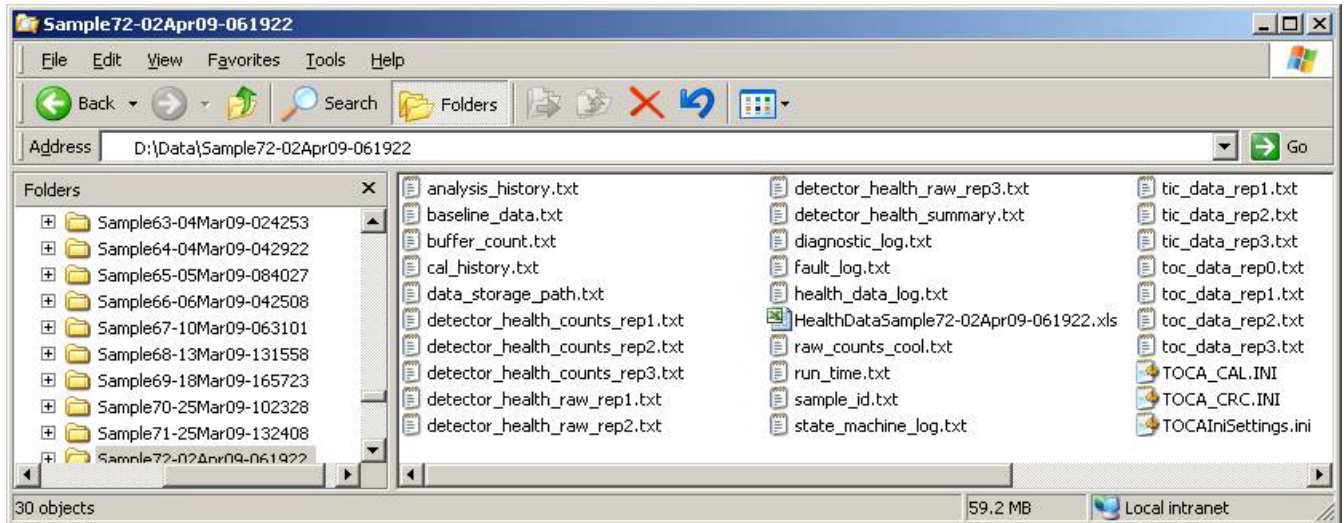


### 3.2.4.11. Resupply/Maintenance Schedule

The first TOCA unit is to be replaced with PFU2 in late 2010 or early 2011. The current unit, PFU1, has a cycle life that has been extended to allow operation through 2011. PFU2 will have an on orbit life of 5 years. The ORUs will be manifested on an as-needed basis.

### 3.2.4.12. Data/Commanding Capabilities

The primary data storage is on an internal Compact Flash (CF) disk. Sample data on the CF disk is automatically transferred to the TOCA USB drive after a completed or aborted analysis. Data transfer from CF to USB can also be manually initiated by the user on the Maintenance display.



**Figure 56. USB Drive structure**

### 3.2.4.13. Hazard Concerns

Haz #	Hazard Title	Hazard Causes	App	Severity/ Likelihood	Classification
1	Structural failure	1. Inadequate design of the TOCA to withstand crew induced loads and on-orbit loads	X	Catastrophic	Improbable
		2. Improper materials are used in the construction of the TOCA	X	Catastrophic	Improbable
		3. Inadequate design of the TOCA to withstand depressurization/repressurization loads	X	Catastrophic	Improbable
2	Particulate contamination	1. Release of fragments from shatterable materials	X	Critical	Improbable
3	Low energy rotating machinery/propelled debris	1. Inadequate fracture control of rotating equipment	X	Critical	Improbable
4	Fire/Explosion	1. Use of flammable materials in the TOCA design	X	Catastrophic	Improbable
		2. Improper design of TOCA electrical components and wiring	X	Catastrophic	Improbable
		3. Inadequate design of TOCA to prevent uncontrollable H2 ignition	X	Catastrophic	Improbable
5	Electrical shock	1. Improper design of the TOCA electrical components and wiring	X	Catastrophic	Improbable
		2. Inadvertent exposure to terminals or connectors	X	Catastrophic	Improbable
6	EMI	1. EMI generated by the TOCA (radiated and/or conducted emissions)	X	Catastrophic	Improbable
		2. EMI generated by other systems or hardware (radiated and/or conducted susceptibility)	X	Catastrophic	Improbable
7	Battery leakage/rupture	1. Battery overdischarge	X	Catastrophic	Improbable
		2. External short across the battery	X	Catastrophic	Improbable
		3. Internal short circuit or open circuit in battery cells	X	Catastrophic	Improbable
8	Lasers				
9	Sharp edges / pinch points	1. Improper hardware design may result in sharp edges	X	Critical	Improbable
10	Appendage entrapment in holes	N/A	N/A	N/A	N/a
11	Toxicity/Offgassing	1. Use of materials that offgas excessive quantities of toxic trace gas contaminants	X	Critical	Improbable
12	Noise level too loud	1. Excessive acoustic noise is caused by the fans and pumps in the TOCA	X	Critical	Improbable
13	Interference with translation path	1. Improper installation of the TOCA external hoses and cables may cause a translation path interference	X	Catastrophic	Improbable
14	Touch temperature	1. Heat generated by the TOCA may result in an IVA touch temperature hazard	X	Critical	Improbable
16	TOCA returns undetectable erroneous low data	1. Failure of control circuitry, electronic/ electro- mechanical piece part failures, or software error	X	Catastrophic	Improbable
		2. Failure of mechanical piece parts	X	Catastrophic	Improbable
		3. Software Error	X	Catastrophic	Improbable
		4. Ionizing radiation	X	Catastrophic	Improbable
17	Loss of fluid containment	1. Improper design of the TOCA sample hose	X	Catastrophic	Improbable
18	Accumulation of hazardous gases	1. Excessive generation of CO2	X	Catastrophic	Improbable
		2. Excessive generation of O2	X	Catastrophic	Improbable
		3. Excessive generation of O and O3	X	Catastrophic	Improbable
		4. Release of an excessive amount of N2	X	Catastrophic	Improbable
		5. Release of an excessive amount of Cl	X	Catastrophic	Improbable
19	Pressure Leakage/Rupture	1. Inadequate design strength to withstand maximum design pressure (MDP)	X	Catastrophic	Improbable
		2. Improper materials are used in the construction of the TOCA	X	Catastrophic	Improbable

### 3.3. Radiation Monitoring

The purpose of the Radiation Subsystem is to characterize the complex, multi-component radiation environment to which the ISS crew is exposed, and to record the crewmembers' cumulative exposures. The ionizing radiation environment encountered by ISS consists of a mixture of primary and secondary radiation types:

- a. Primary radiation varies as a function of ISS altitude and consists mostly of trapped protons, electrons, galactic cosmic radiation and solar flux.
- b. Secondary radiation products are produced by collisions of primary radiation with the ISS and its hardware inside, as well as inside the crewmembers' bodies.

#### 3.3.1. Extravehicular Charged Particle Directional Spectrometer (EVCPS)

##### 3.3.1.1. EVCPS Description

The EVCPS is used to measure the flux of trapped galactic cosmic rays, and solar protons as a function of time, charge, energy, and direction outside the ISS throughout the solar cycle.



Figure 1. EVCPS



Figure 2. EVCPS attached to the S0 Truss

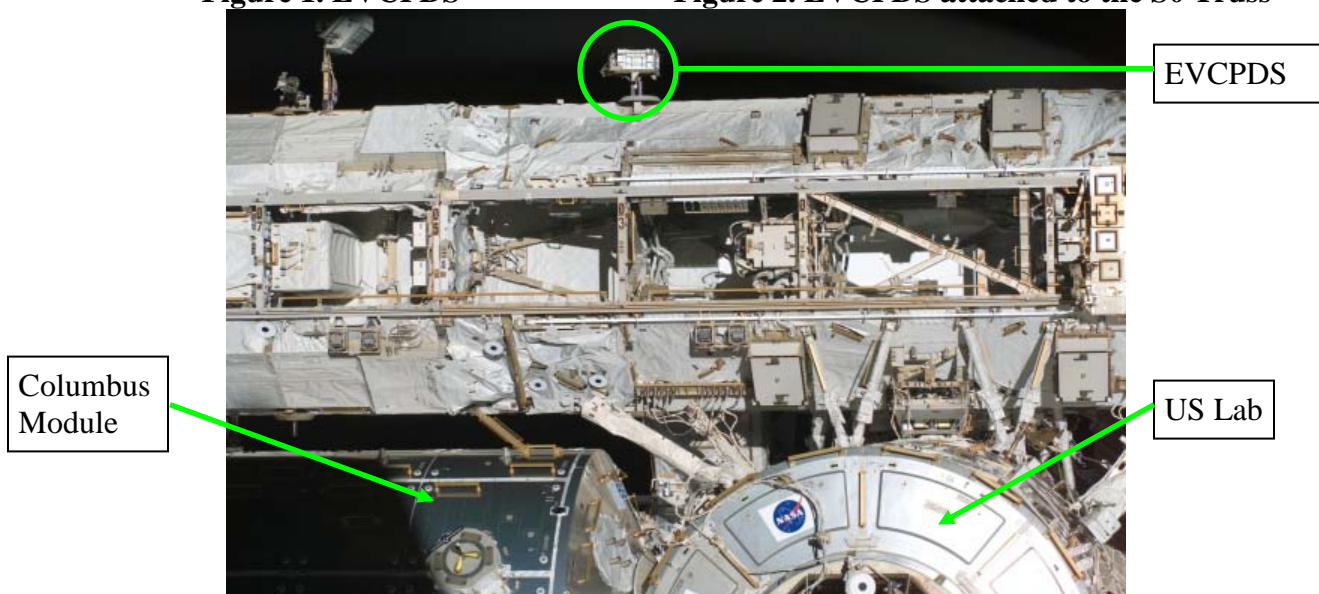
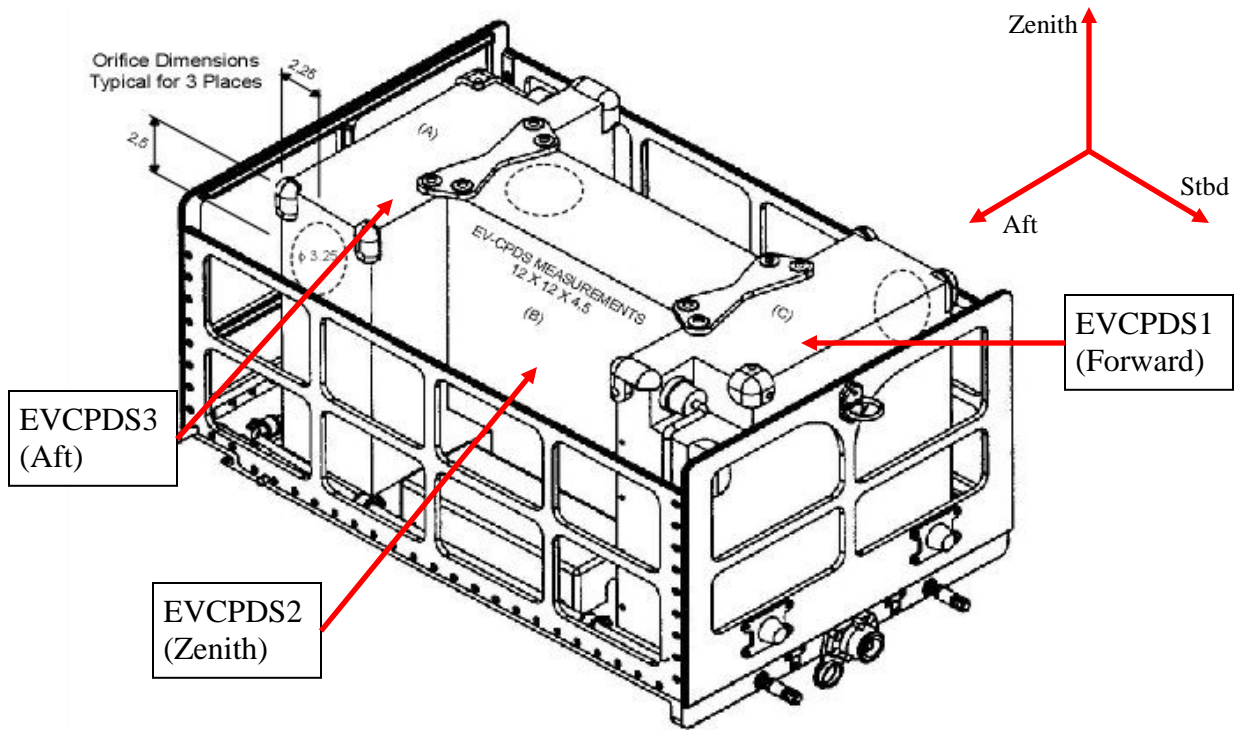


Figure 3. EVCPS on S0Truss



Assembly Configuration: SEG16102821-303

Figure 4. EVCPDS Assembly Configuration

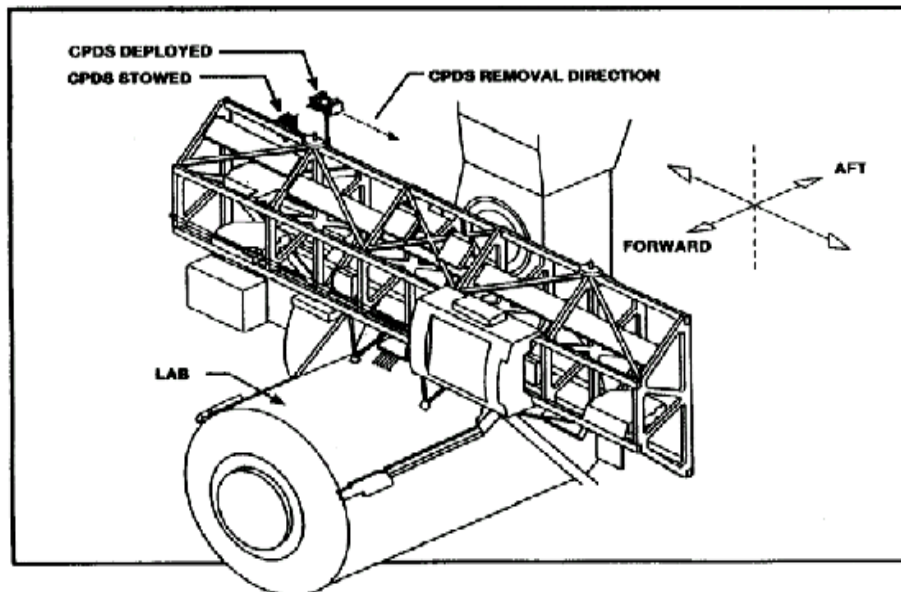


Figure 5. EVCPDS Location on S0 Truss



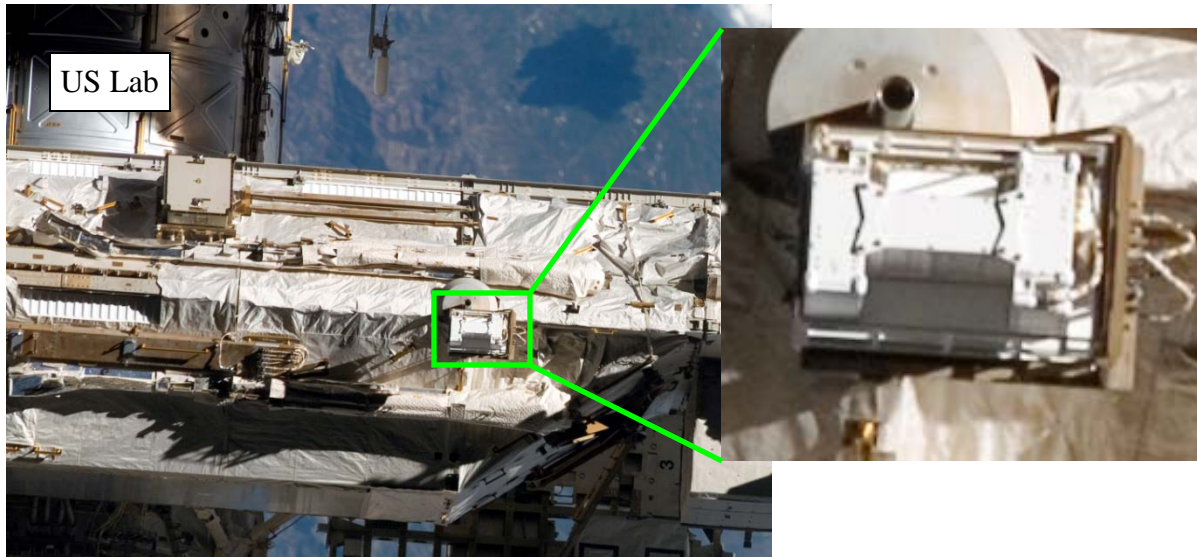


Figure 6. EVCPS on S0 Truss During STS-122/1E

### 3.3.1.2. EVCPS Component List and Description

Three (3) single-axis Charged Particle Directional Spectrometers (CPDS) are installed in a 6B avionics box with mechanical hardware for mounting on the boom of the Integrated Truss Structure S0 outside the ISS. EV1 monitors in the **FORWARD** direction, EV2 monitors in the **ZENITH** direction, and EV3 monitors in the **AFT** direction.

The CPDS instruments are composed of several different types of silicon detectors arranged in a stack configuration. The Position Sensitive Detectors (PSDs) are capable of determining the “path of incident” radiation through the detector stack. The ‘A’ detector cards (3) identify the specific particle event. The ‘B’ detector cards (3) provide additional information regarding the total particle energy. The ‘C’ detector card (1) amplifies and shapes the electrical signal resulting from a charged particle collision inside the detector.

#### EVCPS Heater Configuration

The EVCPS has two heater systems: a manually controlled heater (external) and an automatic heater (internal). The manually controlled heater is controlled by a different RPCM (S02B\_C) than the EVCPS instrument RPCM (S01A\_C). The automatic heaters are controlled by thermostats (activated at -20°C) in each instrument and are powered via the EVCPS instrument RPCM.

It is not required that the external heaters be turned on immediately after the EV instruments are unpowered; it is important, however, to activate the external heaters for **at least 4 hours** prior to powering on the EVCPS instruments anytime the instruments have been powered off for more than one hour.

It is important to reiterate that any time the boxes are off for more than 1 hour, the external heaters must be allowed to run for at least 4 hours. In a case where someone turns the heaters on at the same time the instrument is turned off, and the system is then left in that configuration for more than a hour (even with the heaters on for 1 hour), then they would have to ignore the fact

that the heaters were on since the instrument was turned off and let them run for 4 hours. But they could start counting from the moment the instrument was off, and heaters were turned on. This would mean an additional 3 hours if the heaters have already been on for 1 hour.

Any time the instruments are powered OFF longer than 2 hours, SRAG should be notified. There is no set limit to how long the EV instruments can be off, but CHeCS MER should be contacted if the known duration of the powerdown will exceed 24 hours. When the instruments are powered down for more than 24 hours, CHeCS MER will need to provide the duration for external heater activation before powering on the instruments (duration will be more than 4 hours). For specific instructions on powerdown preparation and recovery, refer to SODF: Ground Handbook: Support Systems book in the Medical Operations: Radiation section.

The nominal operations configuration for the EVCPS is: EV instruments ON, EV external heaters OFF. However, there have been instances where both the EV instruments and external heaters were powered on. After monitoring the operations of the EVCPS instruments over time (from launch on STS 110/8A to current operations), it has been determined by radiation hardware and software engineers and Space Radiation Analysis Group (SRAG) that operating the instruments and external heaters simultaneously for a limited/known amount of time will not cause any damage to the hardware or software; however, CHeCS MER and SRAG should be consulted whenever this off-nominal configuration is occurring. In most cases, this configuration will not occur unless it is specifically requested by SRAG or CHeCS MER.

**Table 3.3.1.2-1 General Hardware Specifications**

Kit and Component List	Mass M(E)	Volume M(E)	Dimensions M(E)	Nominal Stowage Location	Storage Temp °C (°F)	Operating Temp °C (°F)	Operating Pressure mmHg (psia)
EVCPS Assy. (3 units in 6B Av. Box)	33.11 kg (73lbs)	0.10 m <sup>3</sup> (3.65 ft <sup>3</sup> )	35.41cm x 63.02cm x 41.15cm (13.94" x 24.81" x 16.2")	S0 Truss	-53 - 50°C (-63- 122 °F)	-53 - 50°C (-63-122 °F)	15 PSI - Vacuum* [ $<1\text{mmHg}$ ]

\*Care must be taken to assure instrument is not operated in the coronal region (~10-20 mmHg).

**Table 3.3.1.2-2 Hardware-Specific Parameters**

EVCPS Component	Power Draw per Unit (W)	Total Power Draw For All 3 Units (W)	Remote Power Controller Module (RPCM)	Remote Power Controller (RPC)
EV Instrument	12	36	S0-1A_C	3
Internal Heater	5	15		
<b>Total<sup>1</sup></b>	17	<b>51</b>		
External Heater	15	45	S0-2B_C	3
<b>Max Power Draw<sup>2</sup></b>	~32	<b>~96</b>		

<sup>1</sup>Nominal operating configuration with instrument and internal heaters on.

<sup>2</sup>Maximum power draw if instruments, internal and external heaters are powered; off-nominal config.



### **3.3.1.3. Hardware/Power Interfaces with Vehicle**

The 6B avionics box, which holds the 3 EVCPDS instruments, is mounted externally to the ISS on a 2 ft. boom on the Integrated Truss Structure S0 between bulkheads 1 and 2 on the starboard/aft upper face.

The EVCPDS instruments and heaters require a 120 VDC power source, which is supplied from 2 separate power buses through 3.5 amp Remote Power Controller Modules (RPCM). Each CPDS unit also contains a lithium thionyl battery to maintain the clock when the instrument is powered down.

Because the ISS Crew cannot physically power down the instruments at the power switch, the only way to powerdown and powerup the EV instruments is to open and close the RPC via ground commanding. In addition to ground commanding, the ISS Crew has the capability to send commands to the station's RPCMs via the ISS Homepage on a PCS. Although this is not the preferred method of operations, it is an accepted risk for the EV instruments since the only other way is to perform an EVA. All CPDS instruments are recommended to be commanded to "Standby" prior to powercycles, whenever feasible.

### **3.3.1.4. Resupply Schedule**

There is no scheduled resupply for the EV-CPDS instruments.

### **3.3.1.5. Data/Commanding Capabilities**

EVCPDS data is available to the ground via data dumps and Cyclic Data, which is available to the ground displays through telemetry using the 1553 bus architecture via S-band resources. EVCPDS dose rate data is provided continuously through telemetry. Flight controllers will dump detailed raw data from each of the 3 EV instruments weekly for processing to determine the spectral characteristics of the radiation environment. The Cyclic Data includes:

- Absorbed dose rate
- Accumulated absorbed dose rate
- Elapsed Time
- Health Status Data
- Instrument Mode
- Data required for Commanding Sessions (File counts, real-time monitor codes, etc.)

Ground flight controllers are able to command data dumps, built in tests, and instrument resets. Procedures are located in the SODF: Ground Handbook: Support Systems in the Medical Operations: Radiation section. The EVCPDS also has the capability to perform simple commands via PCS.

### **Powercycle File System Concern**

Following a powercycle, an individual EVCPDS instrument should nominally take up to 15 minutes to return to Standby mode from NO SIGNAL. However, in some cases the EV may take anywhere up to 16 to 24 hours to go back into acquisition mode after a power cycle if the file system has been corrupted and needs to be rebuilt automatically.

Nominal Reboot

The CPDS instruments will reboot themselves when the “Accumulated Time” (elapsed time) reaches 65,000 minutes. The device will turn off, turn back on, remain in standby mode for the nominal hour, then transition to acquire and all values will reset back to zero.

Maximum Number of Files

The maximum number of files that may be stored in the internal memory of any one of the EV-CPDS instruments is 550. (Each file is ~96kB in size.) When the maximum number of files are reached, the EV-CPDS will begin overwriting files starting with the oldest. This should not be allowed to happen. As the number of files stored on a single EV-CPDS instrument approaches or exceeds 500 files, BME should place that instrument into Standby as soon as possible in order to prevent the maximum number of files from being reached.

**3.3.1.6. Hazard Concerns**

<b>Hazard Title</b>	<b>Severity</b>	<b>Likelihood</b>
Fire/Explosion	Catastrophic	Improbable
Environmental	Critical	Improbable
EMI	Catastrophic	Improbable
Contamination	Catastrophic	Improbable
Sharp Edges/Corners	Marginal	Improbable
Biological/Physiological/Psychological	Marginal/Catastrophic	Improbable
Impact	Critical	Improbable
Toxicity	Catastrophic	Improbable
Electrical Discharge/Shock	Catastrophic	Improbable
Structural Failure	Catastrophic	Improbable
Battery Hazards	Critical	Improbable

### 3.3.2. *Passive Dosimeter Kit (PDK)*

#### 3.3.2.1. PDK Description

The Passive Dosimeter Kit (PDK) is composed of a collective system of hardware used to monitor radiation dose levels inside the habitable volume of the ISS. The PDK hardware records the radiation exposure of specific sites. This data will assist with a comprehensive radiological control program, which includes preflight crew exposure projections, real-time space environment monitoring and crew exposure measurements.

#### 3.3.2.2. PDK Component List and Description

- Radiation Area Monitor (RAM)
- High Rate Dosimeter (HRD) (2 units in PDK)
- Crew Passive Dosimeter (CPD)



**Figure 1. Passive Dosimeter Kit**



**Figure 2. Passive Dosimeter Kit (open)**

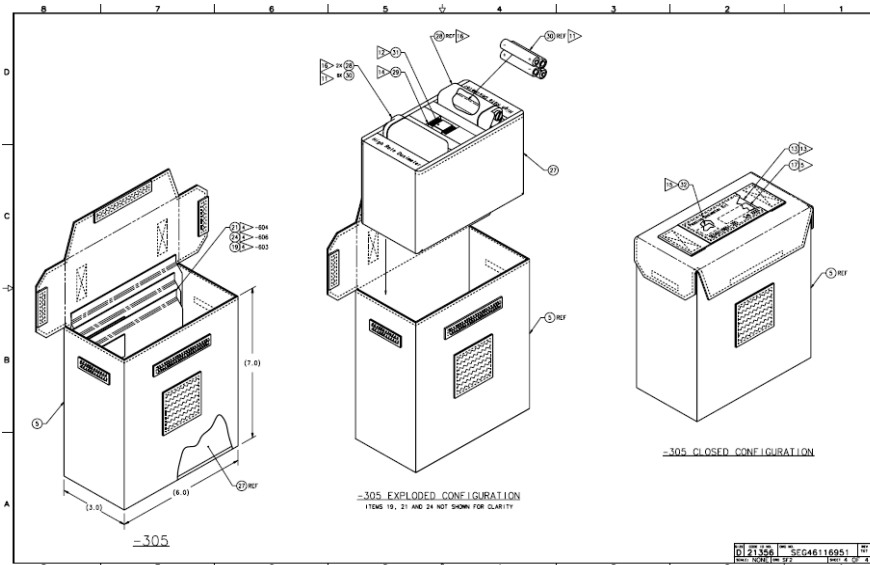


Figure 3. Schematic of PDK with High Rate Dosimeter Foam Insert

Table 3.3.2.2-1 General Hardware Specifications

Kit and Component List	Mass M(E)	Volume M(E)	Dimensions M(E)	Nominal Stowage Location	Storage Temp °C (°F)	Operating Temp °C (°F)	Operating Pressure mmHg (psia)
Passive Dosimeter Kit	1.4 kg (3 lbs)	2064.8 cm <sup>3</sup> (126.0 in <sup>3</sup> )	15.2 cm x 8.9 cm x 17.8 cm (6" x 3.5" x 7")	LAB105_A2	-10 - 80°C (14 -176°F)		13.5-15.2 psia
RAM	0.0136 kg, (0.03 lb)	1.8x10 <sup>-5</sup> m <sup>3</sup> (6.51x10 <sup>-4</sup> ft <sup>3</sup> )	6.4 cm x 3.8 cm x 1.3cm (2.5" x 1.5" x 0.5")	22-24 deploy locations	-10 - 80°C (14 -176°F)	1.7 - 46°C (35 115°F)	13.5-15.2 psia
CPD	0.0136 kg, (0.03 lb.)	1.8x10 <sup>-5</sup> m <sup>3</sup> (6.51x10 <sup>-4</sup> ft <sup>3</sup> )	6.4 cm x 3.8 cm x 1.3cm (2.5" x 1.5" x 0.5")	On US CM at all times	-10 - 80°C (14 -176°F)	1.7 - 46°C (35 115°F)	13.5-15.2 psia
HRD	.27 kg (.59 lbs)	1.7x10 <sup>-4</sup> m <sup>3</sup> (6.1x10 <sup>-3</sup> ft <sup>3</sup> )	10 cm x 6.6 cm x 2.8 cm (3.9" x 2.6" x 1.1")	Inside PDK			

**3.3.2.2.1 Radiation Area Monitor (RAM)**

The RAMs provide a means to measure the absorbed dose at various locations within the Station. RAMs are identical to the CPDs in their materials and function. Each RAM measures absorbed dose and dose equivalent through the use of thermoluminescent dosimeter (TLD) chips, optically stimulated luminescence dosimeter (OSLD), and plastic nuclear track detectors (PNTDs). The materials are analyzed upon return to earth. RAMs measure absorbed dose rate with a range of 0.05 to 10 rad and dose equivalent with a range of 0.05 rem and 30 rem.

The RAMs, like the CPDs, are housed in Lexan covers fastened with nylon screws. No operating power, electrical, acoustic, heat or ignition sources are required. Velcro and Velcro straps allow the units to be deployed.

RAM deployment/swap occurs during the docked phase of a crew rotation flight (both US and Russian vehicles). RAMs are deployed in the following ISS modules: LAB, SM, NOD1, NOD2, COL, JEM and the Joint Airlock (specific locations can be found in the ISS RAM INSTALLATION procedure in the SODF: Ground Handbook: Support Systems in the Medical

Operations: Radiation section). The deploy locations will be updated whenever new modules are added to ISS or whenever new hardware is added that may require long term monitoring (e.g. sleep stations). Dosimeter colors interchange from blue to white and vice versa between each hardware exchange. The RAM hardware is nominally launched in the Passive Dosimeter Kit for Shuttle missions, but also can be sent as a stand-alone kit (a shielded Ziploc bag).



**Figure 4. Radiation Area Monitor**



**Figure 5. RAM with Tether**

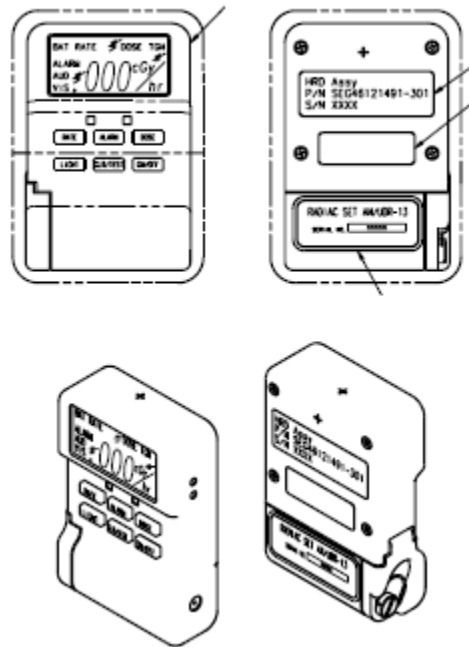
#### **3.3.2.2.2 High Rate Dosimeter (HRD)**

The High Rate Dosimeter (HRD) is a COTS portable radiation detector used for detecting high rate Neutron/Gamma radiation dose and Gamma radiation dose. The HRD measures and display radiation doses from  $10^{-6}$ -9.99Gy (0.001-999 rad). The HRD uses a PMOS-FET (P-type Metal-Oxide-Semiconductor Field-Effect Transistor) to detect prompt gammas (also called prompt photons), a PIN (Positive Intrinsic Negative) diode to detect prompt neutrons and a GM (Geiger-Müller) detector for residual gammas.

The HRD may respond in a passive manner. Without any power applied to the instrument, the prompt neutrons will “damage” the PIN diode. When the HRD is turned ON, it will read the “damage” as an absorbed radiation dose in centi-Grays (cGy). One Gray (1 Gy) = 100 rad. The HRD will remain stored in PDK in locker unless crew is instructed by the ground to read the instrument.



**Figure 6. High Rate Dosimeter**



**Figure 7. High Rate Dosimeter Schematic**

### 3.3.2.2.3 Crew Passive Dosimeter (CPD)

Like the RAMs, the CPDs will measure absorbed dose and dose equivalent through the use of thermoluminescent dosimeter (TLD) chips, optically stimulated luminescence dosimeter (OSLD), and plastic nuclear track detectors (PNTDs). The CPD is required to be worn by each US crewmember throughout the duration of his/her flight, including during EVAs. Russian crewmembers will wear a Russian passive dosimeter and European crewmembers have EuCPDs. The CPD measures the radiation dose to which a crewmember is exposed during the course of a mission and will be analyzed on the ground. CPDs measure absorbed dose rate with a range of 0.05 to 10 rad and dose equivalent with a range of 0.05 rem and 30 rem.



**Figure 8. Crew Passive Dosimeter**

The CPDs are housed in Lexan covers fastened with nylon screws. There are no electrical, acoustic, heat, or ignition sources.

### 3.3.2.3. Hardware Interfaces with Vehicle

- RAM has adhesive backing and Velcro tethers to attach it to ISS module surfaces.
- HRDs and CPDs have no interface with the vehicle.



#### **3.3.2.4. Resupply Schedule**

- Resupply of the on-orbit HRDs/PDK occurs every three years.
- The Alkaline AAA batteries in the HRDs will be replaced on-orbit once per year.
- CPDs are resupplied for each crew rotation.
- RAMs are exchanged approximately every 6 months, provided that the new monitors are resupplied using a vehicle capable of returning with the old monitors. The exchange requires 60 minutes and is performed by an ISS or Shuttle crewmember during the docked phase. RAMs require late stow (L-10 days) and early retrieval (R+48 hours).

#### **3.3.2.5. Data/Commanding Capabilities**

The RAM and CPD data is analyzed post-flight; there is no real-time data or commanding capability.

#### **3.3.2.6. Hazard Concerns**

N/A

### 3.3.3. Tissue Equivalent Proportional Counter (TEPC)

#### 3.3.3.1. TEPC Description

The TEPC is used to monitor radiation doses in near real time at the cellular level inside the habitable volume of the ISS. The TEPC provides absorbed dose rate, dose equivalent rate, accumulated absorbed dose, accumulated dose equivalent, accumulated time, equipment status and linear energy transfer spectrum. Periodically, TEPC measured dose is compared with the Russian radiation monitor, R-16, located in the Russian Service Module, behind SM Panel 327. The TEPC is omni-directional and operates continuously. The TEPC is periodically relocated; target relocation areas include crew occupancy areas, crew quarters, thinly shielded regions, and potential “maximum shielded” locations.

The TEPC interfaces with the C&DH 1553 system to send continuous cyclic data and weekly transfers of detailed data. The TEPC has the capability to perform simple commands via PCS.

The TEPC has a local alarm that sounds on the unit like an ISS Class 1 Caution & Warning (C&W) alarm. The alarm also interfaces with the ISS C&W System, providing a Class 3 alarm and message if the dose rate exceeds a programmed set point ( $\geq 5$  mrad/min). There is a manual On/Off switch capability. Once the rate drops below the set point, the alarm will silence itself.

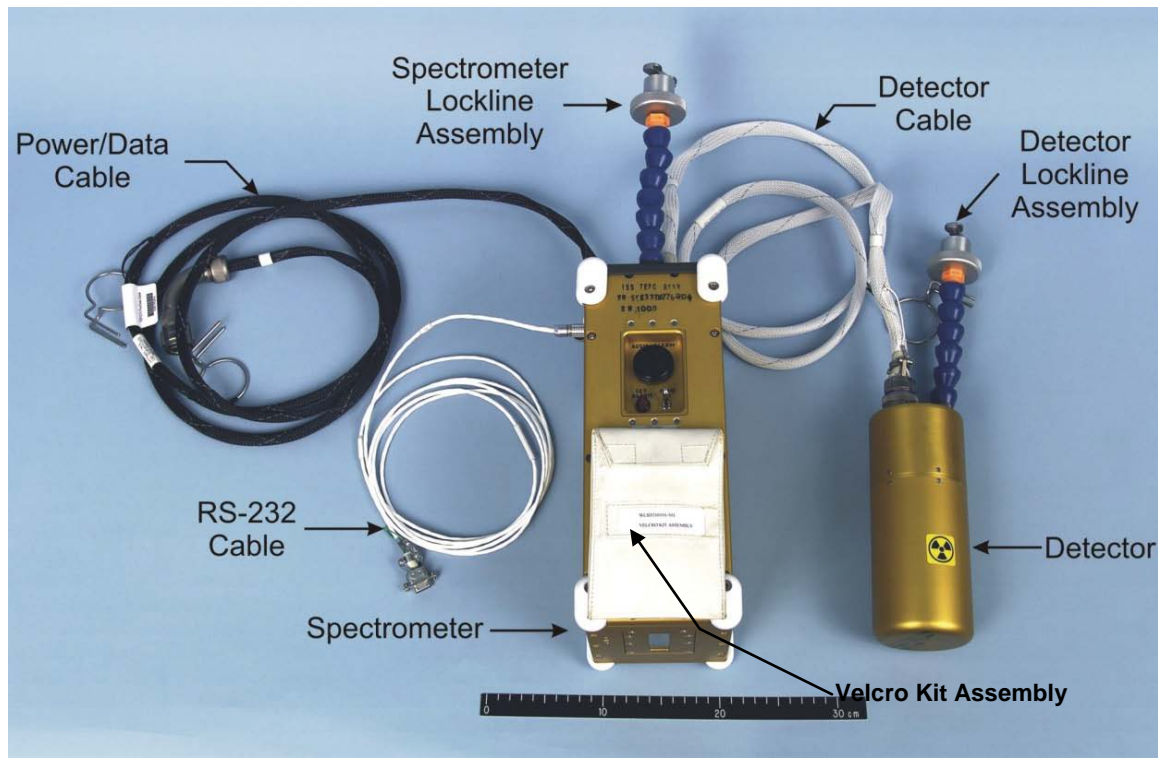
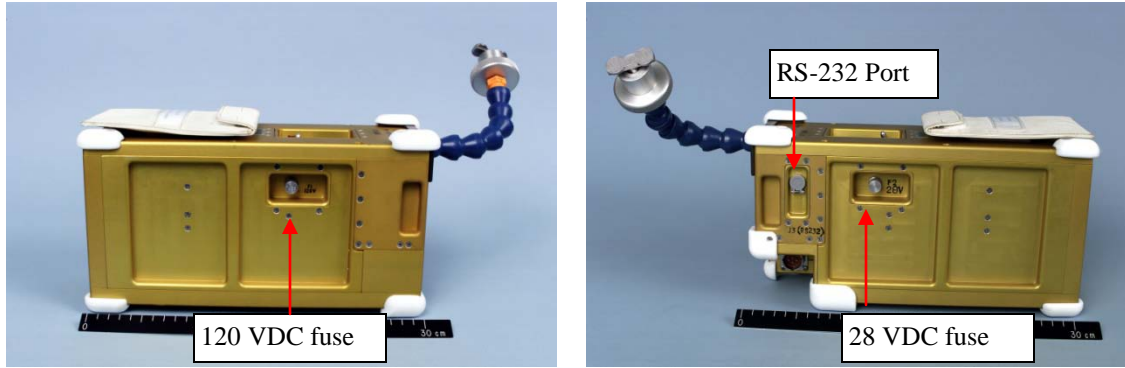


Figure 1. TEPC with Power/Data Cable Assembly



Figures 2-3. TEPC Spectrometer

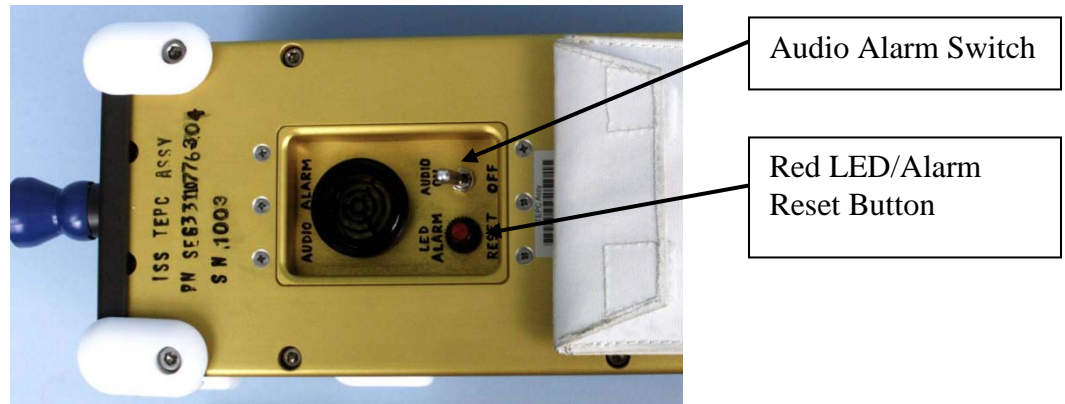


Figure 4. TEPC Audio Alarm

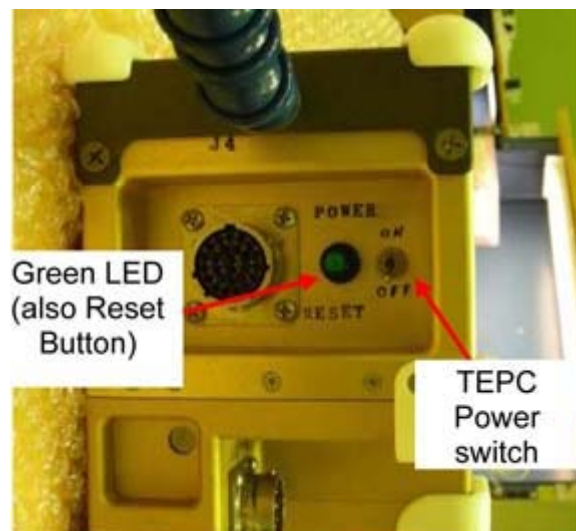
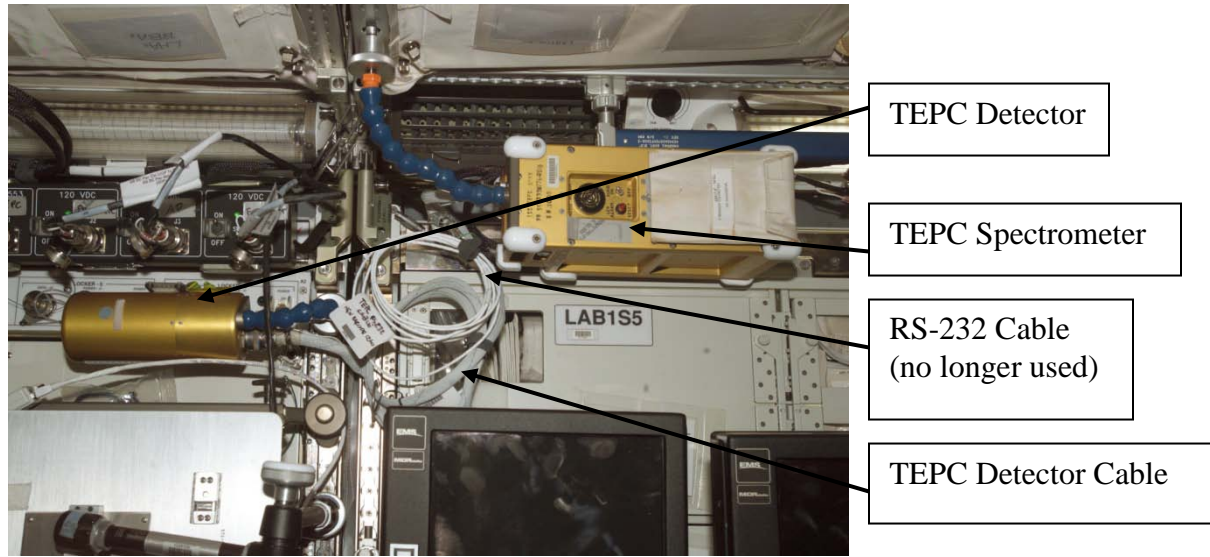


Figure 5. TEPC Power Controls



**Figure 6. TEPC Spectrometer and Detector deployed in US LAB**

**3.3.3.2. TEPC Component List and Description**

- Spectrometer
- Detector
- Detector Cable (6 ft.)
- Power/Data Cable (10 ft.)
- Extender Arms (~8 in. long)
- RS-232 Cable
- Velcro Kit Assembly (Velcro and Spare Fuses)

**Table 3.3.3.2-1 General Hardware Specifications**

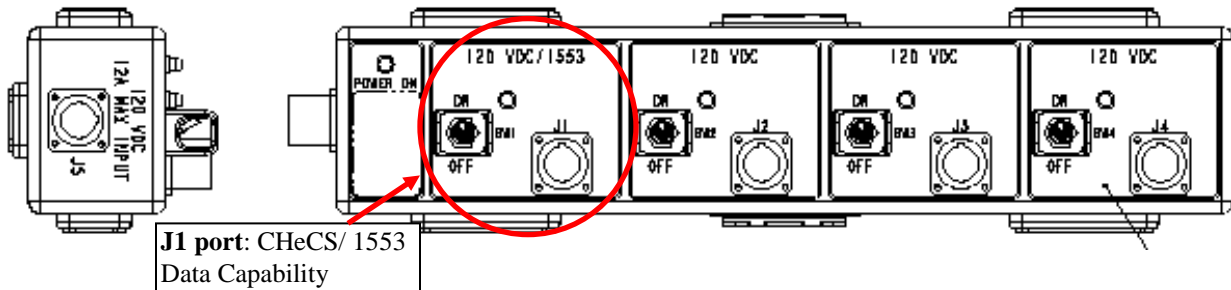
Kit and Component List	Mass M(E)	Volume M(E)	Dimensions M(E)	Nominal Stowage Location	Storage Temp °C (°F)	Operating Temp °C (°F)	Operating Pressure mmHg (psia)
TEPC Spectrometer	3.63 kg (8 lbs)	7067.7 cm <sup>3</sup> (431.31 in <sup>3</sup> )	32.03 x 12.78 x 17.27 cm (12.61”Lx 5.03”W x 6.8”H)	Determined by SRAG	-40 - 80 °C (-40 - 176°F)	1.7 -43.3°C (35- 110°F)	9 - 15 psia
TEPC Detector	0.96 kg (2.12 lbs)		22.2 x 8.25 cm (8.75”L x 3.25”Diam.)	With TEPC Spectrom.	-40 - 80 °C (-40 - 176°F)	1.7 -43.3°C (35- 110°F)	9 - 15 psia

**Table 3.3.3.2-2 Hardware Specific Parameters**

Power Requirements	120VDC for US/EU/JP, 28VDC for Russian modules
Power Draw	7.5 W
Power Source	UOP, CHeCS PCR, SUP
Measurement Parameters/ Analysis Capabilities	Operating Ranges: Accumulated Dose: 1microrad to 1000 rad Absorbed Dose Rate: 1 microrad/minute to 300 millirad/minute Sensor Error: ±6% for dose and dose equivalent

### PS-120 Junction Box

Due to the increased demand for power outlets in the US Lab, a PS-120 Junction Box has been installed in the J3 outlet of UOP 2 (LAB10S4). This provides 4 power outlets, only one of which has 1553 capability to allow CHeCS data to flow through to the 1553 data bus.



**Figure 7. PS-120 Schematic**

Each outlet on the junction box has its own power switch. When disconnecting one hardware item, it is not necessary to power down the UOP or the junction box; only the individual power switch for that specific outlet needs to be powered down.

### US Segment UOP Issue

When a US Segment UOP loses power or the RPC to that UOP is opened via ground commanding, before power can be restored to that UOP, an ISS Crewmember must reset the UOP before power can flow downstream to the hardware plugged into that UOP. If this scenario occurs before the TEPC power switch can be turned OFF, before the ISS Crewmember resets the UOP, he/she must first turn the TEPC instrument off, then reset the UOP, and finally turn the TEPC power switch to ON.

### TEPC Spectrometer

The TEPC Spectrometer is composed of several different components:

- a) MCA Card – multi-channel analyzer card which performs generic functions; 2 temperature sensors, current monitors which provides a controlled high voltage power supply.
- b) Backplane – serves as the data and power bus and provides the 2-line LCD.
- c) Power Card – provides proper voltages to power the spectrometer electronics depending on the module (28 or 120 VDC); EMI filtering, backup battery source; the one bit of telemetry that is seen on ground displays under “PWR” card status is responsible for providing the status the following parameters: temperature sensor, voltage/current monitor, system-wide reset control, signal to CPU indicating when power is within acceptable parameters.
- d) 1553B Telemetry Card – provides capability to send data thru the 1553 power bus.
- e) Flash Memory Storage Card – mass storage capability in a 60 MB module (10% for memory load and data dump telemetry, 90% for data storage); approximately 2 months of storage capacity before overwriting begins and older data is lost.
- f) CPU Card – “brain” of instrument controlling all system functions; real-time clock.

### TEPC Detector

The TEPC Detector is composed of several inner components:

- a) Internal Foam – for impact protection
- b) Inner Stainless Steel Vessel – hermetically sealed vessel filled with pure propane (about 1 cubic inch); the detector also contains 0.9 microCurie of Curium 244 (radiation source used for calibration) which is triple-contained.
- c) 2 Electronic Boards – mounted to the outside of the inner vessel

### **3.3.3.3. Hardware Interfaces with Vehicle**

The TEPC is attached via seat track in the US Segment and by Velcro in other segments.

### **3.3.3.4. Resupply/Maintenance Schedule**

Currently, the TEPC is scheduled to be swapped out every five years or as needed. There is no scheduled maintenance. There are two existing TEPC flight units.

### **3.3.3.5. Data Capabilities**

The TEPC is capable of providing the following data:

- Accumulated Absorbed Dose (rad)
- Absorbed Dose rate (mrad/min)
- Accumulated Dose Equivalent (rem)
- Dose Equivalent rate (mrem/min)
- Elapsed time (minutes)
- Health and status information/memory pointer
- Detailed non-cyclic data

This data is available to the ground displays through telemetry using the 1553 bus architecture via S-band resources, or can be downloaded to the MEC, then downlinked to the ground (see Section 2.5.5.1 for file extensions and locations on the MEC). Data Dump files are also available via Ku-Band resources, which are downlinked by the Payloads officer (PRO) to a ground server (PIMS) where the files are retrieved by a SRAG representative.

The TEPC Reset button is also the Instrument Reset button. A solid green light (LED) is displayed when the instrument is powered on. When TEPC is powered on, the LCD on the TEPC front panel will display “Standby” mode and the TEPC RT address for approximately 1 hour. After power is supplied, there are 2 minutes of Startup time, followed by 60 minutes in standby mode, followed by an automatic mode switch and 5 minutes of initialization, then acquisition mode. Total time from power up to “acquire” mode is ~69 minutes. After transitioning to acquisition mode, the TEPC begins scrolling through the startup screens (only scroll one time), sequence cycles, and then begins displaying radiation data.

### **Powercycle File System Concern**

Following a powercycle, the TEPC may take anywhere from 16 to 24 hours to go back into acquisition mode if the file system has been corrupted and is rebuilding automatically.

### **Nominal Reset**



The TEPC instrument will **reset** the cyclic telemetry values when the “Accumulated Time” (elapsed time) reaches 65,000 minutes. The device will NOT turn off or change modes as the CPDS instruments do (reboot), but will remain in acquisition mode.

#### Maximum Number of Files

The maximum number of files that may be stored in the internal memory of the TEPC instrument is 550. (Each file is ~96kB in size.) When the maximum number of files are reached, the TEPC will begin overwriting files starting with the oldest. This should not be allowed to happen. As the number of files stored on the TEPC instrument approaches or exceeds 500 files, BME should place it into Standby as soon as possible in order to prevent the maximum number of files from being reached.

#### Standby Mode During Relocations

As part of the transition to Standby mode, the voltage across the components within the TEPC Detector are ramped down. If it can be helped, the TEPC Detector should not be touched, jostled, or kicked while the components inside are under high voltage (i.e. if the instrument is in Acquisition mode). Jostling of the TEPC Detector while it is Acquisition mode could potentially lead to unexpected contact between the components that are under high voltage, which could cause permanent harm to the hardware.

Before any scheduled or expected contact between the crew and any portion of the TEPC, it is advisable that the instrument be placed into Standby mode if commanding is possible.

#### **3.3.3.6. Hazard Concerns**

N/A

### ***3.3.4. Failed/Obsolete Hardware***

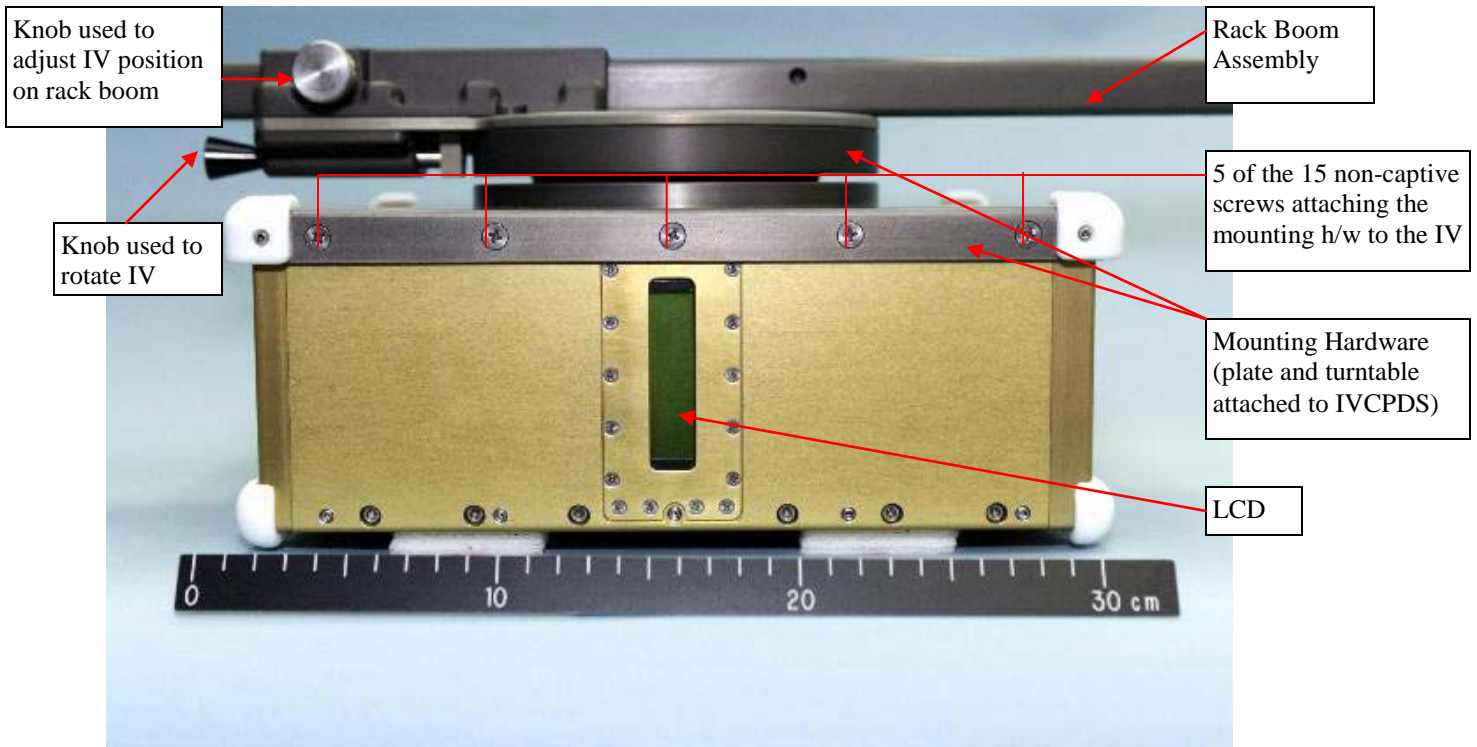
#### **3.3.4.1. Intravehicular Charged Particle Directional Spectrometer (IVCPDS)**

##### **3.3.4.1.1. IVCPDS Description**

The IVCPDS characterizes the primary trapped galactic cosmic radiation, and solar protons penetrating the ISS and the secondary radiation resulting from interactions with ISS materials. The IVCPDS is a uni-directional spectrometer and is almost identical to the EVCPDS instruments, except that the IV is deployed internally to the ISS. For more information on the CPDS unit, see section 3.3.1 EVCPDS.



**Figure 1. Intravehicular Charged Particle Directional Spectrometer**



**Figure 2. Side View of Intravehicular Charged Particle Directional Spectrometer**

**3.3.4.1.2. IVCPDS Component List and Description**

- CPDS instrument
- Mechanical hardware for mounting on rack boom assembly
- Rack Boom Assembly which attaches to seat tracks in US segment (approx. 41.5” long)
- Velcro for mounting in Russian segment
- Power/Data cable

**Table 3.3.4.1.2-1 General Hardware Specifications**

Kit and Component List	Mass M(E)	Volume M(E)	Dimensions M(E)	Nominal Stowage Location	Storage Temp °C (°F)	Operating Temp °C (°F)	Operating Pressure mmHg (psia)
IVCPDS (w/o mounting hardware)	7.2 kg (15.87 lbs)	13986.4 cm <sup>3</sup> (853.5 in <sup>3</sup> )	32.4cm x 32.4cm x 13.3cm (12.75”x 12.75”x 5.25”)	US LAB (varies)	-31 - 52 °C (-25 - 125 °F)	-40 - 50 °C (-40- 122°F)	9 - 15 psi

**Table 3.3.4.1.2-2 Hardware-Specific Parameters**

Power Requirements	120VDC, 28VDC
Power Draw	<b>12 W</b>
Power Source	CHeCS PCR

### US Segment UOP Issue

When a US Segment UOP loses power or the RPC to that UOP is opened via ground commanding, before power can be restored to that UOP, an ISS Crewmember must reset the UOP before power can flow downstream to the hardware plugged into that UOP. If this scenario occurs before the IVCPS power switch can be turned OFF, before the ISS Crewmember resets the UOP, he/she must first turn the IVCPS instrument off, then reset the UOP, and finally turn the IVCPS power switch to ON.

#### 3.3.4.1.3. Hardware Interfaces with Vehicle

- Power/Data from CHeCS Power/Data Outlet
- Seat Track
- Velcro

The IVCPS is periodically relocated to acquire measurements in different areas of the ISS. A relocation may simply require the crewmember to rotate the IVCPS 90° (using the black knob, see Figure 2), which can be performed without unplugging the power cable since the instrument is mounted on a turntable. It can be rotated in 4 different orientations at a single location.

The Rack Boom Assembly can be mounted horizontally across a rack or vertically on one seat track and the IVCPS position on the rack boom can be adjusted by loosening the silver knob and sliding the assembly either way on the rack boom (see Figure 2).

#### 3.3.4.1.4. Resupply Schedule

Currently, the IVCPS is scheduled to be swapped out every five years or as needed. There is no scheduled maintenance.

#### 3.3.4.1.5. Data/Commanding Capabilities

IVCPS Data is available to the ground via data dumps and Cyclic Data, which is available to the ground displays through telemetry using the 1553 bus architecture via S-band resources, or can be downloaded to the MEC, then downlinked to the ground. Data Dump files are also available via Ku-Band resources, which are downlinked by the Payloads officer (CPO) to a ground server (PIMS) where the files are retrieved by a SRAG representative. IVCPS dose rate data is provided continuously through telemetry. Flight controllers will dump detailed raw data weekly (or daily as needed) for processing to determine the spectral characteristics of the radiation environment.

Flight controllers can command data dumps, built in tests, and instrument resets. Procedures are located in the SODF: Ground Handbook: Support Systems in the Medical Operations: Radiation section. The IVCPS also has the capability to perform simple commands via PCS.

When the instrument is powered on, a solid green LED is seen on the front panel. When the IVCPS is powered on, the LCD on the front panel displays “Instrument in Standby” mode and the IVCPS RT address for approximately 1 hour. After power is supplied, there are 2 minutes of startup time, followed by 60 minutes in standby mode, followed by an automatic mode switch, then finally “acquire” mode. Once in this mode, the IVCPS software will transition to data

acquisition mode, scroll through the startup screens, sequence cycles, and begin displaying radiation data.

Following a powercycle, the IVCPDS may take anywhere from 16 to 24 hours to go back into acquisition mode if the file system has been corrupted and is rebuilt automatically.

#### **3.3.4.1.6. Hazard Concerns**

- Fire/Explosion: severity – catastrophic, likelihood – improbable
- Environmental: severity – critical, likelihood – improbable
- EMI: severity – catastrophic, likelihood – improbable
- Contamination: severity – catastrophic, likelihood – improbable
- Sharp Edges and Corners: severity – marginal, likelihood - improbable
- Biological/Physiological/Psychological: severity – marginal/catastrophic, likelihood – improbable
- Impact: severity – critical, likelihood – improbable
- Toxicity: severity – catastrophic, likelihood – improbable
- Electrical Discharge/Shock: severity – catastrophic, likelihood – improbable
- Structural Failure: severity – catastrophic, likelihood – improbable
- Battery Hazards: severity – critical, likelihood – improbable

## 3.4. Toxicology

### 3.4.1. Carbon Dioxide Monitoring (CDM) Kit

#### 3.4.1.1. CDM Description

The Carbon Dioxide Monitoring Kit (CDMK) assembly contains two portable carbon dioxide monitors and ancillary components that are capable of detecting, quantifying, and recording the concentration of carbon dioxide (CO<sub>2</sub>) in the spacecraft cabin atmosphere. The CDM has an internal data logger that begins logging upon CDM activation and can store 110 hours of data in one-minute increments. The CDM averages the readings over each minute and logs that average value in the data log. Each line of stored data contains the time of day, date, and the average CO<sub>2</sub> concentration. When the data log reaches full capacity, the CDM stops recording data.

The CDM may be used for personal monitoring using the Nomex belt and pouch assembly contained in the kit, or deployed to a fixed location using Velcro included in the kit.

Additionally, spot checks or surveys may be conducted by taking the CDM to any desired location. The CDM may be used at the crewmember's discretion or per MCC instruction and is not required to be continuously deployed. Circumstances requiring the use of the CDM may include the following:

1. First ingress/egress of module
2. While working in confined or poorly ventilated spaces
3. During exercise sessions
4. Following a combustion event
5. Verification of fixed CO<sub>2</sub> sensors.

#### 3.4.1.2. CDM Kit Component List and Description

- Stowage Kit
  - a. CDM units (2)
  - b. Marker
  - c. Spare Battery Packs (5) (C)
  - d. Clean Filter Assemblies (5) (C)
  - e. Nomex Belt Pouch Assembly
  - f. Adhesive-backed Velcro (hook) patches (5)
  - g. Data Logbook

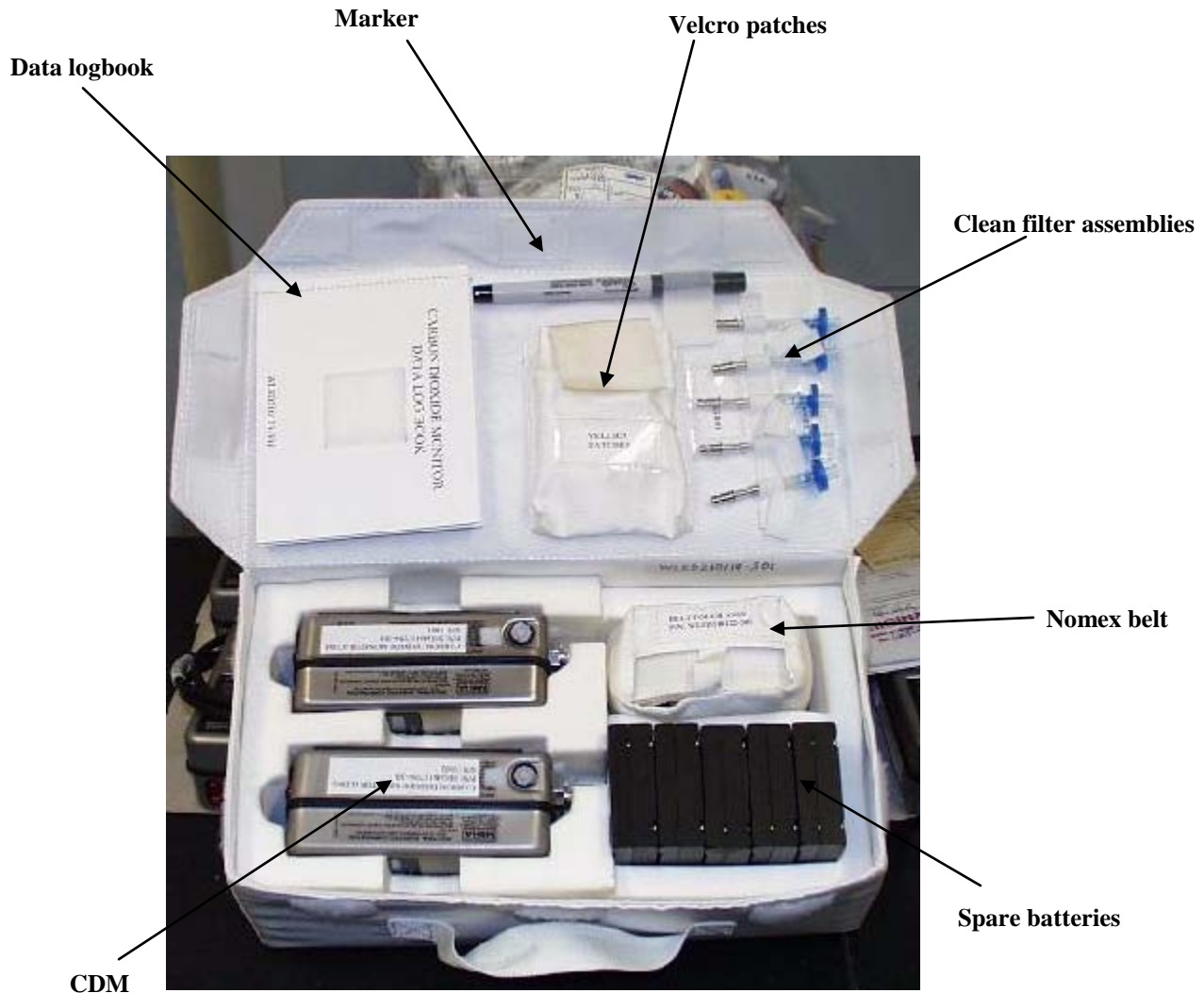
**Table 3.4.1.2-1 General Hardware Specifications**

Kit and Component List	Mass M(E)	Volume M(E)	Dimensions M(E)	Nominal Stowage Location	Storage Temp °C (°F)	Operating Temp °C (°F)	Operating Pressure mmHg (psia)
CDM Kit	2.59 kg (5.7 lbs)	4843 cm <sup>3</sup> (295.5 in <sup>3</sup> )	29 cm x 15.2 cm x 10.9 cm (11.4" x 6" x 4.3")	LAB1O5_B2	-20 - 50°C (-5 - 122°F)		
Carbon Dioxide Monitor	0.85 kg (1.87 lbs)		12.1 cm x 7.0 cm x 5.1 cm (4.75" x 2.75" x 2.0")	In CDMK	-20 - 50°C (-5 - 122°F)	18 - 38°C (65 - 100°F)	9.0 - 15.0 psi*

\*For the most accurate data, the displayed reading should be corrected if the cabin pressure lies outside the range of approx. 14.3 – 15.0 psia. Formulas are available for this correction.



The CDM Stowage Kit is stowed in a foam locker or equivalent stowage location during on-orbit operations. Two CDMs are available for use at all times. Both will have a designated stowage location within the kit. The CDMs, Nomex belt, spare batteries, Logbook, Filter Assemblies, marker, and adhesive-backed Velcro will be stowed in the kit during nominal operations.



**Figure 1. CDM Stowage Kit**

### **3.4.1.2.2 Carbon Dioxide Monitor**

The Carbon Dioxide Monitor (CDM) contains an infrared-based carbon dioxide sensor that does not require oxygen to measure the CO<sub>2</sub> concentrations, and is not poisoned by other gases.

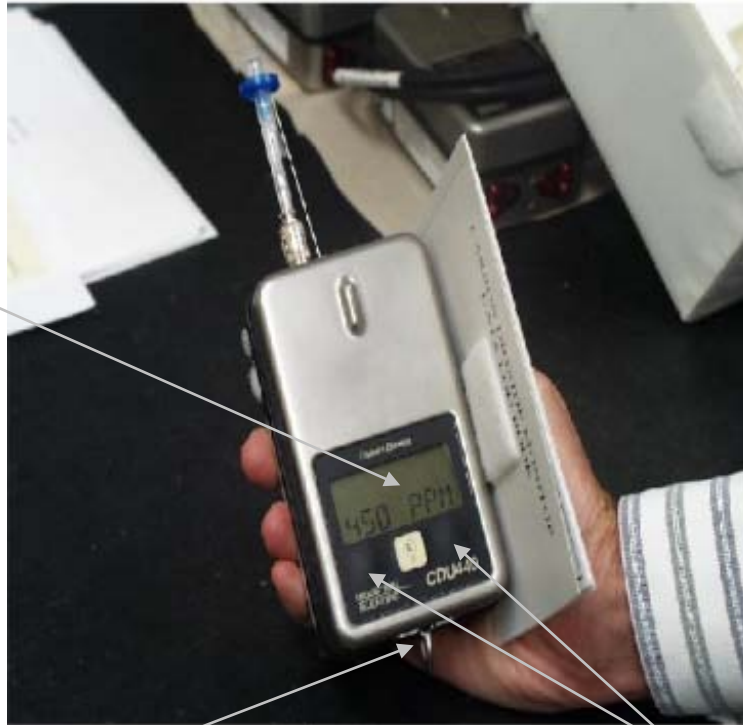
The stainless steel (type 304) casing houses all of the components. An internal pump pulls ambient air through an inlet filter assembly and through the infrared-detection cell at a rate of 0.75 cubic feet per hour. An opening in the case allows for the sample to be exhausted outside the case. The sample inlet consists of a quick-disconnect connector that attaches to the filter assembly. The quick-disconnect closes off (self-sealing) when the filter assembly is removed.

The battery compartment is covered with an access cover with two captive screws. An approximate 2 inch square piece of Velcro (hook) is attached to the outside of the access cover. This allows the instrument to be deployed in the Russian Service Module (SM) as required. The liquid crystal display (LCD) is covered with a plastic faceplate. A keypad is incorporated into the casing/faceplate for user input.

**Table 3.4.1.2.2-1. Hardware-Specific Parameters**

Power Requirements	(2) 9 volt lithium-manganese batteries contained inside 1 battery pack (Not rechargeable on orbit)			
Measurement Capabilities of CO <sub>2</sub> Sensor	Full Scale Range (%)	Display Resolution (%)	Response—Baseline to 90% Maximum Response	Recovery-Maximum Response to 10% above Baseline
	0.01%-6.0% (volume)	0.01%	10 secs	10 secs
Accuracy (same temperature and pressure conditions as calibration)	CO <sub>2</sub> Concentration (%)	Precision (%) 8 - hr	Accuracy (%) 1 day*	Accuracy (%) 14 days*
	≤0.10	± 0.03	± 0.03	± 0.03
	0.10<x<2.0	<u>Linear interpolation between 0.03 and 0.3</u>		
	≥2.00	<u>undefined</u>	<u>undefined</u>	<u>undefined</u>
	@ 80% Relative Humidity	± 0.20	± 0.20	± 0.30
	*Time following sensor calibration			

Sensor Readings



Mode pushbutton

+/- pushbuttons (for alarm setting changes)

**Figure 2. Carbon Dioxide Monitor Display**

### CDM Display

The CDM offers eight different operating modes for accessing various instrument features. To scroll through the operating modes, press and release the MODE pushbutton. The instrument reverts to the INSTANT READINGS mode 10 seconds after the last MODE key press. The operating modes will be accessed in the following sequence:

**INSTANT READINGS** – The instantaneous carbon dioxide concentration is continuously displayed and the values are updated every 1-2 seconds. When the gas concentration is greater than 1000ppm the readout will be displayed in percent of volume units.

**BATTERY** – Shows if the battery is “OK” or “LOW” and displays a graphical representation of the remaining operating time with even-numbered tick marks.

Note: The battery status during startup may not be an accurate reading. The internal pump starts about the same time the battery status is displayed during the startup sequence. The pump draws a considerable amount of power, so the battery status will display a more accurate reading after the initialization routine and should be taken after that time.

**ZERO** – Allows user to zero the instrument and calibrate the infrared carbon dioxide sensor (not nominally performed on orbit).

**PUMP** – Allows the user to turn off the internal sampling pump between readings and conserve instrument battery power (not nominally performed on orbit).

Note: If the CDM pump fails, the CSA-CP Sampling Pump cannot be used on the CDM. The flow rate differs between the CSA-CP pump and the CDM internal pump, and the effect that would make on the reading is unknown. Also, the valve of the CDM internal pump is closed when not in use, so the CSA-CP pump would not be helpful in this case. The CDM is not a crit 1 device and there are no major implications if the unit is lost.

PEAK – Displays the highest level of carbon dioxide gas measured since the peak reading was last cleared.

PEAK CLEAR – Allows the user to clear the previous peak reading from the instrument memory.

ALARM – Allows user to temporarily turn ON or OFF the audible and visual alarms. When you mute the alarm, the audible alarm stops, but the concentration display continues to flash. If the alarm is muted, and the unit is powercycled, the CDM reverts back to the standard settings – in this case, the standard setting is alarm enabled.

CAL DATE – displays the last date the CDM was calibrated.

### CO<sub>2</sub> Sensors

The infrared sensor must be replaced on the ground. It has an approximate 5-year shelf life. Its primary component is an infrared lamp. The lamp is contained inside a sealed aluminum shell. An inlet and outlet hose bring air into the sensor shell from the pump and exhaust the air from the shell through a particulate baffle.

### CDM Alarm

The CDM has 4 alarm ultra-bright light-emitting diodes (LED's), which illuminate when the displayed concentration exceeds the preset limit. The CDM also generates an audible alarm when the limit is exceeded. The high and low alarm settings on the CDMs are set to the same value: 1.0%. When the detected concentration of CO<sub>2</sub> exceeds this preset limit, the audio and visual alarms are enunciated. The audible alarm enunciates at approximately 80 dB (@12 inches), 2000 Hz frequency for the duration of the out-of-limits condition. If the CDM alarm is activated, the battery level indicator may read lower than when the alarm is not annunciating. The alarm can be turned off by a series of key presses, if desired.

### Maintenance and Calibration

The only on-orbit maintenance activity is the changeout of a battery pack as needed. A battery replacement must be completed within 30 minutes or all stored data in the data logger will be lost. No on-orbit calibration re-zeroing is possible. The calibration is currently valid for only eight months. If the inlet filter assembly becomes clogged with particulates or water and the flow rate drops too low for measurement purposes, the CDM will provide an audible beep and “low flow” will be displayed. The inlet filter should be removed, marked as used, and replaced with a new one from the kit.

#### **3.4.1.2.2. CDM Battery Pack**

The battery pack is a modified COTS item and contains two 9-V cells of the Lithium-Manganese-Dioxide chemistry in parallel and contained in a plastic case. It has a capacity of 2400 mA-hours, which allows approximately 18 hours of operation before the battery pack is discharged. There is little to no self-discharge in an uninstalled CDM battery pack. The battery pack contains redundant diodes, redundant polyswitches, and a fuse for circuit protection. The pack also contains wicking material for any possible electrolyte leakage. The battery pack is easily replaced using simple tools.

Low Battery Warning – With approximately 3 – 8 hours of run time remaining, the CDM will emit a short beep once every 15 seconds to indicate the low battery condition. The BATTERY screen on the CDM shows if the battery is “OK” or “LOW” and displays a graphical representation of the remaining operating time. If the CDM is only being used infrequently and for short periods at a time, a unit may last for weeks before Battery Failure.

Battery Failure – When the battery has insufficient charge to operate the instrument, BATTERY FAIL is displayed, the instrument stops monitoring, and it emits a short beep once every second.

#### **3.4.1.3. Hardware Interfaces with Vehicle**

Hardware is attached to ISS surface using Velcro.

#### **3.4.1.4. Resupply Schedule**

On-orbit hardware replacement occurs approximately every six months, before the 8-month calibration expiration life is reached. The recommended refurbishment of the units is every 5 years. The following is a list of limited-life components:

- CO2 Sensor – 5 years
- Lithium Battery Pack – 10 years
- Keypad – 5 to 10 years
- Velcro Patch – 3 years
- Internal Pump Assembly – 5000 hours

#### **3.4.1.5. Data/Commanding Capabilities**

In a contingency situation, data from the CDM may be collected and downloaded to the MEC and then downlinked to ground for analysis using the CSA-CP RS-232 cable (see Section 2.5.5.1 for file extensions and locations on the MEC). Because the CDM data files are saved with the CSA-CP file extension (“\*.csa”) the CDM files are saved in the MEC default folder, which is the CSA-CP data folder. The files are located on the MEC in the CHeCS\CSA\_CP\DATA folder. There are no commanding capabilities.

### 3.4.1.6. Hazard Concerns

Section Number	Hazard Title	Sev	Like-likelihood	Hazard Condition Description	Applicability/Hazard Report
5.3.1	Fire/Explosion (Detonation)	CAT	IMP	Fire/Explosion within hardware causes injury to crew or damage to station	Applicable/ GEN-CDMK-1
5.3.2	Explosion/ Implosion (No Detonation)	N/A	N/A	Explosion inside hardware due to a ruptured pressure vessel	N/A
5.3.3	Environmental	N/A	N/A	Exposure to extreme temperature/pressure variations of space	N/A
5.3.4	EMI	CRT	IMP	Hardware emits excessive EMI (radiative or conductive)	Applicable/ GEN-CDMK-2
5.3.5	Contamination	CAT	IMP	Shatterable materials released into crew cabin due to impact to LCD.	Applicable / GEN-CDMK-3
5.3.6	Radiation	N/A	N/A	Exposure of crew to ionizing radiation	N/A
5.3.7	Biological/ Physiological/ Psychological	CRT	IMP	Exposure of crew to biological/physiological/ psychological hazards such as sharp edges/corners, contact with extreme surface temperatures, and/or acoustic hazards	Applicable/ GEN-CDMK-4
5.3.8	Impact	N/A	N/A	Shatterable materials release due to rotating equipment fracture	N/A
5.3.9	Toxicity	CAT	IMP	Crew exposed to the effects of toxic contamination from materials offgassing	Applicable/ GEN-CDMK-5
5.3.10	Electrical Discharge/ Shock	N/A	N/A	Crew exposure to electrical shock leading to burns/injury to the crew	N/A
5.3.11	Vibration/ Shock/ Acoustic	N/A	N/A	Damage to instrument during launch/entry leads to hazard or emission of acoustic noise above maximum allowable values	N/A
5.3.12	Structural Failure	N/A	N/A	Failure of structural element leading to crew injury	N/A
5.3.13	Rapid Safing	N/A	N/A	Emergency egress from a module impeded by hardware component due to biomedical wiring/restraint	N/A
5.3.14	Battery Hazards	CAT	IMP	Release of chemicals into cabin due to improper design	Applicable/ GEN-CDMK-6
5.3.15	Created by Failure to Function	N/A	N/A	Instrument fails to function leading to injury to crew or damage to Station	N/A
5.3.16	Created by Inadvertent Function	N/A	N/A	Instrument inadvertently functions and displays false reading on display leading to injury to crew or damage to Station	N/A
5.4	Unique Hazards	N/A	N/A	None identified	N/A



### 3.4.2. Compound Specific Analyzer - Combustion Products (CSA-CP)

#### 3.4.2.1. CSA-CP Description

The CSA-CP Kits contain the CSA-CP and ancillary components that measure the concentrations of carbon monoxide (CO), hydrogen cyanide (HCN), hydrogen chloride (HCl), and oxygen (O<sub>2</sub>) in the air.

The CSA-CP can be used in the passive mode or active mode using a pump attachment. Nominally, a prime CSA-CP is deployed for passive sampling at a location designated by the crew or per MCC instruction. If the response of any sensor (except O<sub>2</sub>) exceeds a preset threshold concentration, a local audio and visual alarm is activated. Furthermore, the internal datalogger is automatically activated when any preset threshold is exceeded.

The backup CSA-CPs, sampling pumps, and sample probes are used primarily in a contingency situation, such as a combustion event where active sampling is required. In such a situation, the CSA-CPs, pumps, and sample probes are taken to the location of interest and used to sample the atmosphere in remote locations, such as behind a rack via a fire port. Following such an event, the CSA-CPs may also be used to provide information that indicates the effectiveness of contingency atmospheric cleanup procedures and if gas masks or portable breathing apparatus can be removed.

#### 3.4.2.2. CSA-CP Kit Component List and Description

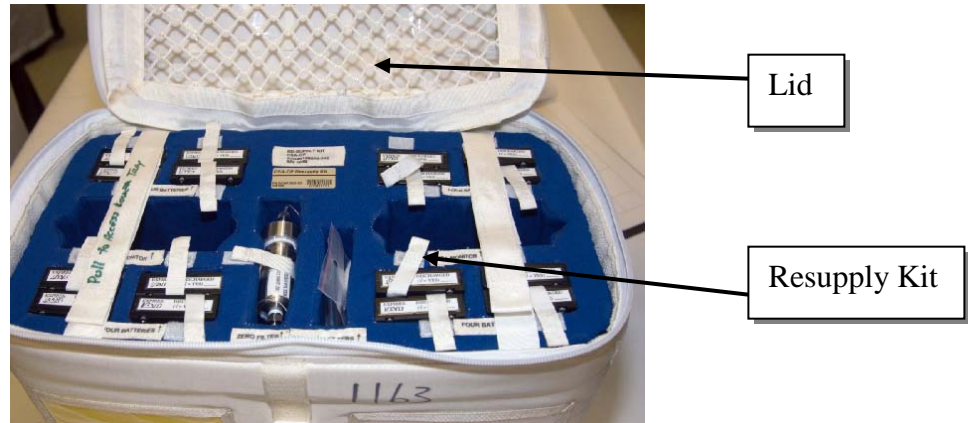
- CSA-CP Transport Kit
  1. CSA-CP Resupply Kit
    - a. CSA-CP units (2)
    - b. Spare battery packs (16)
    - c. Zero filter
    - d. Bag of sampling pump filters (2)
  2. CSA-CP Accessories Kit
    - a. Sampling pump
    - b. Sampling probe
    - c. RS-232 serial data cable

**Table 3.4.2.2-1 General Hardware Specifications**

Kit and Component List	Mass M(E)	Volume M(E)	Dimensions M(E)	Nominal Stowage Location	Storage Temp °C (°F)	Operating Temp °C (°F)	Operating Pressure (psia)
CSA-CP Transport Kit	6.36 kg (14.03 lbs)	26093.1 cm <sup>3</sup> (1592.3 in <sup>3</sup> )	42.5 cm x 24.8 cm x 24.8 cm (16.8" x 9.8" x 9.8")	Crew Pref.	-40-50°C (-40-122°F)	18.3-29.4°C (65-85°F)	
CSA-CP Resupply Kit	5.7 kg (12.5 lbs)	10299.9 cm <sup>3</sup> (627 in <sup>3</sup> )	41.9 cm x 24.1 cm x 10.2 cm (16.5" x 9.5" x 4.0")	LAB1O5_B2	-40-50°C (-40-122°F)	18.3-29.4°C (65-85°F)	
CSA-CP Accessories Kit	2.15 kg (4.75 lbs)	10299.9 cm <sup>3</sup> (627 in <sup>3</sup> )	41.9 cm x 24.1 cm x 10.2 cm (16.5" x 9.5" x 4.0")	Crew Pref	-40-50°C (-40-122°F)	18.3-29.4°C (65-85°F)	
CSA-CP unit	0.6 kg (1.32 lbs)	431.97 cm <sup>3</sup> (26.1 in <sup>3</sup> )	12.1 cm x 7.0 cm x 5.1 cm (4.75" x 2.75" x 2.0")	PRIME: SM Central Post BACKUPS: SM 208, NOD1S4-03	-40-50°C (-40-122°F)	18.3-29.4°C (65-85°F)	13.9-14.9

**3.4.2.2.1. CSA-CP Transport Kit**

The CSA-CP Transport Kit is a 0.5 CTB-sized Nomex bag that stores the Accessories and Resupply Kits when both are being transported together. The Transport Kit has no on-orbit nominal stowage location, but rather is usually stowed according to crew preference after the removal of its contents.

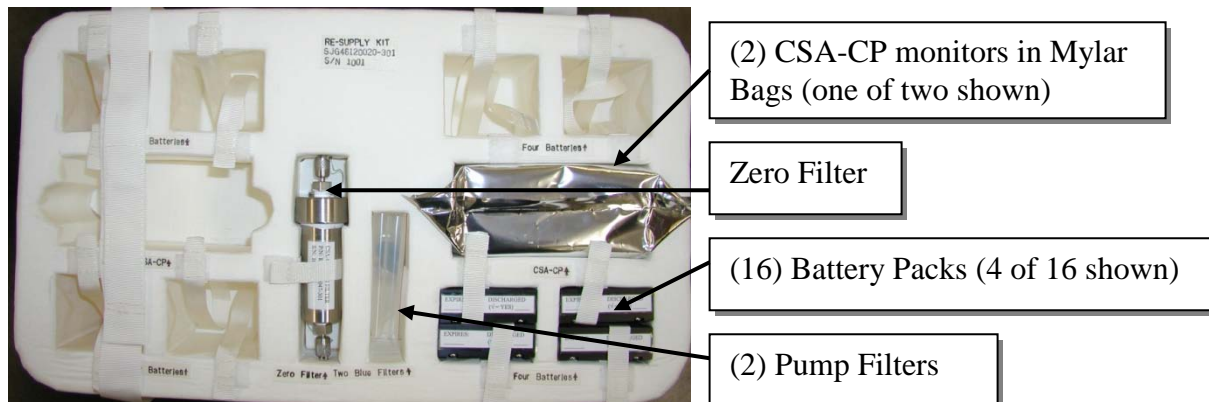


**Figure 1. CSA-CP Transport Kit (open, oblique view)**

**3.4.2.2.2. CSA-CP Resupply Kit**

The CSA-CP Resupply Kit is the primary means of replacing the CSA-CP monitors and other components. Approximately every 9 months a new Resupply Kit is used to refurbish the components that are approaching or have exceeded their on-orbit shelf life.

The CSA-CP units are flown up in Mylar bags with alkaline batteries installed. This configuration isolates the units within the kit, lessening the contamination of the CO and HCl sensors from the off-gassing of the lithium batteries. Once the kit arrives on station, the units must be removed from the Mylar Bags, and the alkaline batteries must be replaced with lithium batteries.

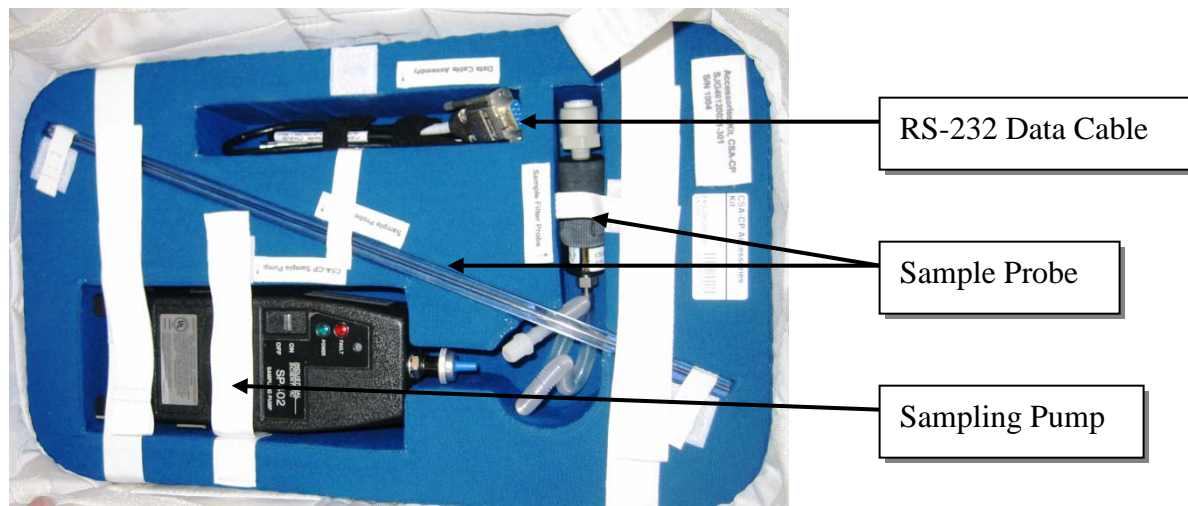


**Figure 2. CSA-CP Resupply Kit**

### 3.4.2.2.3. CSA-CP Accessories Kit

The CSA-CP Accessories Kit is resupplied much less frequently than the Resupply Kit, primarily only when its components are nearing the end of their shelf life or when new monitors are being added to the station's complement.

Like the Transport Kit, the CSA-CP Accessories Kit has no nominal stowage location, but rather is stowed according to crew preference once its contents have been removed. The Sampling Pump and Probe are stored adjacent to the backup CSA-CP units and must be easily accessible during a contingency event, but cannot be stored mated to the backup monitors because that configuration would promote contamination of the CO and HCl sensors by the off-gassing of the lithium battery pack.



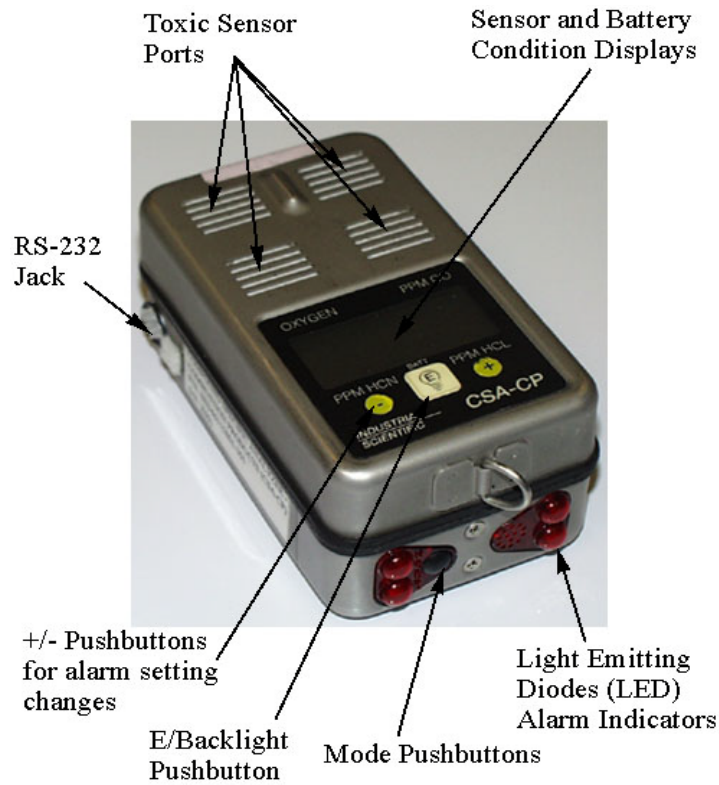
**Figure 3. CSA-CP Accessories Kit**

### 3.4.2.2.4. CSA-CP Monitor

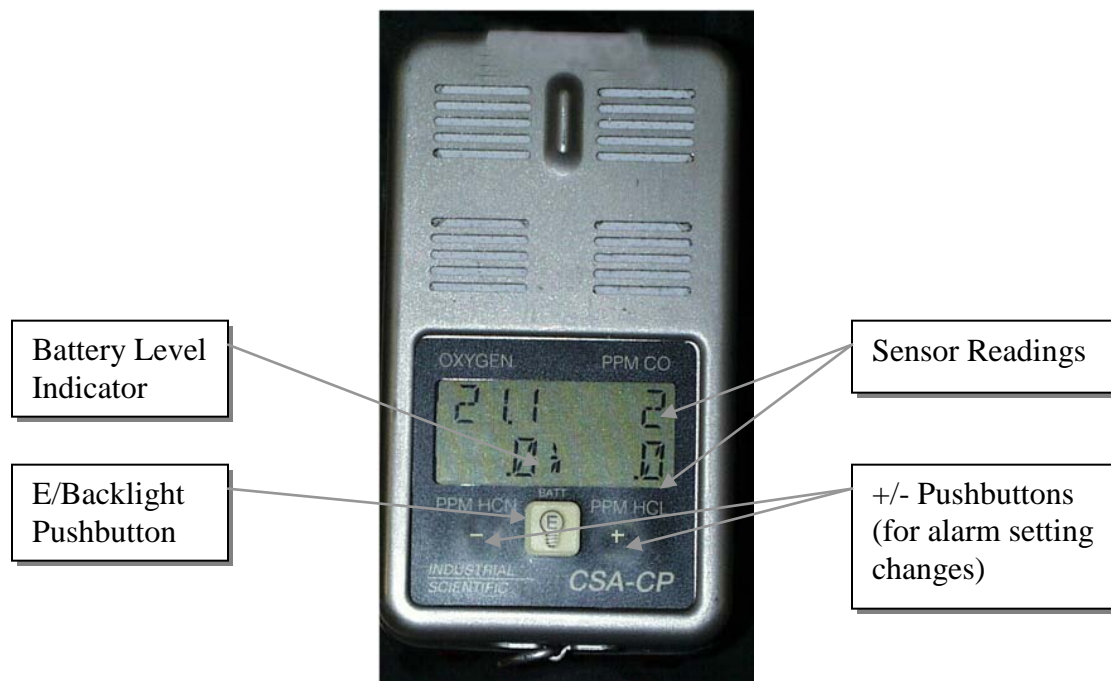
The CSA-CP Monitor is an application-specific gas detector configured with four electrochemical sensors to monitor CO, HCN, HCl and O<sub>2</sub> and is powered by a replaceable battery pack. The CSA-CP draws a steady state current of  $1.22 \pm 0.19$  mA with the unit powered off and  $4.80 \pm 0.23$  mA powered on. This allows for 18 days of continuous, powered use and 61 days of sitting unpowered before the batteries lose their charge and calibration settings are lost.

The stainless steel (type 204) casing houses all of the CSA-CP components. It is perforated in 3 places: once for air vents to the gas sensors, once for battery access, and once for the LCD screen on which measurements are displayed. The air vent slits are covered on the inside of the case with hydrophobic filters to prevent contaminants and moisture from interfering with the sensors. An access cover (with gasket) seals the battery compartment and is held in place by two captive screws. The LCD opening is covered by a plastic faceplate. A keypad is incorporated into the casing/faceplate for data entry.

The outside of the access cover has a 2 inch square piece of Velcro (hook) which allows the instrument to be mounted as required throughout the ISS.



**Figure 4. CSA-CP with parts labeled**



**Figure 5. CSA-CP Monitor View**

**Table 3.4.2.2.4-1 Hardware-Specific Parameters**

Power Requirements	(2) 9 volt batteries (Lithium Manganese Dioxide) contained within 1 battery pack (Not rechargeable on-orbit)					
Storage	Relative humidity must be between 10-90%* Atmospheric pressure is be between 8.7-18.7 psi† The storage area must be free of alkaline, acidic, and other corrosive vapors The total duration of CSA-CP storage (sensors removed) is not to exceed 5 years					
	* Operating range: 20-80% RH † Operating range: 13.9-14.9 psi					
Measurement Parameters/Analysis Capabilities	Sensor	Linear Response Range	Full Scale Range†	Display Resolution	Response – Baseline to 80% Maximum Response	Recovery – Maximum Response to 20% Above Baseline
	CO*	3-400 ppm	-999-999 ppm	1 ppm	≤30 seconds	≤30 seconds
	HCN	0.4-30 ppm	-99.9-99.9 ppm	0.1 ppm	≤1.5 minutes	≤1.5 minutes
	HCl	0.4-30 ppm	-99.9-99.9 ppm	0.1 ppm	≤3 minutes	≤3 minutes
	Oxygen	14-32%	0-40%	0.1% (by volume)	≤1 minute	≤1 minute
	* CO sensor compensates for hydrogen concentration up to 500 ppm † A sensor current equal to or exceeding the Full Scale Range for any sensor will be displayed as +OR or –OR, meaning positive or negative over range					
Accuracy	Sensor	Concentration*	Accuracy†	Affects of Low Pressure on Accuracy		
	CO	40 ppm 500 ppm	± 10 ppm ± 50 ppm	Less than 10% effect in accuracy to a pressure of 9 psi Max. pressure range: 13.2-15.2 psi		
	HCN	10 ppm 20 ppm	± 4 ppm ± 6 ppm	Accuracy at lower pressures is significantly worse (up to 50%) Max. pressure range: 13.2-15.2 psi		
	HCl	10 ppm 20 ppm	± 5 ppm ± 6 ppm	Unknown (no testing performed) Max. pressure range: 13.2-15.2 psi		
	Oxygen		± 6 mmHg	No significant effect Max. pressure range: 9.5-15.2 psi		
	* Accuracies outside of these ranges can be extrapolated from the linear equations encompassing the high and low concentration data points. † CO, HCN, HCl sensor accuracies are taken 270 days post calibration. Oxygen sensor accuracy taken 30 days post calibration.					

**Display**

The CSA-CP measures HCN, HCL, and CO in ppm. O<sub>2</sub> readings are measured in percentage (%).

The CSA-CP has 12 normal viewing modes. All modes are accessed in sequential order by repeated momentary pressing of the MODE pushbutton. The instrument reverts to the INSTANT READINGS mode 10 seconds after the last MODE key press. The operating modes can be accessed in the following sequence:

- **INSTANT READINGS** – Displays current measured concentrations and is updated every 1-2 seconds. An eight tick battery indicator also appears at the center of the lower display line to show the remaining operating time.
- **SENSOR CONFIGURATION** – Displays position of all sensors.

<b>O2</b>	<b>CO</b>
<b>HCN</b>	<b>HCL</b>

- **PEAK READINGS** – Displays highest measured levels of toxic gases and lowest measured level of oxygen since the peaks were last cleared. Note: powercycling the instrument will not clear these readings. PK identifies this viewing mode.
- **PK CLR** – Provides the means of clearing peak readings in the Peak Mode. Press the (E) key to reset the peak readings.
- **DATE** – Current date “month/day” setting of the data logger clock/calendar.
- **CALDATE** – Last date “month/day” of calibration. The cal date is set automatically when any toxic sensors are calibrated or a TWA, STEL, or AUTOLOG setting is changed.
- **RT/LT CLOCK** – Displays both real time (RT) and log time (LT) clocks. The real time clock indicates the current time. The log time clock indicates the duration of data currently logged by the data logger. Both clocks are displayed in the 24-hour format.
- **TWA** – Displays current Time Weighted Average values for toxic gases. **STEL** – (Short Term Exposure Limit) Displays current 15 minute running average values for toxic gases.
- **STEL** – (Short Term Exposure Limit) Displays current 15 minute running average values for toxic gases.
- **LOG OFF/ON** – When this mode is displayed, the data logger may be switched ON and OFF by pressing the (+) key.
- **UNMUTE/MUTE** – Pressing the (+) key causes the audible and LED visual alarms to toggle between UNMUTE and MUTE.
- **GO CAL** – Press (E) to access calibration functions. The CSA-CP is zero calibrated from this menu.

There are certain display readings that may appear that do not apply to on-orbit operations. These display readings are for industrial hygiene purposes and include the following:

Short Term Exposure Limits (STEL)  
Time Weighted Average (TWA)

### **Plug-In Sensors**

The four sensors – oxygen, CO, HCN, HCl – are COTS electrochemical cells specifically designed for the target gas. All are replaceable on the ground and each is a standard cell sold by commercial vendors.

The oxygen and HCl sensor life is 12 months, and the CO and HCN sensor life is 18 months. Each cell is made up of a plastic material, noble metal electrodes, and small concentrations of inorganic salts and electrolyte. Specific concentrations of toxic materials are addressed in the safety data package since the components are commercially proprietary in nature. The sensors are not accessible unless the protective casing of the CSA-CP is removed.



The operating principle of the electrochemical sensor is gas diffusion across a membrane and interaction of the gas with a noble metal catalyst (electrode). Electrochemical reactions occur at the electrode/electrolyte interface (opposite the gas interface) when a gas of a specific type interacts with the noble metal catalyst. The kinetics of the diffusion and reaction drives an electrical potential that is proportional to the gas concentration in the air. Selection of specific electrolytes and metal catalyst allows the sensor to detect a specific gas of interest. The electrolyte is in liquid or gel form. The use of a liquid electrolyte represents a slightly higher exposure risk to the crew, but also provides a much better medium for gas diffusion and helps to reduce sensor drift over time.

It takes 15-20 seconds for the oxygen, CO and HCN sensors to stabilize. The HCl sensor takes longer to respond, so a minimum sample time of 3 minutes is needed to get an acceptable reading.

**Alarm**

The CSA-CP has 4 alarm ultra-bright LED’s with plastic covers, which illuminate when one of the sensors goes out of limits. Sensor limits can be set by the user to a desired level and when the detected concentration of a gas exceeds this preset limit, the alarm enunciates by illumination of the 4 LED's and the audio alarm. Limits are accessed through the main menu of the instrument. The data-logger will automatically activate and record data when the low limits are exceeded.

When the instantaneous level of a monitored gas reaches the level alarm set point concentration, the instrument emits a continuous warble tone alarm, the four (4) red LED’s will flash, the backlight will be on, and the alarming gas reading will blink. The audible alarm enunciates at approximately 95dB (68dB @ 5 feet). If the CSA-CP alarm is activated, the battery level indicator may read lower than when the alarm is not annunciating. The alarm can be turned off by a series of key presses, if desired.

**Alarm Settings**

The CSA-CP alarm will be set on the ground to enunciate at the following limits:

CO <u>10PPM</u>	} Low alarm Data logger Auto start	CO <u>10PPM</u>	} High Alarm
HCN <u>1PPM</u>		HCN <u>1PPM</u>	
HCL <u>1PPM</u>		HCL <u>1PPM</u>	
O <sub>2</sub> <u>1%</u>		O <sub>2</sub> <u>40%</u>	

The alarm thresholds will be preset prior to launch for CO, HCN, and HCL. For the combustible product sensors, the high alarm values are set to be the same as the low alarm values. Alarm thresholds for the O<sub>2</sub> sensor will be set to extreme values in order to prevent the O<sub>2</sub> alarm from being triggered. The O<sub>2</sub> alarm values are set to 1% for the low threshold and 40 % for the high.

**Deployment Location**

The prime or backup unit should not be stowed inside the CSA-CP stowage kit or within a closed environment due to the potential for contamination of the sensors from the Lithium battery off gassing. When the CSA-CP is deployed, the instrument location will be restricted based on the following guidelines:

1. Located no closer than 4 feet from any conditioned air discharge duct/register.
2. Shall not be located in a stagnant airflow area such as an alcove-like region.
3. Shall not be deployed behind a stowage rack.
4. Shall not be located in close proximity to other equipment that might obstruct the module ventilation airflow across the face of the instrument.
5. Shall not be deployed with the front of the instrument facing the attachment surface.
6. Shall not be deployed in front of a rack that sees a lot of traffic, such as the glove box, stowage drawers, etc.

These general guidelines should be used at the present time. However, the real-time flight control team or crew can deploy the CSA-CP to locations as required to support any operational scenario at their discretion.

### **Maintenance and Calibration**

The CSA-CP battery pack is discharged on the prime unit after 18 days of continuous operation and on the backup units after 61 days of being un-powered. The battery pack in the prime CSA-CP is replaced every 15 days. The battery packs on the backup CSA-CPs are replaced every 60 days.

Electrochemical sensors gradually drift in the value they give for the detection of a gas. After a few months, the reading can be significant enough to require calibration in order to correct the reading. The combustible products sensors can be re-zeroed, but there is no ability to calibrate the units on orbit. The CSA-CP instrument requires periodic ground calibration approximately every 9 months in order to remain within acceptable specifications. This is performed by returning the units to the ground for refurbishment. However, every month, the CSA-CP combustible sensors must be “zeroed” using the zero filter. This is performed by connecting the zero filter to the Sampling Pump and drawing air through the zero filter and across the CSA-CP sensors. The zero filter filters combustion gasses from the inlet stream of the sampling pump, allowing only clean air to reach the CSA-CP sensors. The CSA-CP can be “zeroed” during this activity, eliminating any sensor drift that might come from exposure for long durations to combustion products.

On-orbit procedures require periodic comparison of units during combustion events. In the event that one unit is indicating degraded performance, the zero filter will be used to re-zero the instrument.

Using the Portable Gas Delivery System, it is possible to calibrate the oxygen sensor of a CSA unit on-orbit. Because the exact concentration of the calibration gas within the Portable Gas Delivery system changes every time a new gas cylinder is filled, ground testing must be performed on the ground to determine the exact oxygen concentration of the newly filled gas cylinder. This exact concentration is also used to correct the oxygen span value on a CSA unit undergoing its first calibration with a resupplied Portable Gas Delivery system. It is not required to alter the oxygen span value during subsequent calibrations using an existing Portable Gas Delivery System.

There are no requirements to keep the oxygen sensor of the on-orbit CSA-CP units in calibration but they may be calibrated used the Portable Gas Delivery System as needed (a chit from CHeCS MER may be required).

### **Battery Pack**

The battery pack is used to power the CSA-CP and the sampling pump and is a modified COTS item. It contains two 9-V cells of the Lithium-Manganese-Dioxide chemistry in parallel and contained in a plastic case. It also contains redundant diodes, redundant polyswitches, a fuse for circuit protection and wicking material for any possible electrolyte leakage. It has a capacity of 2400 mA-hours.

The CSA-CP battery pack will last for approximately eighteen days when used in the passive sampling mode. A fully charged lithium battery pack will maintain a deactivated CSA-CP (e.g. maintain sensor bias voltage, data, clock) for approximately 61 days. When the CSA-CP is used to perform active sampling, the Sampling Pump Battery will last approximately 40 – 50 hours. Both the CSA-CP and the Sampling Pump have low battery indications.

### **CSA-CP Battery Status Indicators:**

CSA-CP battery status is indicated by tick marks on the display in even-numbered increments. While these marks provide a means of quickly judging whether or not sufficient battery life is available to complete certain activities with the CSAS hardware, it is not possible to accurately estimate the amount of battery life by counting the tick marks.

Low Battery Warning – When the battery is low (approximately 90 minutes of operation remaining) the CSA-CP will begin sounding a short beep once every 30 seconds.

Battery Failure – When the battery cannot supply sufficient power to operate the CSA-CP the instrument will indicate battery failure and stop monitoring gas. In this condition the instrument will emit a short beep every 2.5 seconds.

The CSA-CP has a built in capability for the clock to maintain the correct time for up to 30 minutes without a battery installed. After 30 minutes, the clock time will be lost. After approximately 48 hours, the data stored and the alarm settings will be lost. Removing the batteries for more than 30 minutes causes loss of sensor bias. The sensors can stabilize from a dead battery after 8 hours with a fresh battery, but the CSA-CP is required to be immediately available to respond to a combustion event.

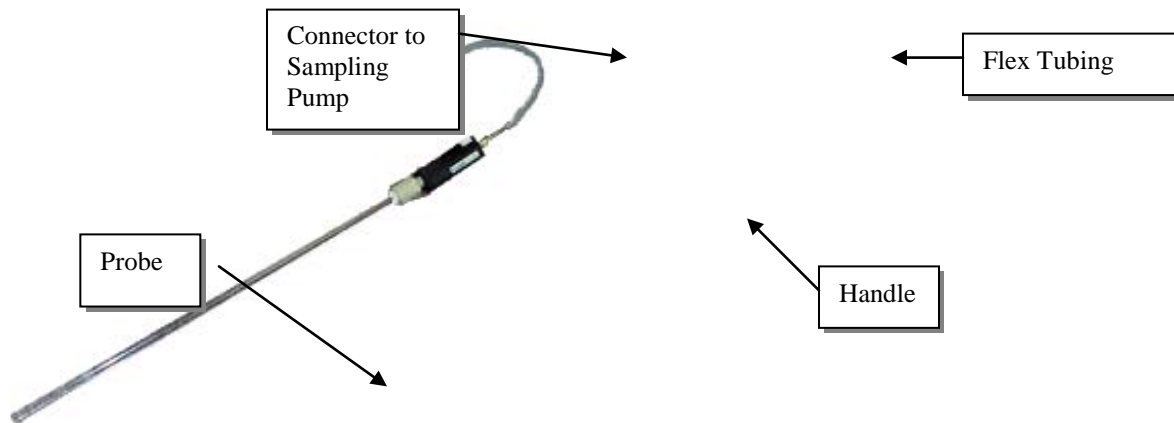
### **CSA-CP Sampling Pump Battery Status Indicators:**

Low Battery Warning – If the sampling pump battery is low (approximately 1-4 hours of operating time remaining), there is a beep every minute. The red fault light does not turn on.

Battery Failure – When the battery has only a few minutes of operating time, the pump will shut off, the green light will shut off, the red fault light will illuminate, and there is no tone.

### **CSA-CP Probe**

The sample probe is a handle/probe combination. The probe is a polycarbonate tube, which locks into the open end of the handle. Teflon flex tubing is attached to the opposite end of the handle, to pass sampled gases to the Sampling Pump. The sample probe material has an off-gassing limit of 160°F and a melting point of 220°F. If the probe is inserted into a fire port and the temperatures reach these levels behind a panel, the probe would off-gas and gives a false reading. The sampling probe inner is 1/16" and the outer diameter is 3/8". The polycarbonate probe length is 16" and Teflon tubing length is 10".



**Figure 6. Sample Probe for CSA-CP Active Mode Remote Sampling**

### **CSA-CP Data Cable**

The CSA-CP can output the entire contents of the data logger to a laptop computer via an RS-232 connector. The 4-foot RS-232 cable takes the 3-pin signal from the instrument and outputs it on a 9-pin connector. Data that can be downloaded includes up to 110 hours of sensor concentration values. Software is available on the Medical Equipment Computer for viewing the data, or downlinking it to the ground for analysis.

### **CSA-CP Zero Filter**

The zero filter is a stainless steel cylinder filled with Hopcalite, with caps on the ends. The Hopcalite is contained in the cylinder by redundant filters in each end. The fittings are designed to interface to the Sampling Pump in order to pull an air sample through the filter.



**Figure 7. Zero Filter**

### **CSA-CP Sampling Pump**

The sampling pump is composed of a casing, which contains the pump motor, tubing, and circuit board. The casing is a molded thermoplastic polycarbonate/polyester alloy. It is approximately 9.2”x3.5”x3.0” in size. The casing includes an on/off switch and indicator LEDs. The LEDs indicate power status and low flow status. The sampling pump is not providing enough airflow for a proper sample, the red fault light will illuminate and a continuous tone is annunciated until the flow path is unobstructed. If the pump alarm enunciates, the crew can attempt to restore function by power cycling or by replacing the pump particulate filters if the filter is clogged. The Canon EN22-T23NIA pump motor is capable of drawing 1.0 cubic feet per hour of air through the inlet tubing and exhausting it out the exit vent. On the inlet nozzle of the pump, there is a filter to block particulates from being sucked into the pump plumbing. The motor has a rated speed of 4700 RPM (max 5800 RPM with no load). The nominal pump airflow with blue filter attached is ~1 liter/min and ~0.70 liter/min with the zero filter attached. The flow rate of the CSA-CP pump with sampling probe attached is ~0.85 liter/min. The pump flow sensor that measures low flow status is rated to alarm at ~0.45 liter/min, with an accuracy of -0.10/+0.19 liter/min.

Velcro straps are included in the design for connecting the CSA-CP to the pump outlet vent for gas sampling. A Velcro strip is also included on the exterior of the case for temporary use as needed.



**Figure 8. Sampling Pump**

### 3.4.2.3. Hardware Interfaces with Vehicle

Velcro is used to attach the hardware in the desired location.

### 3.4.2.4. Resupply Schedule

The CSA-CP Resupply Kit is resupplied approximately every 4.5 months.

The CSA-CP Accessories Kit is resupplied approximately every 2 years.

Replacement of CSA-CP monitors occurs approximately every 9 months in order to accommodate the calibration expiration of its sensors.

### 3.4.2.5. Data/Commanding Capabilities

After a combustion event, the CSA-CP will be used to monitor the environment. Data may be collected and downloaded to the MEC and then downlinked to the ground for analysis and clean-up trends (see Section 2.5.5.1 for file extensions and locations on the MEC). The CSA-CP can store approximately 110 hours of data. No commanding capabilities or requirements.

### 3.4.2.6. Hazard Concerns

Hazard Title	Severity	Likelihood	Hazard Condition Description
Fire/Explosion	Catastrophic	Improbable	Use of flammable materials, external debris or loose particles inside the CSAS, and/or over-voltage of electrical circuitry will lead to loss of crew, damage to the ISS and other payloads through fire, smoke, and/or heat.
EMI	Critical	Improbable	Disruption of critical ISS systems from the effects of EMI would lead to injury to crew and/or loss of mission.
Sharp Edges, Corners, Pinch Points, Holes and Burrs	Critical	Improbable	Flight hardware manufactured with sharp edges, corners, pinch points, holes or burrs may result in injuries to the IVA crew.
Thermal/Touch Temperature	Critical	Improbable	Surface temperature of CSA-CP/O <sub>2</sub> and Sampling Pump exceeds 113°F due to instrument overheating causing injury to the IVA crewmembers.
Contamination	Critical-Catastrophic	Improbable	Release of hazardous contaminants into the IVA habitable environment potentially resulting in loss of crew and/or Station.
Toxicity	Catastrophic	Improbable	Materials of construction release hazardous vapors that, retained in a confined area, could result in loss of life.
Vibration/ Shock/ Acoustic	Critical	Improbable	Unacceptably high acoustic noise causing injury to crewmembers.
Battery Hazards	Catastrophic	Improbable	Lithium and/or alkaline batteries could potentially release electrolyte resulting in a fire which could result in loss of crew and vehicle.
Loss of Function (Post Combustion Event)	Catastrophic	Improbable	Erroneous readings displayed by the CSA-CP monitor causes the crew to take improper actions resulting in loss of crew and vehicle.
Structural Failure	Catastrophic	Improbable	Structural failure due to depressurization, re-pressurization or over-pressurization results in a hazardous rupture of the CSAS resulting in loss of



<b>Hazard Title</b>	<b>Severity</b>	<b>Likelihood</b>	<b>Hazard Condition Description</b>
			crew and vehicle.
Inadvertent Activation	Catastrophic	Improbable	Inadvertent activation of the CSA-CP/O2 or the Sampling Pump will disrupt active guidance/navigation systems and/or other communication systems during ascent.
Failure of Calibration Adapter to Accurately Calibrate CSA-CP/O2	Catastrophic	Improbable	Erroneous high/low readings displayed by the CSA-CP/O2 monitor due to failure of Portable Gas Delivery System to flow oxygen to correctly calibrate the CSA-CP/O2 causes the crew to take improper actions resulting in loss of crew and vehicle.

### 3.4.3. Compound Specific Analyzer – Oxygen (CSA-O<sub>2</sub>)

#### 3.4.3.1. CSA-O<sub>2</sub> Description

The CSA-O<sub>2</sub> is outwardly very similar to the CSA-CP. However, unlike the CSA-CP, the CSA-O<sub>2</sub> contains only an O<sub>2</sub>-sensitive electrochemical sensor rather than the CSA-CP’s full complement of O<sub>2</sub>, HCN, CO, and HCl sensors.

Without the HCl, HCN, and CO sensors, the crew is able to take the CSA-O<sub>2</sub> into low pressure environments that the CSA-CP sensors cannot tolerate. This is especially useful during exercise and campout EVA prebreathe protocols, which involves the decrease of airlock pressure to 10.2 psia and the increase in O<sub>2</sub> concentration to over 23.5%. During these protocols, at least two CSA-O<sub>2</sub> units are required to provide readings that supplement those of the MCA.

#### 3.4.3.2. CSA-O<sub>2</sub> Kit Component List and Description

- CSA-O<sub>2</sub> Resupply Kit
  - a. CSA-O<sub>2</sub> Units (2)
  - b. Spare Battery Packs (16)

**Table 3.4.3.2-1 General Hardware Specifications**

Kit and Component List	Mass M(E)	Volume M(E)	Dimensions M(E)	Nominal Stowage Location	Storage Temp °C (°F)	Operating Temp °C (°F)	Operating Pressure (psia)
CSA-O <sub>2</sub> Resupply Kit	5.7 kg (12.5 lbs)	10299.9 cm <sup>3</sup> (627 in <sup>3</sup> )	41.9 cm x 24.1 cm x 10.2 cm (16.5" x 9.5" x 4.0")	LAB1S4_C1	-40-50°C (-40-122°F)	18.3-29.4°C (65-85°F)	
CSA-O <sub>2</sub> units	0.6 kg (1.32 lbs)	431.97 cm <sup>3</sup> (26.1 in <sup>3</sup> )	12.1 cm x 7.0 cm x 5.1 cm (4.75" x 2.75" x 2.0")	LAB1S4	-40-50°C (-40-122°F)	18.3-29.4°C (65-85°F)	9.5-15.2

##### 3.4.3.2.1. CSA-O<sub>2</sub> Resupply Kit

The Resupply Kit used for the CSA-O<sub>2</sub> hardware is identical to the kit used with the CSA-CP hardware except that the CSA-O<sub>2</sub> kit contains only spare battery packs in addition to its complement of monitors.

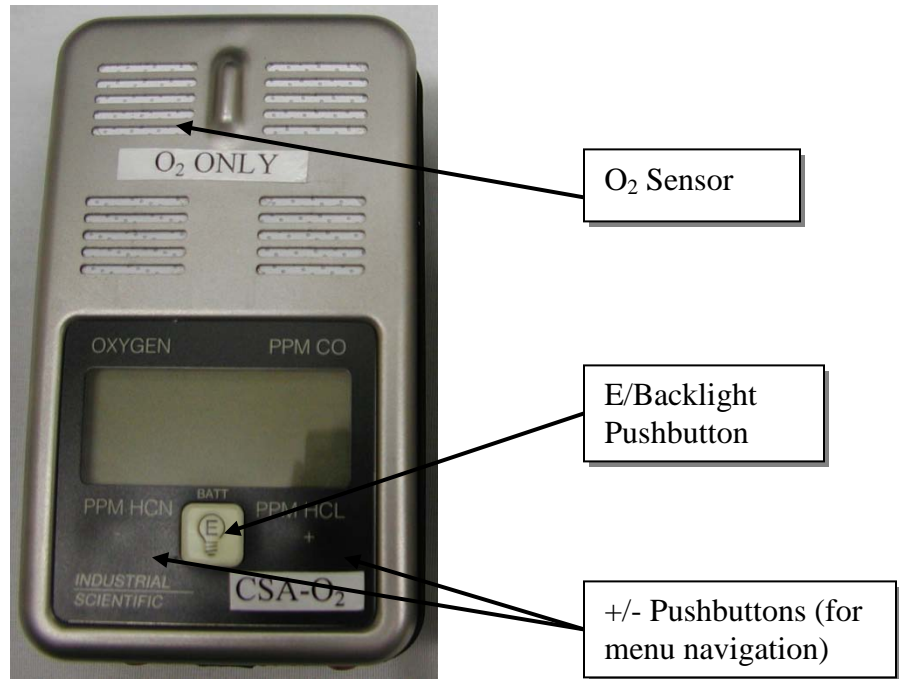
Because the battery changeouts for the CSA-O<sub>2</sub>s occur less frequently than those for the CSA-CPs, new CSA-O<sub>2</sub> Resupply Kits only need to be provided approximately every 12 months.

##### 3.4.3.2.2. CSA-O<sub>2</sub> Monitor

The CSA-O<sub>2</sub> Monitor is an application specific gas detector configured with one electrochemical sensor to monitor oxygen and is powered by a replaceable battery pack.

The stainless steel (type 204) casing houses all of the CSA-O<sub>2</sub> components. It is perforated in 3 places: once for air vents to the gas sensor, once for battery access, and once for the LCD screen on which measurements are displayed. The air vent slits are covered on the inside of the case with hydrophobic filters to prevent contaminants and moisture from interfering with the sensor. An access cover (with gasket) seals the battery compartment and is held in place by two captive screws. The LCD opening is covered by a plastic faceplate. A keypad is incorporated into the casing/faceplate for data entry.

The outside of the access cover has a 2 inch square piece of Velcro (hook) which allows the instrument to be mounted as required throughout the ISS.



**Figure 1. CSA-O2 Monitor**

**Table 3.4.3.2.2-1 Hardware-Specific Parameters**

Power Requirements	(2) 9 volt batteries (Lithium Manganese Dioxide) contained within 1 battery pack (Not rechargeable on-orbit)					
Storage	Relative humidity must be between 10-90%* Atmospheric pressure is between 8.7-18.7 psi† The storage area must be free of alkaline, acidic, and other corrosive vapors The total duration of CSA-O2 storage (sensors removed) is not to exceed 5 years					
	* Operating range: 20-80% RH † Operating range: 9.5-15.2 psi					
Measurement Parameters/Analysis Capabilities	Sensor	Linear Response Range	Full Scale Range†	Display Resolution	Response – Baseline to 80% Maximum Response	Recovery – Maximum Response to 20% Above Baseline
	Oxygen	14-32%	0-40%	0.1% (by volume)	≤1 minute	≤1 minute
	† A sensor current equal to or exceeding the Full Scale Range for any sensor will be displayed as +OR or –OR, meaning positive or negative over range					
Accuracy	Sensor	Accuracy†	Affects of Low Pressure on Accuracy			
	Oxygen	± 6 mmHg	No significant effect Max. pressure range: 9.5-15.2 psi			
	†Oxygen sensor accuracy taken 30 days post calibration.					

## **Display**

The O<sub>2</sub> readings of the CSA-O<sub>2</sub> are measured in percentage (% , by volume).

The CSA-O<sub>2</sub> has 12 normal viewing modes. All modes are accessed in sequential order by repeated momentary pressing of the MODE pushbutton. The instrument reverts to the INSTANT READINGS mode 10 seconds after the last MODE key press. The operating modes can be accessed in the following sequence:

- INSTANT READINGS – Displays current measured concentrations and is updated every 1-2 seconds. An eight tick battery indicator also appears at the center of the lower display line to show the remaining operating time.
- SENSOR CONFIGURATION – Displays position of all sensors. Note: the removed combustion products will not be displayed on the screen.



- PEAK READINGS – Displays highest measured levels of toxic gases and lowest measured level of oxygen since the peaks were last cleared. ‘P’ identifies this viewing mode.
- PK CLR – Provides the means of clearing peak readings in the Peak Mode. Press the (E) key to reset the peak readings.
- DATE – Current date “month/day” setting of the data logger clock/calendar.
- CALDATE – Last date “month/day” of calibration. The cal date is set automatically when any toxic sensors are calibrated or a TWA, STEL, or AUTOLOG setting is changed.
- RT/LT CLOCK – Displays both real time (RT) and log time (LT) clocks. The real time clock indicates the current time. The log time clock indicates the duration of data currently logged by the data logger. Both clocks are displayed in the 24-hour format.
- TWA – Displays current Time Weighted Average values for toxic gases. STEL – (Short Term Exposure Limit) Displays current 15 minute running average values for detected gases.
- STEL – (Short Term Exposure Limit) Displays current 15 minute running average values for detected gases.
- LOG OFF/ON – When this mode is displayed, the data logger may be switched ON and OFF by pressing the (+) key.
- UNMUTE/MUTE – Pressing the (+) key causes the audible and LED visual alarms to toggle between UNMUTE and MUTE.
- GO CAL – Press (E) to access calibration functions, including ‘Set Span’. The CSA-O<sub>2</sub> is calibrated from this menu.

There are certain display readings that may appear that do not apply to on-orbit operations. These display readings are for industrial hygiene purposes and include the following:

Short Term Exposure Limits (STEL)  
Time Weighted Average (TWA)

## **Plug-In Sensors**

The oxygen sensor is a COTS electrochemical cell specifically designed for the target gas. It is replaceable on the ground and is a standard cell sold by commercial vendors.

The oxygen sensor life is 12 months; its calibration life is 1 month. Each cell is made up of a plastic material, noble metal electrodes, and small concentrations of inorganic salts and electrolyte. Specific concentrations of toxic materials are addressed in the safety data package since the components are commercially proprietary in nature. The sensors are not accessible unless the protective casing of the CSA-O2 is removed.

The operating principle of the electrochemical sensor is gas diffusion across a membrane and interaction of the gas with a noble metal catalyst (electrode). Electrochemical reactions occur at the electrode/electrolyte interface (opposite the gas interface) when a gas of a specific type interacts with the noble metal catalyst. The kinetics of the diffusion and reaction drives an electrical potential that is proportional to the gas concentration in the air. Selection of specific electrolytes and metal catalyst allows the sensor to detect a specific gas of interest. The electrolyte can be in liquid or gel form. The use of a liquid electrolyte represents a slightly higher exposure risk to the crew, but also provides a much better medium for gas diffusion and helps to reduce sensor drift over time.

### **Alarm**

The CSA-O2 has 4 alarm ultra-bright LED's with plastic covers, which illuminate when one of the sensors goes out of limits. Sensor limits can be set by the user to a desired level and when the detected concentration of a gas exceeds this preset limit, the alarm enunciates by illumination of the 4 LED's and the audio alarm. Limits are accessed through the main menu of the instrument.

When the instantaneous level of a monitored gas reaches the level alarm set point concentration, the instrument emits a continuous warble tone alarm, the four (4) red LED's will flash, the backlight will be on, and the alarming gas reading will blink. The audible alarm enunciates at approximately 95dB (68dB @ 5 feet). If the CSA-O2 alarm is activated, the battery level indicator may read lower than when the alarm is not annunciating. The alarm can be turned off by a series of key presses, if desired.

However, alarm thresholds for the O2 sensor are set to extreme values in order to prevent the O2 alarm from being triggered. The O2 alarm values are set to 1% for the low threshold and 40 % for the high.

When trying to change the alarm limits, the display scrolls past the absent CP sensors and remains static at the O2 sensor Low and High limits. You cannot change the automatic data logging threshold for the CSA-O2 since that feature only functions with the CP sensors. The unit will not automatically start data logging when an O2 level is reached.

### **Deployment Location**

Unlike the CSA-CP, there are no special deployment/stowing conditions for the CSA-O2. Its sensor is not susceptible to the effects of offgassing from the Lithium Battery Packs.

### **Maintenance and Calibration**

The battery pack in a CSA-O2 is good for approximately 18 days of continuous operation in the passive sampling mode and 61 days while the unit is deactivated. Unlike the CSA-CP, there are no scheduled battery changeouts for the CSA-O2 and they are simply performed as needed.

If the CSA-O2s are to be used for an exercise or campout prebreathe, the status of their batteries is checked beforehand. Any unit displaying a battery status of less than 4 ticks will usually have its battery changed before the prebreathe begins. This procedure is covered in the EVA prebreathe protocols.

Using the Portable Gas Delivery System, it is possible to calibrate the oxygen sensor of a CSA unit on-orbit. Because the exact concentration of the calibration gas within the Portable Gas Delivery system changes every time a new gas cylinder is filled, ground testing must be performed on the ground to determine the exact oxygen concentration of the newly filled gas cylinder. This exact concentration is also used to correct the oxygen span value on a CSA unit undergoing its first calibration with a resupplied Portable Gas Delivery system. It is not required to alter the oxygen span value during subsequent calibrations using an existing Portable Gas Delivery System.

The oxygen sensor of a CSA-O2 monitor is calibrated using a Portable Gas Delivery System approximately every 30 days.

### **Battery Pack**

The battery pack used to power the CSA-O2 is a modified COTS item. It contains two 9-V cells of the Lithium-Manganese-Dioxide chemistry in parallel and contained in a plastic case. It also contains redundant diodes, redundant polyswitches, a fuse for circuit protection and wicking material for any possible electrolyte leakage. It has a capacity of 2400 mA-hours.

The CSA-O2 battery pack will last for approximately eighteen days when used in the passive sampling mode. A fully charged lithium battery pack will maintain a deactivated CSA-O2 (e.g. maintain sensor bias voltage, data, clock) for approximately 61 days.

### **CSA-O2 Battery Status Indicators:**

Battery status is indicated by tick marks on the display in even-numbered increments.

Low Battery Warning – When the battery is low (approximately 90 minutes of operation remaining) the CSA-O2 will begin sounding a short beep once every 30 seconds.

Battery Failure – When the battery cannot supply sufficient power to operate the CSA-O2 the instrument will indicate battery failure and stop monitoring gas. In this condition the instrument will emit a short beep every 2.5 seconds.

The CSA-O2 has a built in capability for the clock to maintain the correct time for up to 30 minutes without a battery installed. After 30 minutes, the clock time will be lost. After approximately 48 hours, the data stored and the alarm settings will be lost. Removing the batteries for more than 30 minutes causes loss of sensor bias. The sensor can stabilize from a dead battery after 24 hours with a fresh battery.

#### **3.4.3.3. Hardware Interfaces with Vehicle**

Velcro is used to attach the hardware in the desired location.



### 3.4.3.4. Resupply Schedule

The CSA-O2 Resupply Kit is resupplied approximately every 12 months. Replacement of CSA-O2 monitors occurs approximately every 12 months in order to accommodate the expiration of its oxygen sensor.

### 3.4.3.5. Data/Commanding Capabilities

Data may be collected and downloaded to the MEC and then downlinked to the ground for analysis (see Section 2.5.5.1 for file extensions and locations on the MEC). The CSA-O2 can store approximately 110 hours of data. No commanding capabilities or requirements.

### 3.4.3.6. Hazard Concerns

Hazard Title	Severity	Likelihood	Hazard Condition Description
Fire/Explosion	Catastrophic	Improbable	Use of flammable materials, external debris or loose particles inside the CSAS, and/or over-voltage of electrical circuitry will lead to loss of crew, damage to the ISS and other payloads through fire, smoke, and/or heat.
EMI	Critical	Improbable	Disruption of critical ISS systems from the effects of EMI would lead to injury to crew and/or loss of mission.
Sharp Edges, Corners, Pinch Points, Holes and Burrs	Critical	Improbable	Flight hardware manufactured with sharp edges, corners, pinch points, holes or burrs may result in injuries to the IVA crew.
Thermal/Touch Temperature	Critical	Improbable	Surface temperature of CSA-CP/O2 and Sampling Pump exceeds 113°F due to instrument overheating causing injury to the IVA crewmembers.
Contamination	Critical-Catastrophic	Improbable	Release of hazardous contaminants into the IVA habitable environment potentially resulting in loss of crew and/or Station.
Toxicity	Catastrophic	Improbable	Materials of construction release hazardous vapors that, retained in a confined area, could result in loss of life.
Vibration/ Shock/ Acoustic	Critical	Improbable	Unacceptably high acoustic noise causing injury to crewmembers.
Battery Hazards	Catastrophic	Improbable	Lithium and/or alkaline batteries could potentially release electrolyte resulting in a fire which could result in loss of crew and vehicle.
Loss of Function (Post Combustion Event)	Catastrophic	Improbable	Erroneous readings displayed by the CSA-CP monitor causes the crew to take improper actions resulting in loss of crew and vehicle.
Structural Failure	Catastrophic	Improbable	Structural failure due to depressurization, re-pressurization or over-pressurization results in a hazardous rupture of the CSAS resulting in loss of crew and vehicle.
Inadvertent Activation	Catastrophic	Improbable	Inadvertent activation of the CSA-CP/O2 or the Sampling Pump will disrupt active guidance/navigation systems and/or other communication systems during ascent.
Failure of Calibration Adapter to Accurately Calibrate CSA-CP/O2	Catastrophic	Improbable	Erroneous high/low readings displayed by the CSA-CP/O2 monitor due to failure of Portable Gas Delivery System to flow oxygen to correctly calibrate the CSA-CP/O2 causes the crew to take improper actions resulting in loss of crew and vehicle.

**3.4.4. Portable Gas Delivery System**

**3.4.4.1. Portable Gas Delivery System Description**

The Portable Gas Delivery System, which is sometimes known by its engineering name – the In-flight Gas Delivery System (IGDS), is the primary means by which the oxygen sensors of the CSAS are calibrated on-orbit. This system of calibration is made up of two major components: the Portable Gas Delivery System and the CSA Calibration Adaptor.

**3.4.4.2. Portable Gas Delivery System Component List and Description**

- Portable Gas Delivery System
- CSA Calibration Adaptor

**Table 3.4.4.2-1 General Hardware Specifications**

<b>Kit and Component List</b>	<b>Mass M(E)</b>	<b>Volume M(E)</b>	<b>Dimensions M(E)</b>	<b>Nominal Stowage Location</b>	<b>Storage Temp °C (°F)</b>	<b>Operating Temp °C (°F)</b>	<b>Operating Pressure (psia)</b>
Portable Gas Delivery System	8.9 lbs* 4.04 kg	14184.5 cm <sup>3</sup> (865.6 in <sup>3</sup> )	41.7 cm x 23.1 cm x 14.7 cm (16.4" x 9.1" x 5.8")	LAB1O5_B2	-40-50°C (-40-122°F)	18.3-29.4°C (65-85°F)	13.9-14.9
CSA Calibration Adaptor	2 lbs .907 kg			LAB1O5_B2	-40-50°C (-40-122°F)	18.3-29.4°C (65-85°F)	13.9-14.9

\*Note: for manifesting purposes, the mass of the Portable Gas Delivery System is sometimes estimated to be 15.1 lbs (6.85 kg). However the actual mass of a filled unit is 8.9 lbs.

**3.4.4.2.1. *Portable Gas Delivery System***

The Portable Gas Delivery System consists of an insulated gas bottle designed to deliver a 23% ± 1% oxygen in nitrogen blend at a flow rate of 0.8 ± 0.2 liters per minute. The gas cylinder within the Portable Gas Delivery System holds between 115 and 142.7 liters of pressurized gas and is designed to provide approximately 40 calibrations of the on-orbit CSA monitors before it is resupplied.

The Portable Gas Delivery system also includes a pressure regulator, relief valves, flow restrictors, and other features intended to maintain the pressure of the gas cylinder. The quick disconnect system (female end; with cover) provides a means to connect the gas cylinder to the CSA Cal Adaptor.

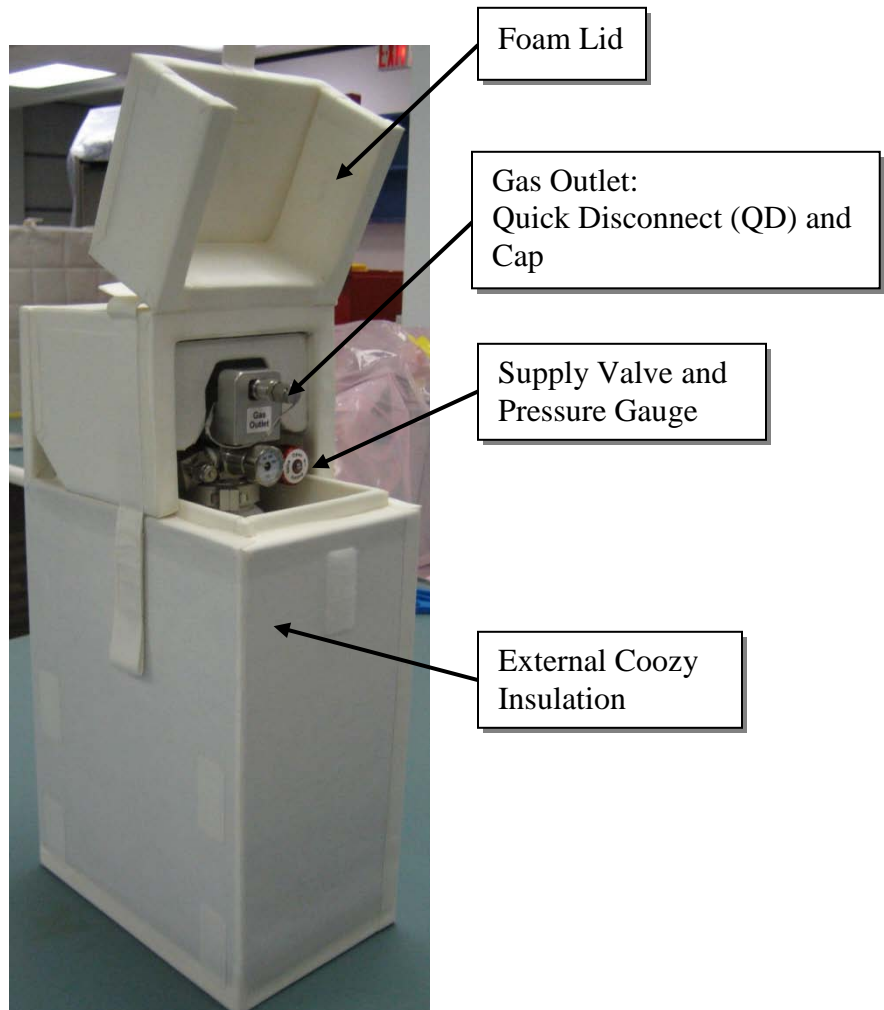


Figure 1. Portable Gas Delivery System

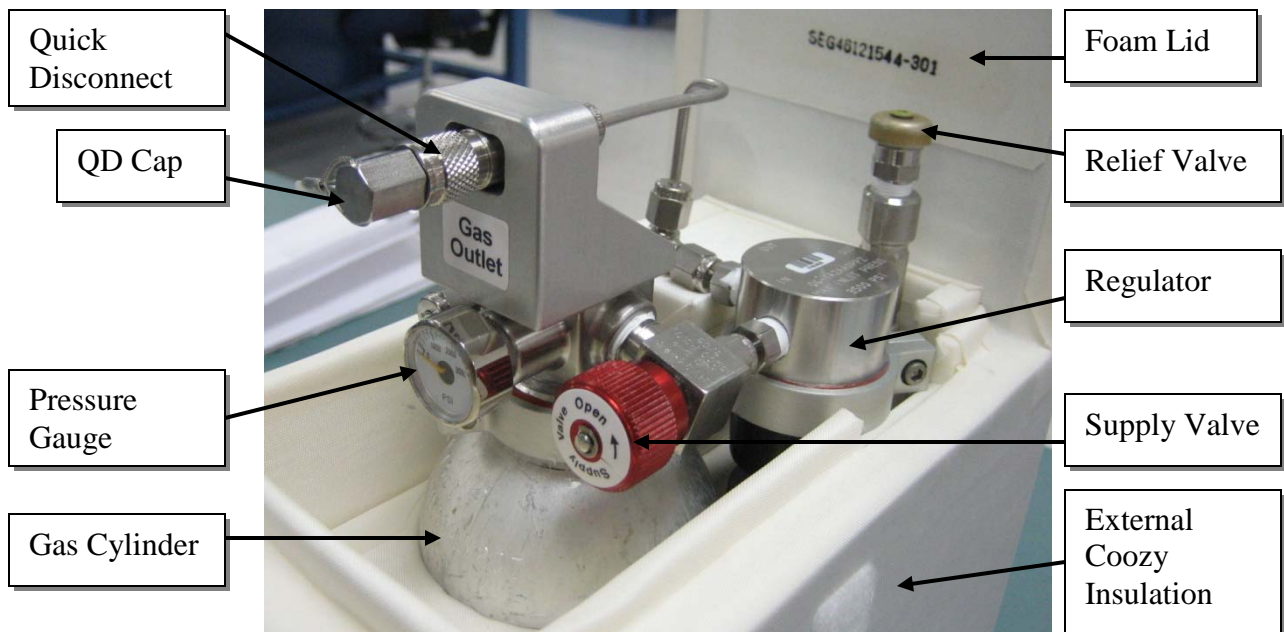


Figure 2. Portable Gas Delivery System (Gas Cylinder Assembly)

**Table 3.4.4.2.1-1 Hardware-Specific Parameters**

Inner Volume of Gas Cylinder	0.869 L
Min. Gas Volume	115 L*
Min. Gas Pressure	1945 psia
Max. Gas Volume	142.7 L
Max. Gas Pressure	2414.7 psia
Leak Rate (worst case)	0.002 L/hr
Volume Used per Calibration (estimated)	2 L
Flow Rate	0.8 ± 0.2 L/min
Gas Concentration	23% ± 1% O <sub>2</sub>

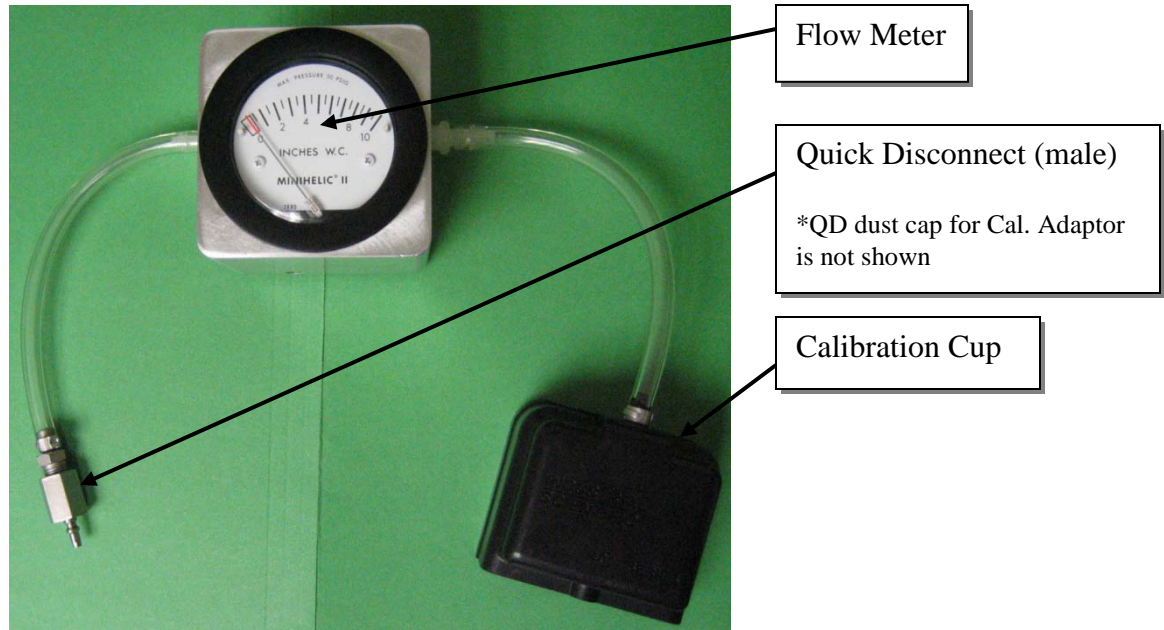
\* Amount of gas estimated to be needed to calibrate 40 CSA units and provide for leak protection and contingency calibrations.

#### **3.4.4.2.2. CSA Calibration Adaptor**

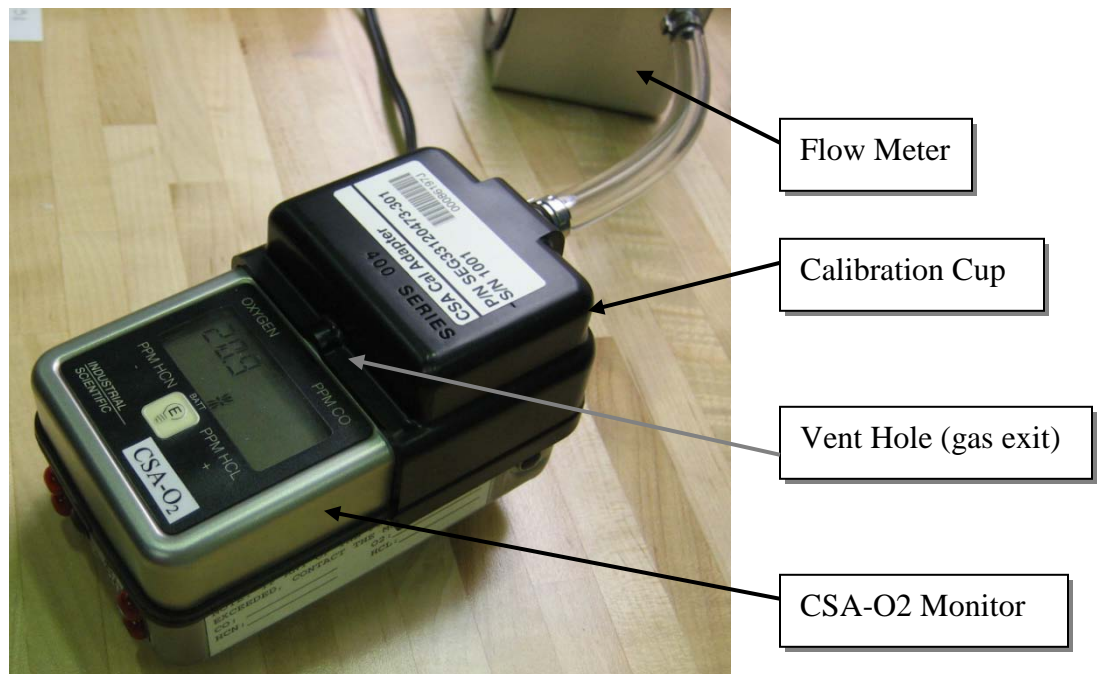
The Compound Specific Analyzer Calibration Adaptor provides an interface between the CSA unit undergoing calibration and the Portable Gas Delivery System. At one end, the Calibration Adaptor includes a male quick disconnect plug and six inches of tubing leading to a flow meter assembly. The flow meter assembly consists of a manometer that measures the pressure at which the gas passes by in inches of the water column (in W.C). This measurement may be converted to psi or converted to an actual flow rate (L/min).

Another six inch length of tubing connects the flow meter to the calibration cup, the component that is slid over the O<sub>2</sub> sensor of the CSA monitor during calibration. The cup encloses the faceplate of the CSA unit in a rubber-lined plastic groove and provides a path the calibration gas to pass over the sensors before exiting through a vent hole in the cup.

The calibration life of the CSA Calibration Adaptor's flow meter is approximately 12 months. The relationship between the pressure detected (in inches of the water column) by the flow meter and the actual flow rate (liters per minute) is determined by ground testing before the hardware is flown.



**Figure 3. CSA Calibration Adaptor**



**Figure 4. CSA Calibration Adaptor (Calibration Cup)**

**3.4.4.3. Hardware Interfaces with Vehicle**

The Portable Gas Delivery System may be either soft-stowed or attached with Velcro at its desired location.

The CSA Calibration Adaptor does not have Velcro and is soft-stowed when not in use.

**3.4.4.4. Resupply Schedule**

The Portable Gas Delivery System has a shelf life of 24 months if left unused. To accommodate nominal usage frequency, the Portable Gas Delivery System is resupplied every 18 months. The CSA Calibration Adaptor is resupplied every 12 months, when the calibration life of its flow meter expires.

#### 3.4.4.5. Data/Commanding Capabilities

None.

#### 3.4.4.6. Hazard Concerns

Hazard Title	Severity	Likelihood	Hazard Condition Description
Fire/Explosion (Detonation)	Catastrophic	Improbable	Use of flammable materials and the presence of potential ignition sources leads to injury to the crew, damage to the vehicle and other payloads through fire, smoke and/or heat
Sharp edges and Corners	Critical	Improbable	Crew injury due to sharp edges, corners, pinch points, snags, or burrs
Thermal/Touch Temperature	Critical	Improbable	Crew exposed to excessive surface temperature
Toxicity/Offgassing	Critical	Improbable	Crew injury due to toxic substances or offgas materials in cabin environment
Rupture of Pressure System	Critical	Improbable	Rupture of the Pressurized System in IGDS could result in injury to the crew, damage to the vehicle and/or payloads
Unrestrained Motion Due to Leak	Catastrophic	Improbable	Damage to IGDS components causing unrestrained motion of IGDS due to rapid release of gas. IGDS could impact crewmember, or hardware resulting in injury or damage



### 3.4.5. Formaldehyde Monitoring Kit (FMK)

#### 3.4.5.1. Formaldehyde Monitoring Kit Description

The FMK is a Ziploc bag, which contains a varying amount of one-time-use formaldehyde monitors, depending on the duration of the stage. Each kit will contain 4 monitors multiplied by the planned number of months in the stage plus 1 control assembly (for example, a planned 3-month stage would require 12 monitors plus the formaldehyde monitor controls). The controls consist of 3 monitors – 2 positive control monitor and 1 negative control monitor – within a sealed plastic bag labeled “Do Not Open.” Within the FMK is a smaller Ziploc bag labeled “Return ‘Used’ Bag” to store formaldehyde monitors after they have been used for sampling sessions. Each formaldehyde monitor contains a bisulfite collector, which absorbs formaldehyde at a known rate. The formaldehyde monitors have a manufacturer shelf life of 12 months, and are usable for 8 months past the date of dosing. The nominal sampling period for the formaldehyde monitor is 48 hours. A minimum of 8 hours of exposure is required for the collection to be valid. The maximum time a monitor can be exposed and still receive valid data is 96 hours.

On orbit the FMK is used to collect periodic scheduled archival air samples, which are analyzed on the ground postflight. The monitors are deployed in duplicate, side by side, in each designated sample location. The deployment site must allow for the air to flow freely over the monitor surface at a rate of 40 ft/min. The monitor update rate is flow dependent; therefore, in an area with an air flow less than 40 ft/min., the zone is being under-sampled. The ‘Used’ formaldehyde monitors must return with the control that it is associated with or data cannot be analyzed on the ground. No in-flight results will be available.

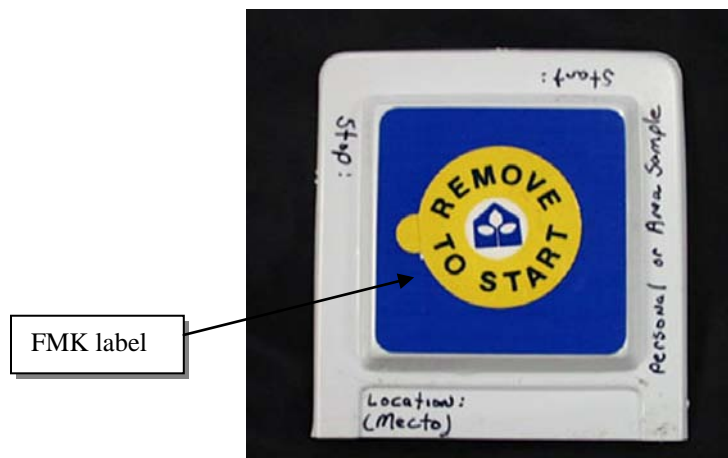


Figure 1. Formaldehyde Monitor

#### 3.4.5.2. FMK Component List and Description

- Formaldehyde monitors (4 monitors x number of months in stage)
- Sealed Plastic Bag with Formaldehyde monitor controls (2 positive monitors + 1 negative monitor)
- Small Ziploc bags to store used formaldehyde monitors

**Table 3.4.5.2-1 General Hardware Specifications**

<b>Kit and Component List</b>	<b>Mass M(E)</b>	<b>Volume M(E)</b>	<b>Dimensions M(E)</b>	<b>Nominal Stowage Location</b>	<b>Storage Temp °C (°F)</b>	<b>Operating Temp °C (°F)</b>	<b>Operating Pressure mmHg (psia)</b>
Formaldehyde Monitoring Kit	0.1 kg (0.22 lbs)	793.0 cm <sup>3</sup> (48.4 in <sup>3</sup> )	22 cm x 12.0 cm x 3.0 cm (8.67" x 4.73" x 1.18")	LAB105_A1	4 - 43 °C (39 - 110 °F)		
Formaldehyde Monitor	3.9 g (0.009 lbs)	31 cm <sup>3</sup> (2 in <sup>3</sup> )	6.5 cm x 6.5 cm x 0.75 cm (2.6" x 2.6" x 0.3")	Inside FMK	4 - 43 °C (39 - 110 °F)	-7 - 38 °C (20- 100 °F)	8 - 16 psia

**3.4.5.3. Hardware Interfaces with Vehicle**

Velcro on the back of each monitor.

**3.4.5.4. Resupply Schedule**

Periodic resupply; no maintenance required.

**3.4.5.5. Data/Commanding Capabilities**

Ground analysis only (post-flight).

**3.4.5.6. Hazard Concerns**

N/A

### 3.4.6. Grab Sample Containers (GSC)

#### 3.4.6.1. Grab Sample Containers

The GSC is a valve-operated, stainless steel container, which is evacuated of air to 5-10 mmHg during preflight preparations. On orbit, the GSC is used to collect instantaneous (grab) air samples, which are analyzed on the ground. The GSC is dosed with a surrogate compound and are usable for 12 months from the date of dosing.

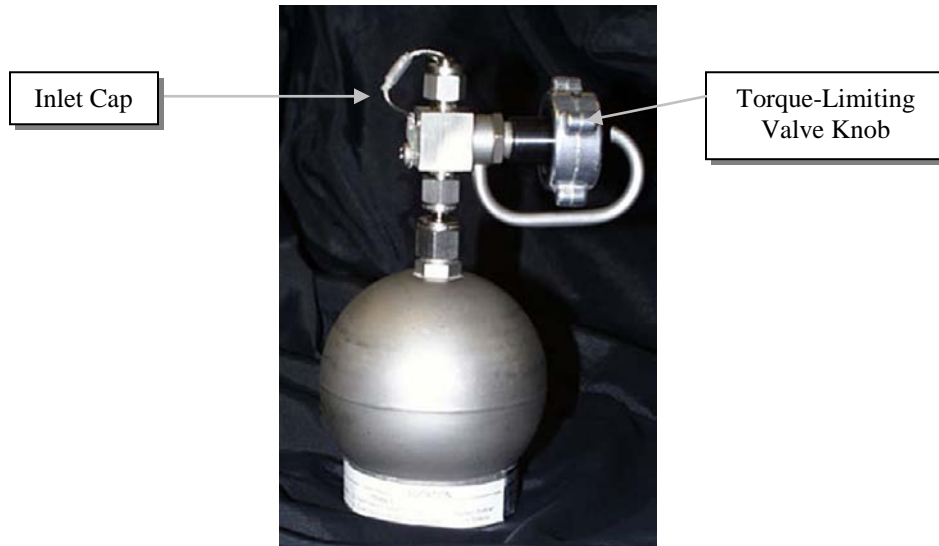


Figure 1. Grab Sample Container

#### 3.4.6.2. GSC Components Description

- Valve
- Container
- Inlet cap

**Table 3.4.6.2-1 General Hardware Specifications**

Kit and Component List	Mass M(E)	Volume M(E)	Dimensions M(E)	Nominal Stowage Location	Storage Temp °C (°F)	Operating Temp °C (°F)	Operating Pressure mmHg (psia)
Grab Sample Container	0.45 kg (1.0 lbs)	2037.2 cm <sup>3</sup> (124.3 in <sup>3</sup> )	17.5cm x 12.1cm x 8.9 cm (6.9" x 4.8" x 3.5")	LAB105_A1	4 – 35 °C (39 – 95 °F)	-7 – 38 °C (20- 100 °F)	8 – 16 psia

#### 3.4.6.3. Hardware Interfaces with Vehicle

The GSC may be attached to the ISS via a Velcro hook patch located on the container.

#### 3.4.6.4. Resupply Schedule

Resupply of GSCs is periodic; no maintenance is required. Each GSC is refurbished after ground processing.

**3.4.6.5. Data/Commanding Capabilities**

Ground analysis (post-flight) only.

**3.4.6.6. Hazard Concerns**

N/A

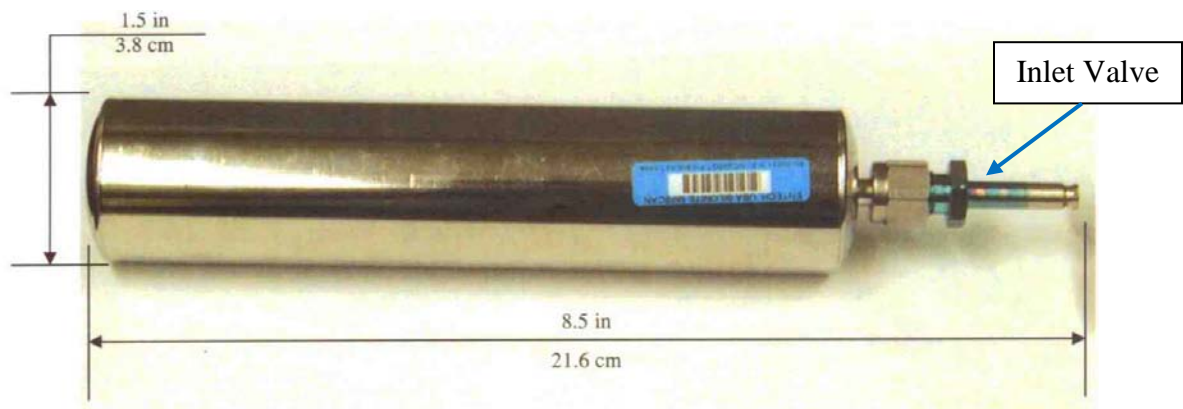
### 3.4.7. Grab Sample Containers (GSC)

#### 3.4.7.1. New “Mini” Grab Sample Containers

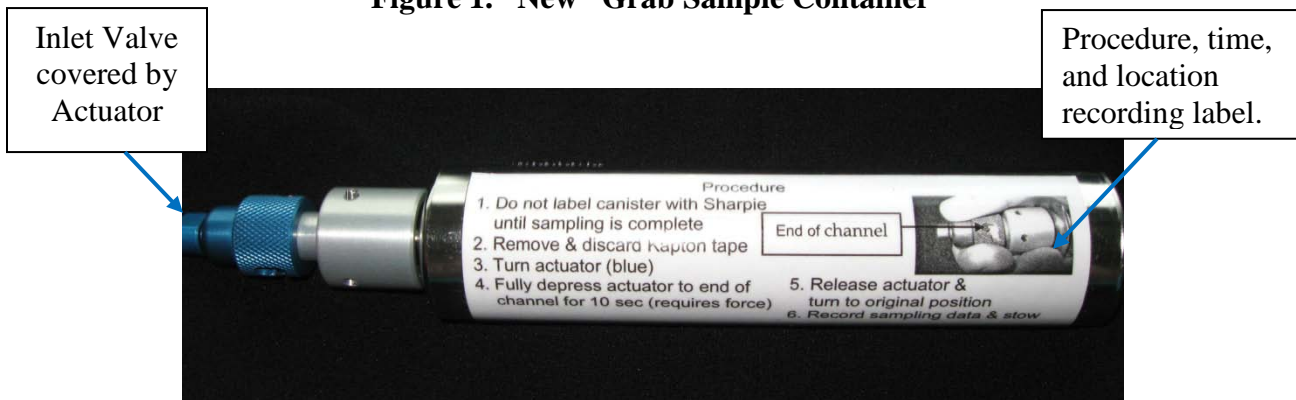
The new Grab Sample Container (GSC), P/N SEG46121657-301, is a small, stainless steel, evacuated canister that will be used to take air samples on the International Space Station (ISS). The hardware is approximately 9.37 inches in total length, 1.5 inches in diameter, and has a sample volume of 183 ml. The new GSC consists of an evacuated stainless steel canister with an attached simple actuator system. The attached actuator system uses an anodized aluminum encasement to secure an actuator pin to the canister. A sample is initiated when the actuator pin is depressed into the canister valve allowing GSC internal pressure to equilibrate with cabin air. The GSC will be affixed with a one square inch piece of hook fastener as well as a label, for recording time and location of the sample.

On orbit the GSC is used to collect instantaneous (grab) air samples, to be later analyzed on the ground. The GSC is dosed with a surrogate compound and is usable for 12 months from the date of dosing.

The new GSC is a replacement for the existing GSC (P/N SDD46108778-301) that will provide archival air sampling after Shuttle retirement. The design will decrease the sample volume from 350 mL to 183 mL, however it will allow for it to be returned to the ground on Soyuz flights. The smaller size will reduce packing volume requirements by ~50%.



**Figure 1. “New” Grab Sample Container**



**Figure 2. “New” Grab Sample Container with actuator and label**

### 3.4.7.2. GSC Components Description

- Container
- Inlet Valve
- Actuator

Kit and Component List	Mass M(E)	Packing Volume M(E)	Dimensions M(E)	Nominal Stowage Location	Storage Temp °C (°F)	Operating Temp °C (°F)	Ambient Pressure mmHg (psia)
Grab Sample Container	0.2 kg (0.4 lbs)	903.9 cm <sup>3</sup> (55.2 in <sup>3</sup> )	23.9 cm L x 4.1 cm Dia (9.4" L x 1.6" Dia)	LAB105_A1	-50 – 50 °C (-58 – 122 °F)	-7 – 38 °C (20 - 100°F)	.01 mmHg (.01mtorr)

### 3.4.7.3. Hardware Interfaces with Vehicle

The GSC may be attached to the ISS or crewmember via a 1" Velcro hook patch located on the container.

### 3.4.7.4. Resupply Schedule

Re-supply schedule is periodic; no maintenance is required. Each GSC is refurbished after ground processing.

### 3.4.7.5. Data/Commanding Capabilities

Ground analysis (post-flight) only.

### 3.4.7.6. Hazard Concerns

N/A



**3.4.8. Failed/Obsolete Hardware**

**3.4.8.1. Volatile Organic Analyzer (VOA)**

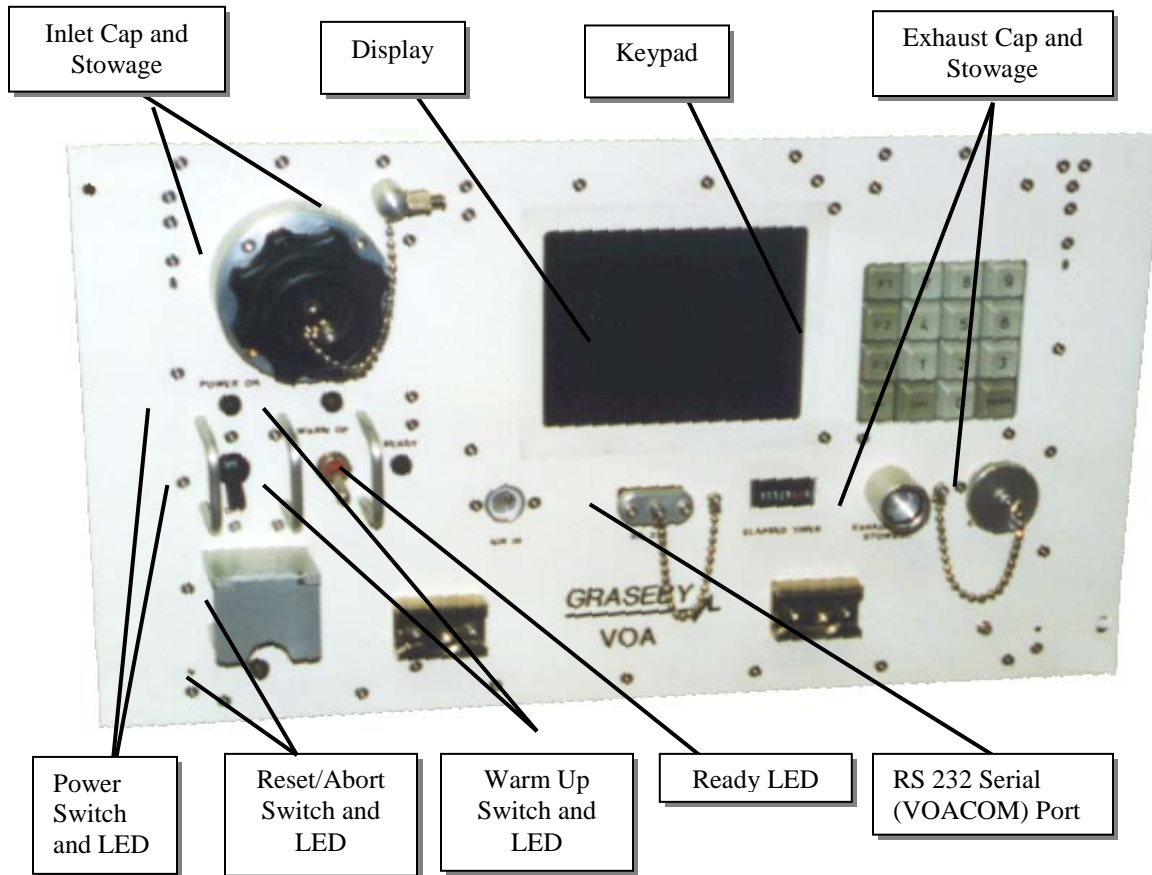
**3.4.8.1.1. VOA and VOA Kit Description**

The VOA is an atmospheric analysis device that uses a Gas Chromatograph Column and Ion Mobility Spectrometer to detect, identify, and quantify a selected list of volatile organic constituents. The VOA provides real-time data as well as receives remote commands from ground based personnel via a dual redundant MIL-STD 1553 bus. The VOA is capable of automatic and remote sampling and is powered by 120 V DC and high-pressure nitrogen. The supporting kits provide replacement parts for the VOA as well as sample bags.

- VOA
- VOA OMI (On-orbit Maintenance Item) Kit
  1. Inlet Nozzle Filter Assembly
  2. Re-circulating Sieve Pack
  3. Air-In Sieve Pack
  4. Hard Disk Drive Assembly
  5. Oxygen Scrubber
  6. Nitrogen Dryer
  7. Pumps (4)
  8. GC cooling Fan
  9. Power Board Fan
  10. Computer Battery (obsolete)
- VOA Sample Bag Kit - Sample Bags (12) (C)

**Table 3.4.8.1.1-1 General Hardware Specifications**

<b>Kit and Component List</b>	<b>Mass M(E)</b>	<b>Volume M(E)</b>	<b>Dimensions M(E)</b>	<b>Nominal Stowage Location</b>	<b>Storage Temp °C (°F)</b>	<b>Operating Temp °C (°F)</b>	<b>Operating Pressure mmHg (psia)</b>
VOA	42.2 kg (93lbs)	109518.8 cm <sup>3</sup> (6683.3 in <sup>3</sup> )	85.1cm x 48.3cm x 26.7 cm (33.5" x 19.0" x 10.5")	CHeCS: LAB1S4_H2	5°C - 40°C (41°F - 104°F)	17°C - 29°C (63°F - 85°F)	13.5 to 15.2 psia
VOA OMI Kit	10.67 kg (23.518 lbs)	27890 cm <sup>3</sup> (1702 in <sup>3</sup> )	29.2 cm x 47 cm x 20.3 cm (11.5" x 18.5" x 8.0")	Refer to IMS	5 - 50°C (41 - 122 °F)	18.3 - 26.7°C (65 - 80°F)	
VOA Sample Bag Kit	1.23 kg (2.708 lbs)	4425 cm <sup>3</sup> (270 in <sup>3</sup> )	25.4 cm x 22.9 cm x 7.62 cm (10" x 9" x 3")	Refer to IMS			



**Figure 1. VOA Front Panel**

**Table 3.4.8.1.1-2 Hardware-Specific Parameters**

Power Requirements	120 V DC: Remote Power Control Module (RPCM) in CHeCS rack LAD4-2B-A (A59) RPC 3)
Peak Power	168 W (in standby), 220 W (during a run)
Avg Power	160 W (in standby). 180 W (during a run)
Battery Description	Rayovac 844-1, 4.5 volt alkaline
Fluid/Gas Description	Nitrogen (Nominal = 120 psi)
Cooling Requirements	AAA @ 20 cfm (VOA requires 20 cfm of air flow, but it receives only 45% of the total air flow from the AAA. This requires the AAA to output an air flow of at least 45 cfm. The AAA must operate at a minimum of 50 cfm to always provide a 5 cfm margin above the minimum 45 cfm specified airflow for the CHeCS AAA network.
Operating Ranges	<ul style="list-style-type: none"> <li>• Voltage: 113-126 VDC; 120 VDC is nominal</li> <li>• Humidity: 27-70% relative humidity, non-condensing</li> <li>• Nitrogen Pressure: 55 psi – 140 ± 10 psi</li> <li>• Nitrogen Usage: 2ml/min in STANDBY, 4-6 ml/min in ACQUIRE</li> <li>• Nitrogen Pressure After Nitrogen Transfer from the Shuttle: Less than 112 psi</li> </ul>

### **3.4.8.1.1.1. Volatile Organic Analyzer Description**

#### **Set up**

The VOA will provide either automatic or remote sampling. The VOA is designed to operate independently except for power up/down, remote sampling and periodic observations. The set-up is accomplished by removing the air inlet and exhaust caps from the VOA front panel. A power switch is located on the front panel to power up. A crewmember will place the power switch in the ON position, but VOA power up will actually occur when the VOA's dedicated RPCM switch is closed. The VOA will nominally be commanded from the ground. However, there is an LCD screen visible for the crew on the front panel of the unit. Warm up is accomplished by crew activation of standby switch or by remote activation via 1553 communications. Initiation of an analysis run is accomplished by crew inputs using the keypad or by remote activation via 1553 communications.

#### **VOA Compound Detection**

The VOA detects trace organic compounds in the ISS atmosphere by taking in an air sample, dividing it between the two channels, and then concentrating the compounds in an adsorption bed called a trap. The trap is then quickly heated to 300 degrees C to desorb the compounds. They proceed through a 60 meter tightly wound gas chromatograph (GC) column to separate out different molecules based on their rates of diffusion. Finally, the compounds reach the Ion Mobility Spectrometer (IMS) detector where they are ionized and further separated based on differences in their rate of mobility through an electric field. The entire sample line from the trap to the cell must remain at an elevated temperature to prevent condensation of the volatile organic compounds. Table 3.4.8.1.1.1-1 lists the compounds that are detected by the VOA.

**Table 3.4.8.1.1.1-1 Compounds Detected by VOA**

COMPOUND
Methanol
Ethanol
2-Propanol
2-Methyl-2-Propanol
1-Butanol
Ethanal
Benzene
m, p - Xylene
Toluene
Dichloromethane
Freon 22
Freon 12
Freon 113
1,1,1- trichloroethane
n-Hexane
n-Pentane
Halon 1301
Propanone
2-Butanone
Isoprene
Ethyl Ethanoate
o-Xylene
Ethyl Acetate

Due to the extreme operating temperatures of the VOA, there are a number of thermal fuses attached to each heater, which prevents the heaters from overheating. If the heaters experience a run-away temperature, the thermal fuse for that heater trips, causing an open circuit. These fuses cannot be reset and requires extensive work to be replaced on orbit. When a fuse trips, the entire channel is lost.

If Channel 1 is lost, the following compounds can be detected by the VOA on channel 2 without any issues: Ethanol, 1-Butanol, Toluene, p-xylene, o-xylene, Isoprene, 2-Butanone, Ethyl Acetate (Ethyl Ethanoate), Propanone, Halon 1301, Freon 22, 1,1,1-Trichloroethane, Dichloromethane. Although channel 2 can detect the presence of Ethanal (acetaldehyde), it cannot accurately quantify the concentration of this compound.

If Channel 2 is lost, the following compounds can be detected by the VOA on channel 1 without any issues: Ethanol, 1-Butanol, Toluene, p-xylene, o-xylene, Isoprene, 2-Butanone, Ethyl Acetate, Ethyl Ethanoate, Propanone, Halon 1301, Freon 22, 1,1,1-Trichloroethane.

VOA channel 1 alone cannot quantify the following compounds: 2-Methyl-2-Propanol, Benzene, n-Hexane, Freon 113. Dichloromethane can be detected if Freon 113 is not present in significant amounts. Due to the loss of channel 2, it is uncertain how well the VOA might detect 2-Propanol, Methanol, Ethanal.

### **VOA Sample Runs**

The VOA will be used to perform atmospheric analyses depending upon direction from Toxicology. The VOA can sample automatically from the rack location or from a sample bag collected at a remote location. Once the sample bag is connected to the inlet port, a nominal sample run is initiated from the keypad. The VOA is capable of performing three types of samples (also called “runs”), each analysis lasting approximately 3.5 hours: Calibrant Sample, Full Sample, or Dilute Sample. In performing the Calibrant Sample, the VOA takes an internal sample of a calibrant. Calibrant Samples are required immediately before or after Full and Dilute Runs, depending on direction from the Toxicology group. Calibrant Samples serve as a means of “cleaning” the VOA and are mandatory if the VOA has been powered off. In performing the Full Sample, the VOA takes a 40 ml sample of the atmosphere in the Lab. Similar to the Full Sample, in performing the Dilute Sample, the VOA takes a 10 ml sample of the atmosphere in the Lab.

### **Power and Nitrogen Requirements**

The VOA contains two IMS cell detectors connected to two GC columns and two preconcentrator traps. The basic requirements for operations of the VOA are electrical power (28V DC; the input 120V DC from the ISS is internally regulated to 28V allowing the supplied power to withstand short variations in the range of 86 to 154V DC) and nitrogen carrier gas (99.9995% pure nitrogen). The nitrogen supply coming from ISS is cleaned to the purity level via a nitrogen scrubber and an oxygen scrubber, both on-orbit maintenance items (OMI) within the VOA. The nominal nitrogen pressure to operate the VOA is 80-120 psi. The minimum nitrogen pressure before the VOA goes into a low-pressure alarm is approximately 55 psi. The maximum nitrogen pressure before damage occurs to the hardware is approximately 140 +/- 10 psi. The nitrogen not only functions as a power source to the VOA, but nitrogen also is the

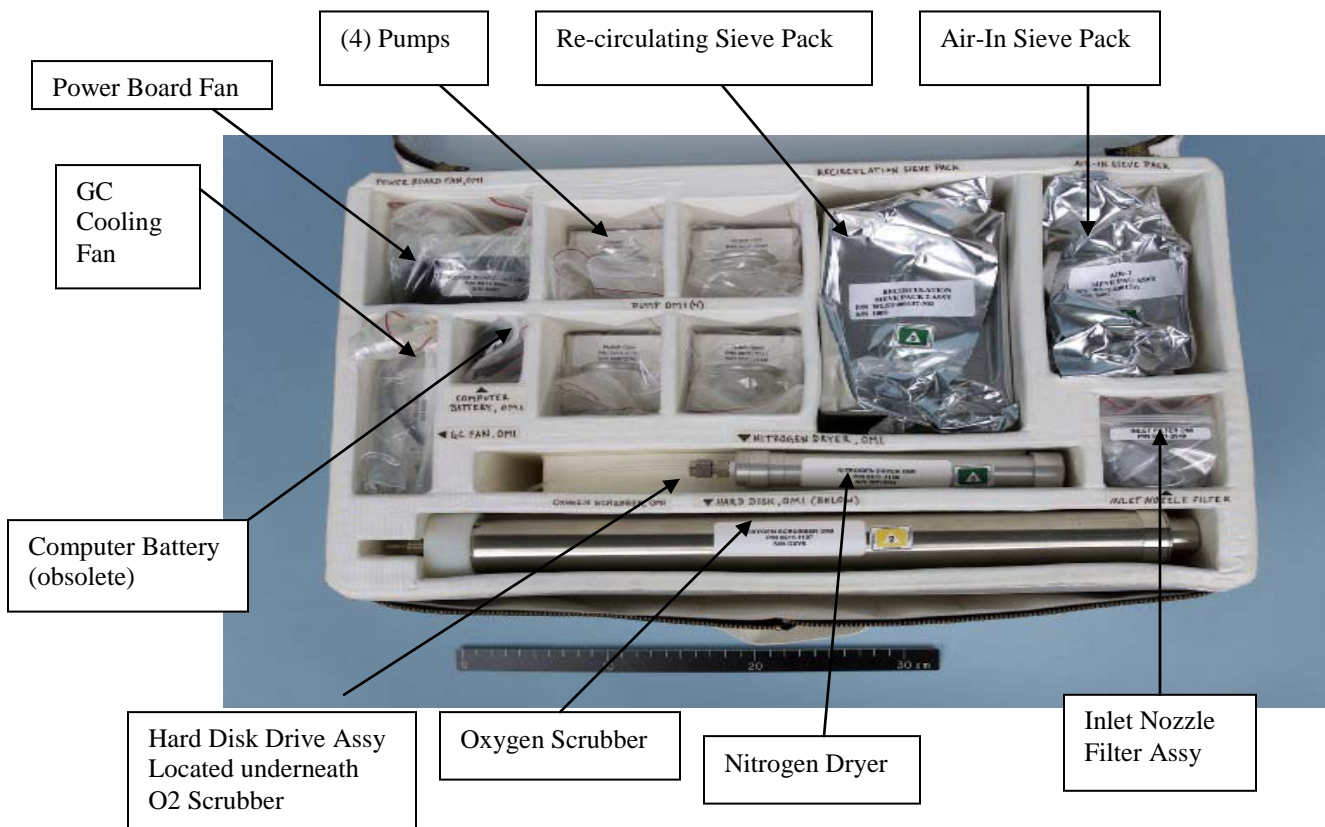
means by which samples are forced through the system. When the VOA is idle or in STANDBY, approximately 2 ml/minute of nitrogen is flushed through the system and vented into the Lab through the exhaust vent. When the VOA is performing a RUN, approximately 4-6 ml/minute of Nitrogen is flushed through the system and vented into the Lab through the exhaust vent.

**Powerdown**

Nominally, the VOA should not be powered OFF, but if absolutely necessary (troubleshooting or other reasons beyond MedOps/CHeCS control), a controlled power down by the crew is required. If the VOA is powered off/shut down for more than 48 hours, it is necessary to perform several Calibrant Samples to ensure cleanliness of the VOA (performed after VOA Activation and Checkout).

**3.4.8.1.1.2. VOA On-Orbit Maintenance Item (OMI) Kit**

The VOA OMI Kit is stowed in a foam locker or equivalent stowage location during on-orbit operations. The function of the VOA OMI Kit is to store VOA OMI's. The kit will be used during regularly scheduled maintenance activities, and if VOA in-flight maintenance is required. The VOA OMI Kit softpack provides the main structure of the VOA OMI Kit. It is constructed from white Nomex, and has a metal zipper closure. The softpack has individual compartments for each OMI. Durret is used as a padding material (sewn between two layers of nomex) to protect the OMI's from vibration and shock. During on-orbit maintenance, the new parts are installed into the VOA and the old parts are marked and stowed in the kit for later refurbishment. The individual components may also be shipped in piece parts with packaging in a CTB instead of the VOA OMI Kit.



## Figure 2. VOA OMI Kit

The VOA OMI Kit contains the following items:

- Oxygen Scrubber – Cleans any oxygen out of the nitrogen gas coming into the VOA from the CHeCS rack nitrogen source. The oxygen scrubber has quick disconnects on both ends so that it can be installed and removed easily. The oxygen scrubber has three levels of containment for the tox level 2 Lithium Hydride resins within it: a glass tube inside a metal tube inside a stainless steel tube.
- Nitrogen Dryer – Removes any water vapor that may be in the nitrogen gas coming into the VOA from the CHeCS rack nitrogen source. Like the oxygen scrubber it has quick disconnects on both ends to facilitate changeout. The nitrogen dryer is tox level 0, and there are no toxicity concerns since the particle size is non-respirable.
- Computer Battery (obsolete) – Maintains the VOA clock when the VOA system is powered off. The battery is a Rayovac alkaline rated at 4.5 Volts. A protection resistor and diode are in line to protect against over current. The battery is wrapped with wicking material and an insulating coating to protect against electrolyte leakage and heat respectively. Although the battery is obsolete, the clock can still be maintained on the VOA when it is synchronized to 1553.
- GC Cooling Fan – Directs cooling air over the VOA's gas chromatograph columns. It is a metal Rotron fan and has 12VDC brushless motor. It is mounted in a metal housing, which facilitates OMI removal and installation.
- Hard Drive – Contains VOA operating software. The main part of the hard drive is a standard hard disk drive. It is a Toshiba 2.16 GB 2.5". It is mounted in a metal frame so that it can easily slide in or out of the unit. Two captive mounting screws secure the hard drive in place. The data connector is attached to the top after the hard drive is secured in place.
- Power Board Fan – Directs cooling air over the VOA's Power Board to prevent overheating. It is a metal Rotron fan and has 12VDC brushless motor. It is mounted in a metal housing, which facilitates OMI removal and installation.
- Re-circulating sieve pack and Air-In sieve pack – Remove contaminants from the VOA detection system (the two sieve packs are identical except for size). The sieve packs are made up of an outer stainless steel case packed with molecular sieve material and carboxen.
- Pumps – Four pumps are used to circulate sample air throughout the system. Pumps 1 and 2 are Sample Pumps. Pumps 3 and 4 are IMS recirculating pumps. The pumps are channel specific. Pumps 1 and 3 operate channel 1; Pumps 2 and 4 operate channel 2. Unlike the sample pumps, the recirculating pumps are on all the time, even if the channel is shutdown. These pumps are brushless and are constructed from aluminum. Two gas system QDs and a self aligning electrical connector are located on the bottom of each pump to connect the pump to the system. A lever releases the QDs for easy removal. A guide bar keeps the pump in the proper position during installation.
- Inlet Nozzle – The inlet filter is a 25 micron and a 100 micron filter designed to remove unwanted particulate matter from the air sample that is entering the VOA detection system.



Below are the OMI parts that can be accessed through the various Access Panels located on the VOA:

- VOA Access Panel 1 (located on top of the VOA near the front panel):
  - GC Cooling Fan
- VOA Access Panel 2 (located on the top of the VOA near the rear):
  - Air in Sieve Pack
  - Recirculating Sieve Pack
  - Pumps (4)
- VOA Access Panel 3 (located on the bottom of the VOA, the smaller of the two access panels):
  - Hard Disk Drive
- VOA Access Panel 4 (located on the bottom of the VOA, the larger of the two access panels):
  - Oxygen Scrubber
  - Nitrogen Dryer
  - Power Board Fan
  - Computer Battery (obsolete)

#### **3.4.8.1.1.3. VOA Sample Bag Kit**

The VOA Sample Bag Kit is stowed in a foam locker or equivalent stowage location during on-orbit operations. The kit contains 12 rolled sample bags, which collect and hold air for remote air sampling. Each bag is capable of holding up to 6L of air. Remote samples are collected using VOA sample bags (with luer lock connections) and then connected to the VOA inlet sample filter nozzle, which allows the sample from the bag to be introduced into the VOA. If the sample bag does not contain enough air required to take a sample, the VOA will abort the run and the software will report an error.



**Figure 3. VOA Sample Bag Kit**



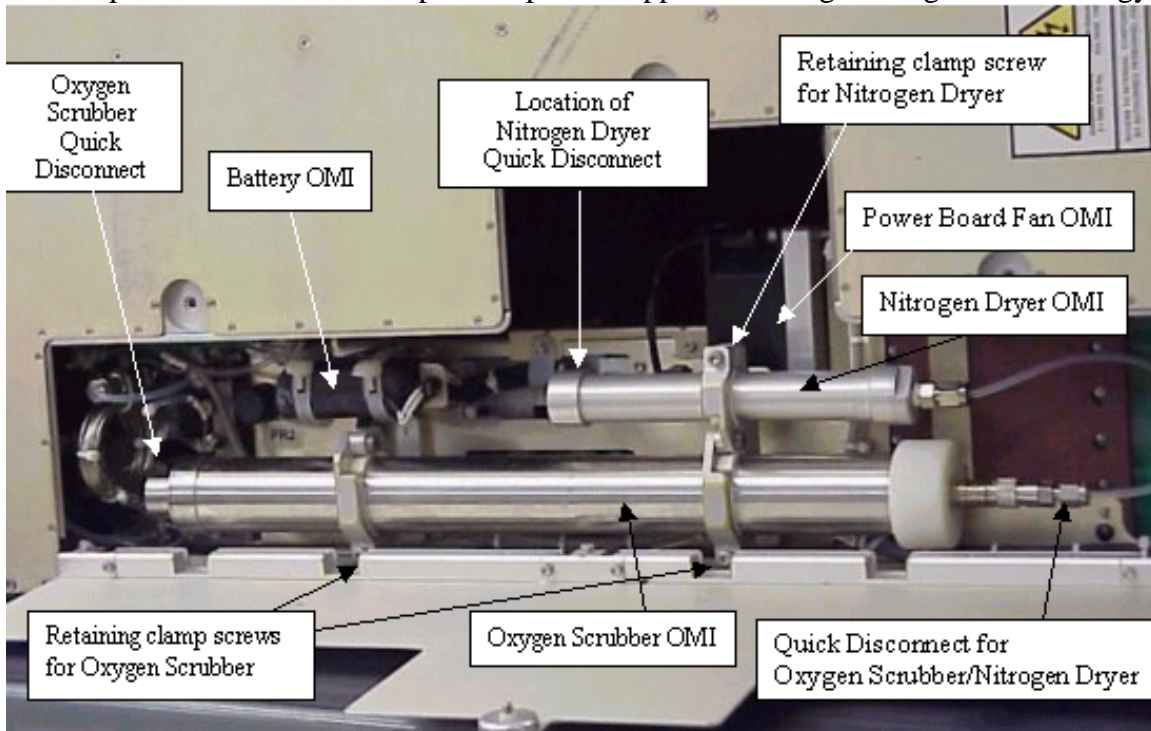
**Figure 4. VOA Sample Bag**

#### **3.4.8.1.2. Hardware Interfaces with Vehicle**

The VOA requires the Avionics Air Assembly located in the CHeCS rack for on-orbit instrument cooling during operations, and the high pressure nitrogen from the nitrogen supply tank in the Airlock.

**3.4.8.1.3. Resupply/Maintenance Schedule**

The VOA OMI Kit is resupplied every six months. The VOA Sample Bag Kit is resupplied as needed. OMI replacements are planned during the life of each VOA unit. Engineers and toxicologists will analyze health and status data of the VOA to determine the need for performing any OMIs. In most cases, when one OMI needs to be replaced, all associated OMIs in the same panel location will be replaced upon the approval of Engineering and Toxicology.



**Figure 5. VOA, Bottom Right, Access Panel #4**

Besides the OMIs, there are a number of other limited-life items within the VOA as summarized in Table 3.4.8.1.3-1 below. All items designated OMI can be replaced on orbit, all other items are ground-based maintainable only.

**Table 3.4.8.1.3-1 Limited life items on board VOA-ISS**

Description	OMI	Minimum Expected life
Air Inlet Filter, (5 microns)	No	>5 Years
Carbon filter, Inlet, Calibrant	No	>5Years
Carbon filter, Inlet, Valco	No	>5Years
Exhaust Pack	No	>5Years
GC Cooling Fan	Yes	21,900 operating hrs (~2.5 years)
Hard Disk Drive	Yes	17,152 operating hrs (~ 2 years)
IMS Recirculation Pumps, (2)	Yes	4,320 operating hrs (~ 6 months)
Air In Sieve Pack	Yes	4,320 operating hrs (~ 6 months)
Recirculation Sieve Pack	Yes	4,320 operating hrs (~ 6 months)
Nitrogen Scrubber	Yes	4,320 operating hrs (~ 6 months)

Nitrogen Inlet Filters, (5 microns), (2)	No	>5 Years
Oxygen Scrubber	Yes	4,320 operating hrs
Computer Battery (obsolete)	Yes	21,900 operating hrs
Pinacolone Calibrant	No	>5 Years
Power Board Fan	Yes	21,900 operating hrs (~2.5 years)
Inlet Nozzle Filter	Yes	4,320 operating hrs (~ 6 months)
Sample Pumps Bypass Filter, (25 microns)	No	>5 Years
Sample Pumps, (2)	Yes	<b>4,320 operating hrs (~ 6 months)</b>
Trap Material CarboTrap, (150mg), (2 off)	No	>5 Years
Trap Material Carboxin, (50mg), (2 off)	No	>5 Years

**3.4.8.1.4. Data/Commanding Capabilities**

The VOA is commanded from the ground (MCC-H) through S-band resources using 1553 bus architecture. Results of samples/runs are displayed on the VOA CHeCS ground display and detailed results are available in files created after each run. The VOA creates three types of files after each run: results files (RE1 and RE2), log files (.LOG), and GC-IMS files (GC1 and GC2). A result file shows the time and date the record was taken, followed by the mode of equipment operation. It then lists any compounds found by the VOA along with levels at which they were detected. The final portion of the file lists any compounds found outside the detection windows set on the VOA. The VOA creates a result file for each of the channels (1 and 2).

The log file (.LOG) is a record of all messages, as they appear on the display panel on the VOA. The GC-IMS file contains the record of IMS-averaged spectra along with all transducer and operating information of the equipment during the analysis run. A GC file is created for each of the channels (1 and 2).

The VOA download directory (VOAHDDIR.LST file) provides the Toxicologists with a list of current files on the VOA. A VOA directory download can only be downloaded once after power-up. If a second directory download is required, then the VOA must be power-cycled prior to download. After VOA runs have been performed, a list of files generated from the runs will be provided for downlink, in order of priority, to the BME on console. The Commanding BME will dump as many files as is feasible in the allotted CHeCS dump time starting with the file of highest priority. The dumped data files will then be delivered to the VOA team.

VOA method file activity should be scheduled to not include the 00:00 GMT hour. Method file activity (activation/checkout, warm-up, calibrant and sample runs) is a timed sequence of events and it has been observed in past failures that when the sequence transitions through the 00:00 GMT hour, it causes the unit to lose track of time which leads to a software hang-up.

The VOA executes a valve exercise method file every 24 hours after the last run or warmup was completed to prevent the valves from sticking. VOA activity should be scheduled around the valve exercise activity. BME should verify when the previous valve cycle or warm-up was performed to calculate when the next expected valve cycle will be performed.

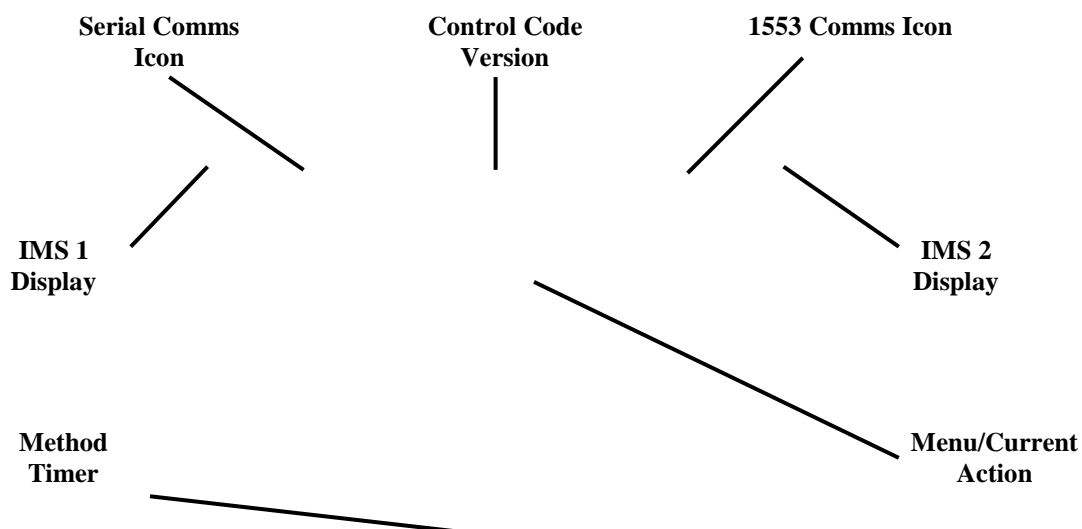
**3.4.8.1.5. Hazard Concerns**

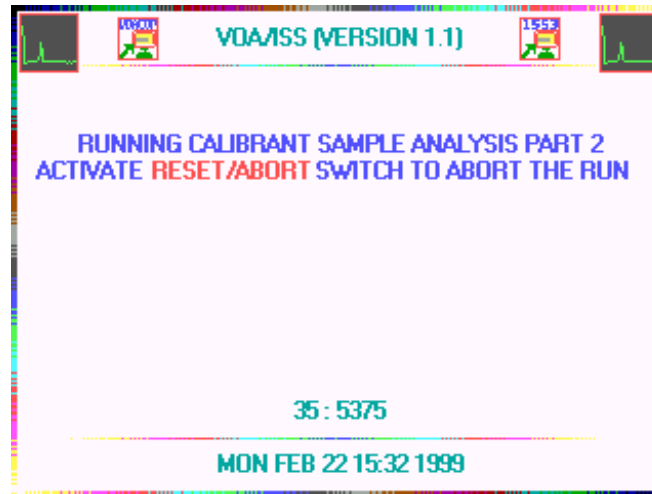
- The heater may cause a detonation risk due to lack of temperature or power control to the heating element.
- Particulate matter contacting the internal circuit boards may cause an electrical short.
- Particulate matter may accumulate at the cooling inlet or on the internal fans, reducing the cooling supplied to the VOA and resulting in an over-temperature condition.
- Rapid decompression of the module may cause VOA components to rupture.
- The VOA contains several chemical compounds that may represent a toxicological hazard if not properly contained.
- The VOA LCD could shatter from crew-applied loads.
- The VOA may cause exposure to excessive levels of radiation.
- Exposed terminal, connectors, and energized conductive surfaces carry a high current.
- Internal components operate at a temperature greater than 45° C.
- Failure of an internal VOA component (valve or regulator) could cause a nitrogen leak through the bleed valve or relief valves.

**3.4.8.1.6 VOA Display Panel**

The VOA liquid crystal color display screen is the main means of user interface together with a simple keypad. The display panel will indicate the present mode of operation of the equipment along with other equipment operating and control information. To prolong the life of the LCD, the VOA will turn off the LCD if a method file has not run in the last thirty minutes. Pressing a key or starting a run causes the display to be reactivated. The VOA LCD is not an on-orbit replaceable item so should it fail there is not a spare display available for replacement. The LCD display does not affect the performance of the instrument. The VOA can still perform analysis and accept keypad input in the LCD is blinking or has permanently malfunctioned. If the LCD cannot provide visual feedback, the 1553 communications will be solely relied upon for commanding the unit and receiving status information. However, not all fault messages, menus, and status displays that appear on the VOA front panel LCD can be determined from ground telemetry.

The display example below shows when the system is running a ‘Calibrant Sample Analysis’, and is described in the following sections.





**Figure 6. VOA Display with Explanations Listed Below**

**Serial Comms Icon:** If a remote PC is connected via the serial port at the front panel and appropriate software to connect it to the VOA-ISS is running, a communications icon will appear.

**Control Code Version:** The control code name and version number will be reflected at the top center of the display.

**1553 Comms Icon:** If a remote 1553 data network is connected and active via the 1553 port at the rear connector, a communications icon will appear.

**IMS1 Display:** If the IMS channel 1 is operating, a thumbnail display of the IMS spectrum will be displayed. If the IMS channel is disabled, its thumbnail display will be an 'X'.

**IMS2 Display:** If the IMS channel 2 is operating, a thumbnail display of the IMS spectrum will be displayed. If the IMS channel is disabled, its thumbnail display will be an 'X'.

**Method Timer:** The sequences of events to describe an analysis run, system startup, warm-up or shutdown are stored in user-definable method files. The method timer shows how long in seconds that each method has been running and how long it has to complete.

**System Date and Time:** The system date and time is displayed at the bottom of the screen. This is normally corrected remotely via the 1553 data network.

#### **3.4.8.1.6.1. Power On Sequence**

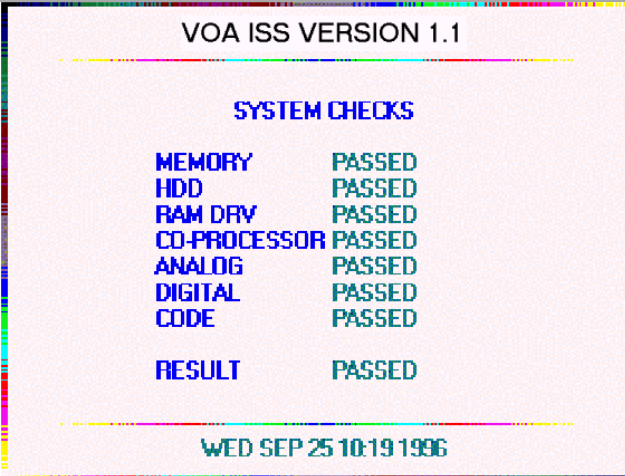
During activation, the VOA undergoes a series method files and mode transitions that are automatically performed when power is supplied to the equipment. After any maintenance, the crew should monitor the screen for any error message during this activation. Any other time the VOA is activated, the console BME should monitor the display during the activation to ensure

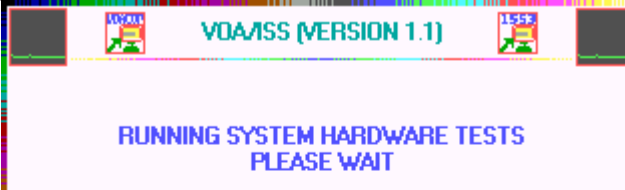


the correct sequence of method files and modes are observed on the ground display. Below is the sequence of events and corresponding VOA displays during VOA activation.

		VOA LCD
<b>Description</b>	<b>USER INPUT:</b> User verifies adequate supply of Nitrogen and AAA Flowrate, then user switches on the VOA main power using the POWER ON control on the left of the front panel.	Blank (VOA off)
<b>VOA DecAlpha Console Display</b>	<b>Mode:</b> Unknown	
<b>Duration</b>	<b>Method File:</b> Unknown N/A	

<b>Description</b>	The <b>ON</b> LED above the power switch will be illuminated. Several stages of operation will begin. The first will be the power on reset of the electronics; the user will hear the 'flap' cooling valves for the GC columns clicking into place, followed by all other valves being driven to their default positions.	Blank
<b>VOA DecAlpha Console Display</b>	<b>Mode:</b> Unknown <b>Method File:</b> No Method File	
<b>Duration</b>	Currently Running 3 minutes	

<b>Description</b>	The onboard computer then starts its own internal self-test, including a reset test of the processor watchdog circuit. Once this basic test has completed, the computer module test code will be loaded. With the test code running, testing is performed on each computer peripheral module	
<b>VOA DecAlpha Console Display</b>	<b>Mode:</b> Unknown <b>Method File:</b> No Method File	
<b>Duration</b>	Currently Running 3 minutes	

<b>Description</b>	Once computer testing has completed, operational sequencing will pass to method file control. The first method file to be loaded is the SYSTEM HARDWARE	

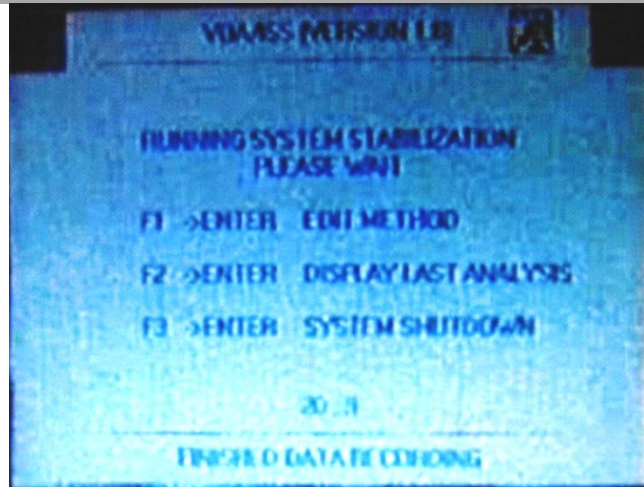


TESTS file. This will test each hardware device by activating it for a short time. The failure of any device on the equipment will be flagged by a HOUSEKEEPING function and reported to the user. During the running of this test file the LED indicators located next to the switch controls will flash to indicate that a test mode is in progress.  
**Mode:** Warming Up  
**Method File:** Hardware Test  
**Duration:** 4 minutes

**VOA DecAlpha Console Display**  
**Duration**

**Description**

Once equipment operational testing has completed, the VOA will run a method file to stabilize the equipment. The stabilization method file resets all of the active elements of the equipment to a known start position.



**VOA DecAlpha Console Display**  
**Duration**

**Mode:** Warming Up  
**Method File:** Stabilization  
**Duration:** 30 seconds

**Description** On completion of the Stabilization method file, the VOA has reached the end of its initial power on sequence and is in a state ready for the next operational stage, warm up.

**VOA DecAlpha Console Display** **Mode:** Standby  
**Method File:** No Method File Currently Running

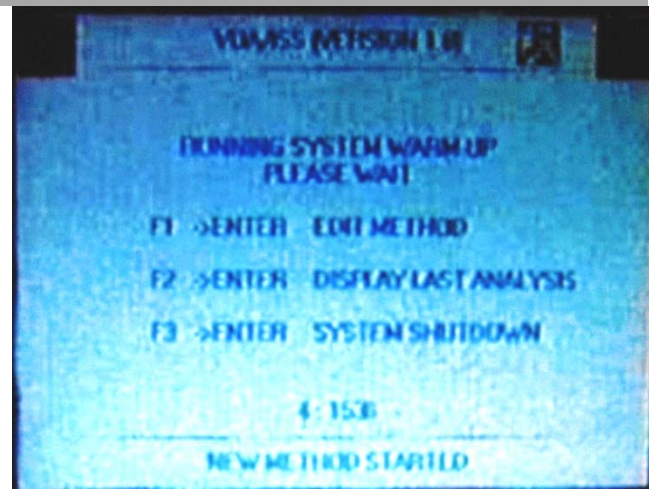
**Duration** N/A (stays in this mode until user input is applied)



**Description** **USER INPUT:** Once initial power on is complete, the VOA must be put in to the warmed up state to prepare the equipment for an analysis activity. Initiating the WARM-UP can be performed from the ground or by operating the Warm Up switch. This operation will initiate the running of the warm up method file and will take between 20 and 70 minutes depending, on previous operation. During the warmup, the Warm Up LED will be illuminated.

**VOA DecAlpha Console Display** **Mode:** Warming Up  
**Method File:** Warm Up

**Duration** 20 to 70 minutes



**Description** Once the Warmup Method File has completed, the equipment is in the STANDBY mode and ready for an analysis run as indicated on the display panel and by illumination of the READY LED located to the right of the Warm Up Switch.

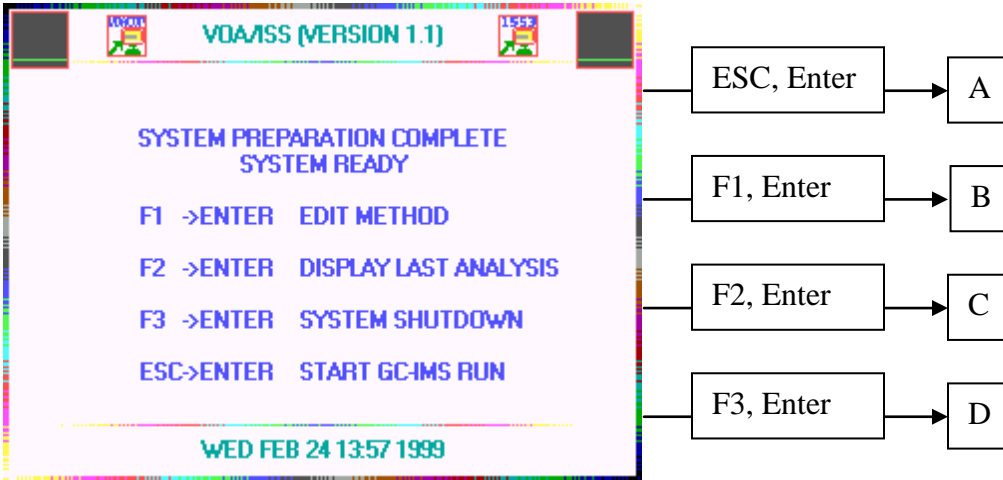
**VOA DecAlpha Console Display** **Mode:** Standby  
**Method File:** No Method File Currently Running

**Duration** N/A (stays in this mode until user input is applied)

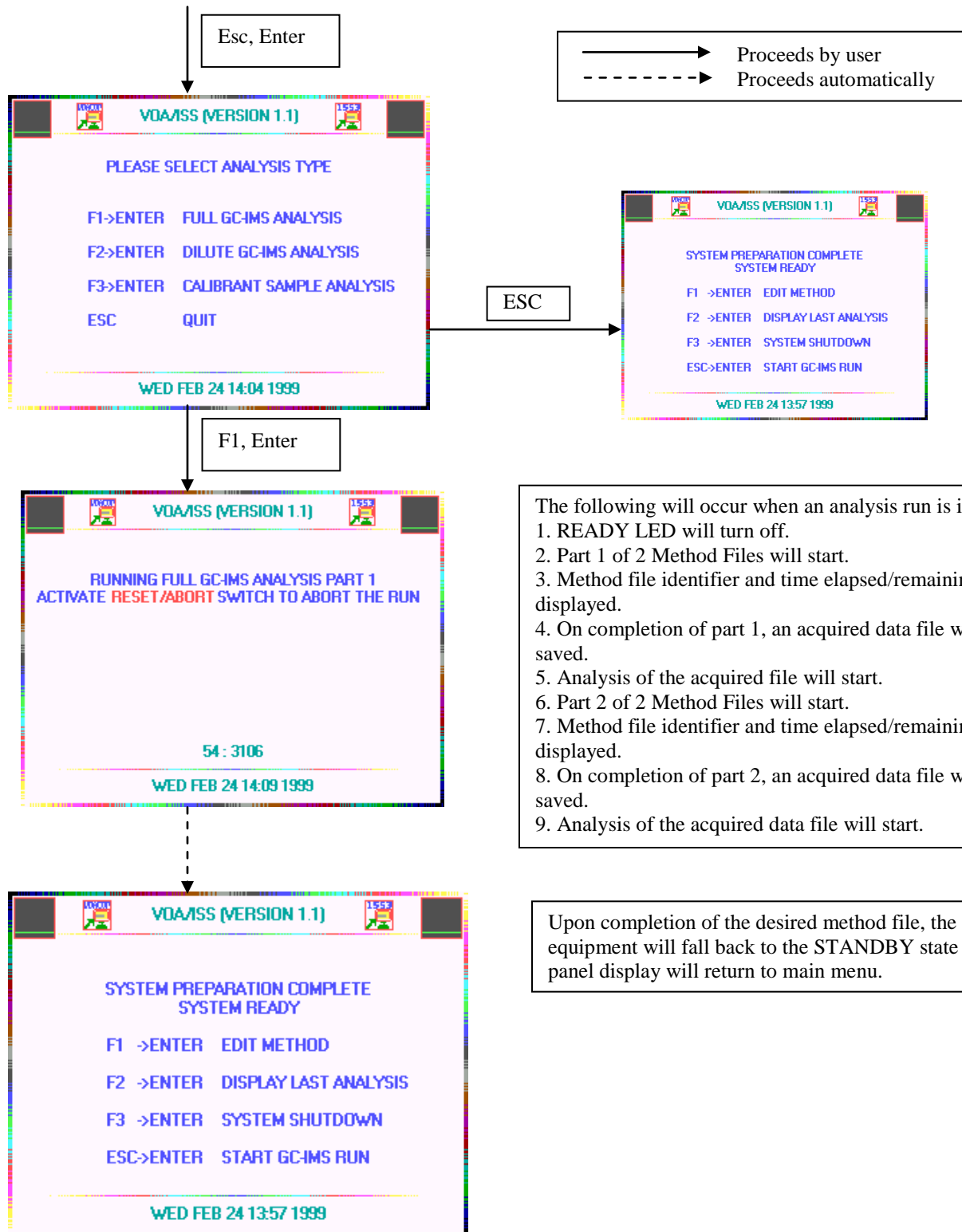


**3.4.8.1.6.2. Main Menu Options**

Below is the Main Menu display. In this menu, the VOA can be commanded to perform analysis runs, edit method files, display the results of the last analysis, and shut down the VOA. Following the flow chart will display what submenus are present when each option is selected.



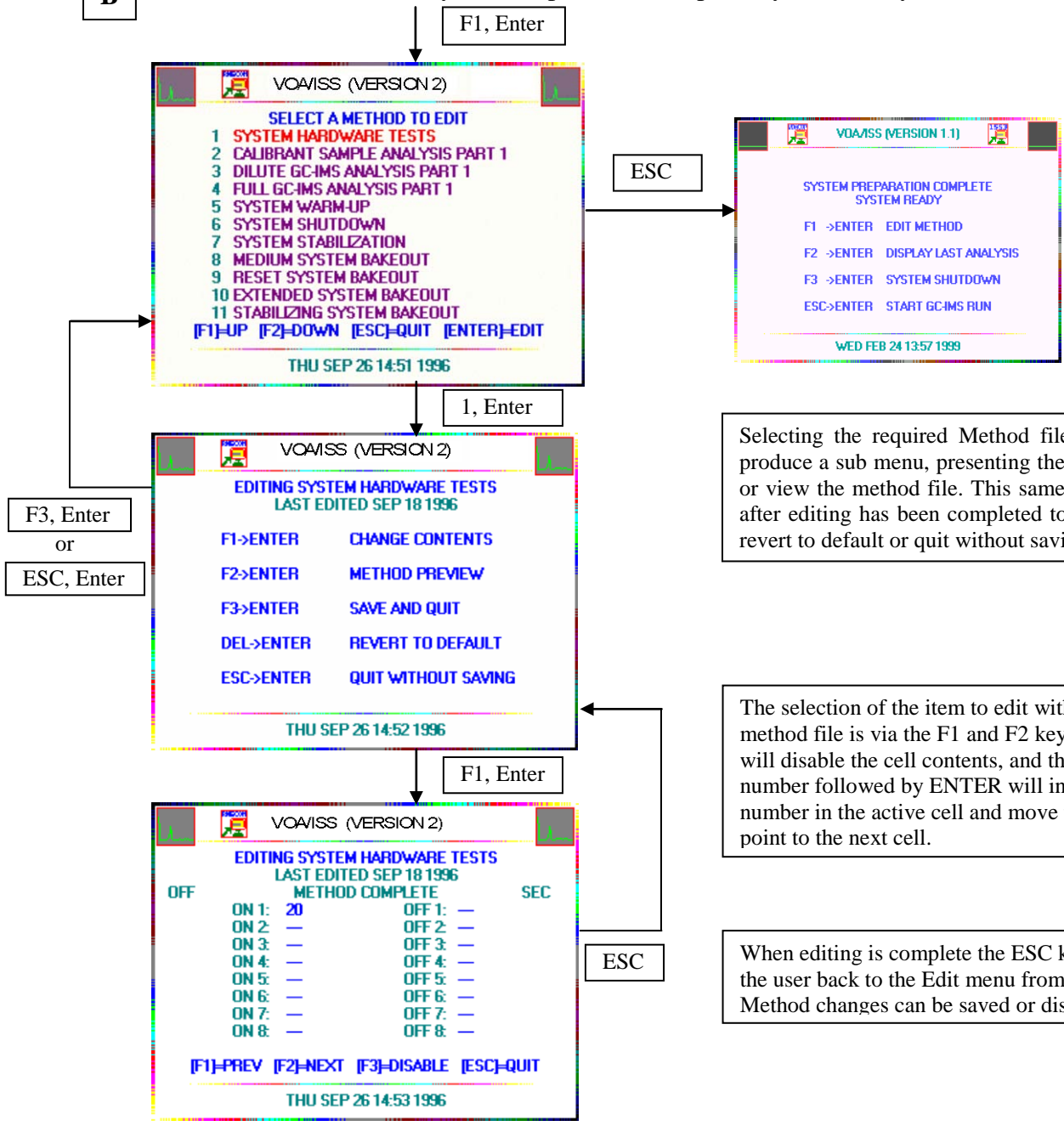
**A** From the Main Menu (“System Preparation Complete System Ready”):



- The following will occur when an analysis run is initiated:
1. READY LED will turn off.
  2. Part 1 of 2 Method Files will start.
  3. Method file identifier and time elapsed/remaining will be displayed.
  4. On completion of part 1, an acquired data file will be saved.
  5. Analysis of the acquired file will start.
  6. Part 2 of 2 Method Files will start.
  7. Method file identifier and time elapsed/remaining will be displayed.
  8. On completion of part 2, an acquired data file will be saved.
  9. Analysis of the acquired data file will start.

Upon completion of the desired method file, the equipment will fall back to the STANDBY state and front panel display will return to main menu.

**B** From the Main Menu (“System Preparation Complete System Ready”):



Selecting the required Method file to edit, will produce a sub menu, presenting the option to edit or view the method file. This same menu is used after editing has been completed to save the file, revert to default or quit without saving.

The selection of the item to edit within the method file is via the F1 and F2 keys. The F3 key will disable the cell contents, and then keying in a number followed by ENTER will input that number in the active cell and move the entry point to the next cell.

When editing is complete the ESC key will put the user back to the Edit menu from which the Method changes can be saved or discarded.

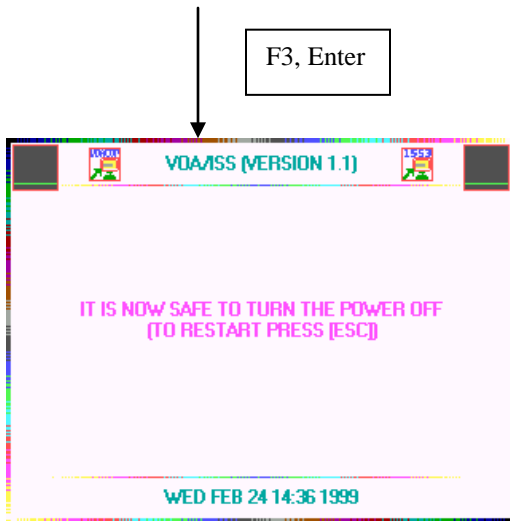
**C** From the Main Menu (“System Preparation Complete System Ready”):



The results of the last analysis performed by the equipment may be viewed when the menu item 'F2>Enter Display Last Analysis' option is available from the Main Menu.



**D** From the main Menu (“System Preparation Complete System Ready”):



In the power off state, neither electrical power nor nitrogen is fed to the equipment.

From this point, the VOA power switch can be flipped to the off position or the dedicated VOA RPC opened to complete the VOA power down. Once power is pulled from the VOA, the LCD display will go blank.

# 4. Health Maintenance System (HMS)

- 4.1. **Advanced Life Support Pack (ALSP)**
- 4.2. **Ambulatory Medical Pack (AMP)**
- 4.3. **Crew Contamination Protection Kit (CCPK)**
- 4.4. **Crew Medical Restraint System (CMRS)**
- 4.5. **Automated External Defibrillator (AED)**
- 4.6. **HMS Ancillary Support Pack (HASP)**
- 4.7. **ISS Medical Accessory Kit (IMAK)**
- 4.8. **Intubation Kit/Airway (IKA)**
- 4.9. **Respiratory Support Pack (RSP)**
- 4.10. **Variable Oxygen System (VOS)**

## 4.1. Advanced Life Support Pack (ALSP)

### 4.1.1. ALSP Description

The ALSP stores medical instruments and supplies to support specific Advanced Cardiac Life Support (ACLS) and Basic Trauma Life Support (BTLS) protocols. It allows a Crew Medical Officer (CMO) to locate and utilize a collection of emergency medical instruments and supplies for initial care and stabilization of a critically ill/injured crewmember. This hardware is deployed during a medical incident aboard ISS or can be used during rescue transport operations. The ALSP separates the contents into organized identifiable packs according to the supported physiologic functions. The ALSP provides for transport and restraint of stored items during ISS operations.

Note: Refer to SODF, ISS Medical Checklist for all information on medications, or to HMS Inventory Tracking Tool (HITT) for specific information on medications or hardware.



**Figure 1-2. ALSP and Contents**

**4.1.2. ALSP Contents List and Description**

<b>Packs</b>	7. Urinary Leg Bag
1. Airway Pack	8. Gloves
2. Assessment Pack	9. Sponges
3. Bandages Pack	10. Intubation Bulb
4. Drug Pack	11. Automatic Blood Pressure Cuff (ABPC) (COTS)
5. Emergency Surgery Pack	12. Syringe, 10cc
6. IV Administration Pack	<b>Additional Components</b>
<b>ALSP Lid</b>	1. Intravenous Fluid (0.9% Sodium Chloride Solution) - 4.5L
1. Stethoscope (COTS)	2. Sharps Container
2. Blood Pressure Cuff (COTS)	3. Ambu Bag and Mask
3. Powered IV Infusion Device	4. Ziploc Bags
4. IV Pump Battery Pack	5. Hormitage Dressing (5x9)
5. Povidone Iodine Swabsticks	6. Dextrose (5%, D5W – 500ml)
6. Foley Catheters	

**Table 4.1.2-1. General Hardware Specifications**

Kit and Component List	Mass M(E)	Volume M(E)	Dimensions M(E)	Nominal Stowage Location	Storage Temp °C (°F)	Operating Temp °C (°F)	Operating Pressure mmHg (psia)
ALSP	16.34kg (36.0lbs)	47719.1 cm <sup>3</sup> (2912.0 in <sup>3</sup> )	66 x 35.6 x 20.3 cm (26.0" x 14.0" x 8.0")	LAB105_D1	15 – 30 °C (59 – 86 °F)		Standard Habitable Module Pressure
Drug Pack	3.6 kg (7.9 lbs)	5436.83 cm <sup>3</sup> (331.78 in <sup>3</sup> )	8.3 x 36.8 x 17.8 cm (8.3" x 14.5" x 7.0")	In ALSP			

**4.1.2.1. Airway Pack**



**Figure 3. Airway Pack**

**Contents\*:**

Chest Drain valve	Magill Forceps
Suction Syringe + Collection Bags	Endotracheal Tube with Stylet
Gloves (nonsterile)	Laryngoscope
Suction ET Catheter	Medical Tape (1")

Scalpel	Povidone-Iodine Swabs
Suction Curette Tip	Alcohol Wipes
Suction Device + Accessories	Vaseline Gauze
Gauze Pads	Tracheostomy Tube
Nasogastric Tube	IV Catheters (14 Gauge, 2'')
Curved Hemostat	Oral Airway
Luer lock Syringe (10cc)	Nasal Airway

\* Current airway procedures call for use of the Intubating Laryngeal Mask Airway (ILMA), which is located in the Intubation Kit/Airway (IKA). The IKA is described in section 4.8, Intubation Kit/Airway. The goal is to have the ILMA incorporated into the ALSP but the schedule for this to happen has not been defined as of June, 2010.

**4.1.2.2. Assessment Pack**



**Figure 4. Assessment Pack**

**Contents:**

Pulse Oximeter	Pulse Oximeter Transducers
Tongue Depressors	Oral Disposable Thermometer
Penlight	

**4.1.2.3. Bandages Pack**



**Figure 5. Bandages Pack**



**Contents:**

Gauze Pads	Cotton Swabs
Tegaderm Dressing	Cotton Balls
Kerlix Dressing	Telfa Pads
Kling Dressing	

**4.1.2.4. Drug Pack**



**Figure 6. Drug Pack**

Contains Medications for Advanced Cardiac Life Support (ACLS) as well as other contingency medications.

\* Reference SODF Medical Checklist for all information regarding medications.

**4.1.2.5. Emergency Surgery Pack**



**Figure 7. Emergency Surgery Pack**



**Contents:**

Steri-Strips	Alcohol Wipes	Bandage Scissors
Benzoin Swabs	Povidone-Iodine Swabs	Carpject Injector
Scalpels	Medical Tape (1")	Gloves (sterile)
Sutures	Sterile Drape	
Surgical Instruments Assembly: Needle Driver, Hemostats, Scissors		

**4.1.2.6. IV Administration Pack**



**Figure 8. IV Administration Pack**

**Contents:**

Tegaderm Dressing	Tourniquet
Butterfly Catheters	Medical Tape (1")
Y-type Catheters	Povidone Iodine Pads
Lever Lock Cannulas	IV Fluid (0.9% Sodium Chloride Solution) – 500ml
IV Administration Infusion sets (non-powered and powered)	Pressure Infusor
IV Flowmeter	IV Intracatheters (16Gauge, 18Gauge, 20Gauge)
Gauze Pads	Syringes (3cc, 20cc)
Alcohol Wipes	

**4.1.2.7. Automatic Blood Pressure Cuff (ABPC) (COTS)**

The Automatic Blood Pressure Cuff will be used by the CMO in taking automatic BP and HR readings. HR and BP are determined within 1 minute of manual activation by oscillometric technique. The ABPC includes a redundant pressure transducer to prevent over inflation of the cuff.



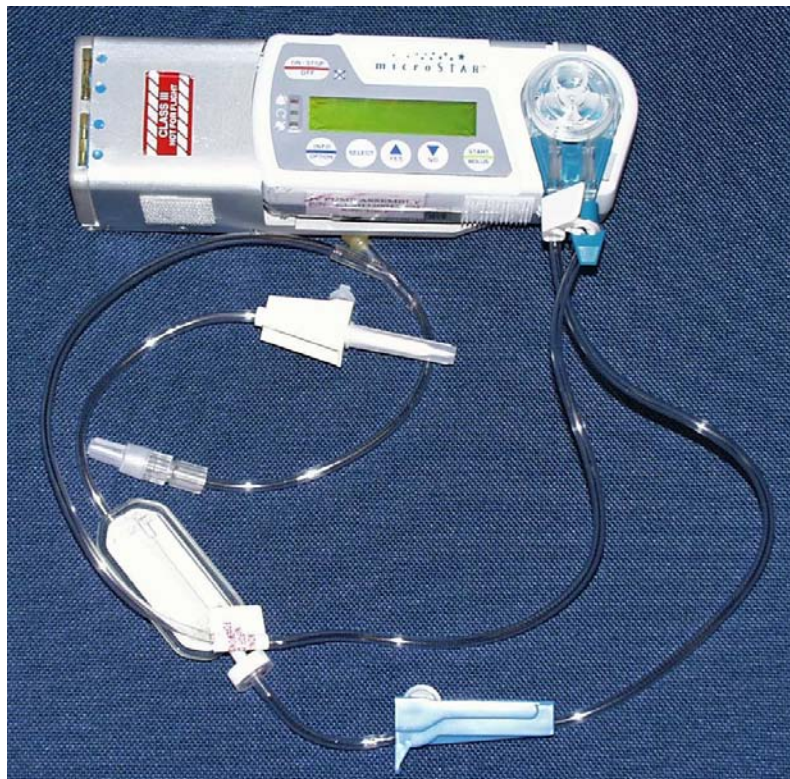
**Figure 9. ABPC**

**Table 4.1.2.7-1 Hardware Specific Parameters**

Power Requirements	1.5V battery; four are required to operate the APBC. All are alkaline – size AA.
Measurement Parameters/ Analysis Capabilities	BP: 20mmHg – 280mmHg HR: 40bpm – 200bpm (beats per minute)
Accuracy	BP: +/- 3mmHg or 2% whichever is greater for BP HR: +/-5%

**4.1.2.8. IV Infusion Pump (modified COTS)**

The IV Infusion Pump provides powered continuous infusion of Intravenous Fluid (0.9% Sodium Chloride or Dextrose) in a microgravity environment.



**Figure 10. IV Infusion Pump**

**Table 4.1.2.8-1 Hardware-Specific Parameters**

Power Source	Primary battery pack composed of 9V lithium batteries; 4 required for nominal operation
Measurement Parameters/ Analysis Capabilities	<ul style="list-style-type: none"> <li>• Operating Ranges: The IV infusion pump power supply shall provide no less than 10 hours of continuous flow at a rate of 125ml/min</li> <li>• Nominal Values of Parameters: Keep Vein Open (KVO) rate: 0.9ml/hr</li> <li>• Accuracy: +/-5%</li> </ul>

**4.1.3. Hardware Interfaces with Vehicle**

Velcro.

#### 4.1.4. *Resupply Schedule*

- The ALSP is resupplied once every 18 months or at the first available opportunity. The Drug Subpack is resupplied once every 6 months with crew rotation.
- The ALSP may be resupplied via IMAK or piece part resupply.
- Batteries are intended to last until the entire ALSP is replaced or are swapped out upon their expiration.
- No in-flight repair will be performed. Defective components will be replaced as needed. Any necessary maintenance will be performed during ground refurbishment.

#### 4.1.5. *Data/Commanding Capabilities*

- The IV infusion pump displays data on an LCD screen. Data regarding the volume infused, volume remaining, and the current infusion rate is stored in internal memory until next use of the instrument.
- The Automatic Blood Pressure Cuff data is displayed on a LCD screen. Data recorded from the previous device activation is only stored in internal memory and accessed via the “Memory” button.
- There are no commanding capabilities.

#### 4.1.6. *Hazard Concerns*

Sharps injuries.

## 4.2. Ambulatory Medical Pack (AMP)

### 4.2.1. AMP Description

The AMP contains oral medications, topical medications, and bandages for most in-flight problems. Oral medications are contained in shrink-wrapped plastic pill bottles with attached tops and push-up dispensers. During ISS Medical Accessory Pack resupply, the medications are resupplied in Ziploc bags. The Portable Clinical Blood Analyzer (PCBA) and EC8+ Cartridge Kit are included. Other items include dental hardware and surgical supplies.

Refer to SODF, ISS Medical Checklist for all information on medications, or to HMS Inventory Tracking Tool (HITT) for specific information on medications or hardware..



Figures 1-2. AMP



**4.2.2. AMP Contents List and Description**

<ul style="list-style-type: none"> <li><b>Packs</b></li> </ul>	<ul style="list-style-type: none"> <li><b>AMP Lid</b></li> </ul>
1. Surgical Supply Pack	1. Stethoscope (AMP-1) (COTS)
2. Injectable Pack	2. Blood Pressure Cuff (AMP-1) (COTS)
3. Dental Pack	3. Ziploc Bags (AMP-2) (AMP-3)
4. Physical Exam Pack	
5. Blood Analyzer Pack	<ul style="list-style-type: none"> <li><b>AMP-3</b></li> </ul>
	1. Medical data logs (AMP-3)
<ul style="list-style-type: none"> <li><b>Pallets</b></li> </ul>	2. Pen (AMP-3) (COTS)
1. Pallet 1 (Oral Medications)	3. PCBA Control Solution Kit (AMP-3)
2. Pallet 2 (Topical Medications)	4. BZK Wipes (AMP-3)
3. Pallet 3 (Bandages and Dressings)	
4. Pallet 4 (Splints, assorted supplies)	
<ul style="list-style-type: none"> <li><b>Additional Components</b></li> </ul>	
1. EC8+ Cartridge Assembly	
2. PCBA (Contained in the PCBA Subpack) (modified COTS)	
3. Tonometer (COTS) (contained in Physical Exam Subpack)	

**Table 4.2.2-1 General Hardware Specifications**

Kit and Component List	Mass M(E)	Volume M(E)	Dimensions M(E)	Nominal Stowage Location	Storage Temp °C (°F)	Operating Temp °C (°F)	Operating Pressure mmHg (psia)
AMP	14.07 kg (31 lbs)	42606.4 cm <sup>3</sup> (2600.0 in <sup>3</sup> )	63.5 x 33 x 20.3 cm (25" x 13" x 8")	LAB1O5_D2	15 – 30 °C (59 – 86 °F)		Standard Habitable Module Pressure



**Figure 3. Injectable Pack**



### 4.2.2.1. Injectable Pack

**Contents:**

Injectable Subpack contains injectable medications. Refer to SODF, ISS Medical Checklist for all information on medications.

Band-aids (Sheer Spots)	Needles
BZK Wipes	Tubex Injector



**Figure 4. Physical, Dental, Surgical Supply and Blood Analyzer Packs**

### 4.2.2.2. Dental Pack

**Contents:**

Dental Subpack contains injectable medications. Refer to SODF, ISS Medical Checklist for all information on medications.

Mirror	Long needles
Carver/File	Toothache Kit
Dental Syringe	Temp Bond Base and Catalyst
Articulating Paper	Short needles
Forceps	Temporary Filling
Elevators	Floss
Explorer/Probe	

### 4.2.2.3. Physical Exam Pack

**Contents:**

Tape Measure	Reflex Hammer
Visual Acuity Card	Tonopen (COTS)
Tonopen Tip Covers	Otoscope Handle and Head (COTS)
Ophthalmoscope spare bulb	Otoscope spare bulb
Otoscope Specula	Ophthalmoscope Head (COTS)
Tongue depressors	Stethoscope eartips

Penlight	Magnifying glass
Mouth/Throat Mirror	

#### 4.2.2.4. Blood Analyzer Pack

##### Contents:

Portable Clinical Blood Analyzer (PCBA) (modified COTS)	Electronic Simulator
Fingerstix	Capillary Bulbs
Capillary Tubes	Capillary Tube Droppers

#### 4.2.2.5. Surgical Supply Pack

##### Contents:

Surgical Subpack contains medications. Refer to SODF, ISS Medical Checklist for all information on medications.

Surgical Instrument Assembly	Staple Remover
a. Forceps	Sterile Drape
b. Hemostats	Tubex Injector
c. Needle Driver	Gauze Pads
d. "Iris" Scissors	Povidone-Iodine Swabs
Forceps	Benzoin Swabs
Scalpels	Tegaderm Dressing
Bandage Scissors	Steri-Strips
Needle Driver/Scissors Combo	Decimel Tape
Skin Stapler	Sterile Gloves

#### 4.2.2.6. AMP Pallet 1

Pallet 1 contains oral medications. Refer to SODF, ISS Medical Checklist for all information on medications, or to HMS Inventory Tracking Tool (HITT) for specific information on medications or hardware..

#### 4.2.2.7. AMP Pallet 2

Pallet 2 contains topical medications. Refer to SODF, ISS Medical Checklist for all information on medications, or to HMS Inventory Tracking Tool (HITT) for specific information on medications or hardware..

Cotton Swabs	Ear Currettes
Elastoplast Tape	Ace Bandage

#### 4.2.2.8. AMP Pallet 3

Contains Bandages and Dressings:

BK Pads	Oral Disposable Thermometers
---------	------------------------------

Povidone Iodine Swabs	Cotton Balls
Kerlix Dressing	Nasostat, Syringe, 10cc
Skin Temp. Monitors	Tape, 0.5 in
Medical Tape, 1 in	Tongue Depressors
Adaptic Dressing	Tegaderm Dressing
Telfa Pads	Pope Otowicks
Nonsterile Gloves	Benzoin Swabs
Gauze Pads	Kling Bandages
Nasal Speculum	

#### 4.2.2.9. AMP Pallet 4

Pallet 4 contains Splints, and assorted supplies. Refer to SODF, ISS Medical Checklist for all information on medications , or to HMS Inventory Tracking Tool (HITT) for specific information on medications or hardware..

Fingersplint	SAM Splint
Urine Chemstrips and color chart	Band-aids
Peak Flow Meter	Air Temp. Monitors
Eye Pads	Posterior Nasal Packing
Eye Shield	Ziploc

#### 4.2.2.10. Portable Clinical Blood Analyzer (PCBA) (modified COTS)

The PCBA provides clinical chemistry analysis of crewmembers' 65µL blood samples. Analysis requires 120 seconds upon activation. It uses a EC8+ cartridge to perform the analysis. The PCBA (modified COTS) has been taped with silver tape.

**Table 4.2.2.10-1 Hardware-Specific Parameters**

Power Requirements	9V alkaline batteries; 2 required for nominal operation
--------------------	---



**Figure 5. Portable Clinical Blood Analyzer (PCBA)**

#### **4.2.2.11. EC8+ Cartridge Assembly**

The EC8+ Cartridge assembly contains EC 8+ cartridges required for clinical chemistry analysis of crewmembers' blood samples. The required 65 $\mu$ L blood sample is placed in a cartridge via a capillary tube. The cartridge is inserted into the PCBA for analysis.

Level 1 and Level 2 control solutions are used prior to blood analysis and results are compared with the range of values on the PCBA data card. Out-of-range parameters must be noted by the CMO. Without refrigeration, the cartridges lose reliability after approximately 2 weeks at ambient temperature.



**Figure 6. EC8+ Cartridge Assembly**

**Table 4.2.2.11-1 Hardware-Specific Parameters**

Measurement Parameters:		
<b>Cartridge Type:</b>	<b>Constituent:</b>	<b>PCBA Ranges:</b>
• EC8+ Cartridge (Mode 2)	Sodium (Na)	100-180mmol/L
	Potassium (K)	2.0-9.0mmol/L
	Chloride (Cl)	65-140mmol/L
	Glucose (Glu)	20-450mg/dl
	pH	6.8-8.0
	Hematocrit (Hct)	10-75% PCV
	Partial Pressure Carbon Dioxide (pCO <sub>2</sub> )	10-100mmHg
	Urea Nitrogen (BUN)	3-140mg/dl
	Total Carbon Dioxide (TCO <sub>2</sub> )	1-85 mmol/L
	Bicarbonate (HC <sub>3</sub> )	1-85 mmol/L
	Base Excess (BE)	(-30)-(+30) mmol/L
	Anion Gap	(-10)-(+99) mmol/L
	Hemoglobin (Hb)	5-25 g/dL
• CREA Cartridge	Creatinine (CREA)	0.2 – 20 mg/dL

#### 4.2.2.12. Tonopen Handheld Tonometer (COTS)

The tonometer will be used as needed by the CMO to assess intraocular pressure (IOP). This device could also be used during emergency medical events. Currently, the Tonopen is not functional due to calibrations issues. A new tonometer is scheduled to be flown in late 2010.



**Figure 7. Tonopen**

**Table 4.2.2.12-1 Hardware-Specific Parameters**

Power Requirements	Battery (4) 1.5V; Silver Oxide, button-cell
Operating Ranges	IOP measurement between 5 mm Hg and 80 mm Hg
Accuracy	+/-10%
Nominal Values of parameters	Normal intraocular pressure (IOP) at 1-G, when measured with the Tonopen instrument, is generally 22mmHg and less. IOP rises in microgravity so the normal is adjusted accordingly to 18mmHg and less.
Sensor Error	N/A
Indications for out-of-range parameters	The Tonopen displays an error bar on the LCD; if the bar is above 5%, the measurement must be repeated.

#### 4.2.3. *Hardware Interfaces with Vehicle*

Velcro.

#### 4.2.4. *Resupply Schedule*

- The AMP is resupplied when items are going to expire. They may be resupplied as a pack or piece parted.
- A freshly calibrated tonometer is flown in the AMP.
- The PCBA is flown in the AMP or in the Blood Analyzer Pack.
- The EC8+ Cartridge Kit is resupplied approximately every 3 months.
- PCBA Control Solutions are replaced approximately every year or sooner as needed.
- Hardware requiring bulbs and batteries can be changed out.
- Any necessary maintenance is done during ground refurbishment.

#### 4.2.5. *Data/Commanding Capabilities*

- The PCBA provides recording, storage, and display of the analysis results on an LCD screen. The PCBA also gives status information on the following parameters: battery



voltage, time, data, serial number, software version number, and air temperature as well as blood constituent levels.

- The Tonopen displays the intraocular pressure (IOP) on the LCD screen.
- There are no commanding capabilities with this hardware.

#### **4.2.6. Hazard Concerns**

- Sharps, Blood Borne Pathogens, i.e. Blood generated from lancets, capillary tubes, or cartridges.
- **WARNING:** Do not perform Tonopen measurements during attitude maneuvers.

*Note:* Refer to Phase II Safety Data Package for details on hazards.

### **4.3. Crew Contamination Protection Kit (CCPK) (COTS except for Eyewash)**

#### **4.3.1. CCPK Description**

The CCPK is a single medical kit that provides protection for the crew from exposure to fluid, particulate, or surface environmental contaminants. It can also be used to support toxic spill contingencies. The Eyewash Kit, which contains the Eyewash used to flush the eyes following chemical contamination, will be velcroed to the bottom of the CCPK for launch. The following information is valid for the 29P and subsequent CCPK deliveries.



**Figure 1. CCPK**



**Figure 2. Eyewash Kit Shown attached to CCPK**



**Figure 3. Eyewash Kit**

**4.3.2. CCPK Contents List and Description\***

- Eyewash Kit
  - a) Eyewash Wastewater Bags (qty 6)
  - b) Eyewash
- Contingency items
  - a) Toxicology Identification Decals
    - 1) Biohazard decal (qty 20)
    - 2) Nonhazardous level “0” green decal (qty 8)
    - 3) Nonhazardous level “1” blue decal (qty 8)
    - 4) Nonhazardous level “2” yellow decal (qty 8)
    - 5) Nonhazardous level “3” orange decal (qty 8)
    - 6) Nonhazardous level “4” red decal (qty 8)
  - b) Silver Shield Bags (qty 8)
  - c) Silver Shield Gloves (qty 7 pair)
  - d) Ziploc Bags (qty 6)
  - e) Nitrile Gloves (qty 7 pair)
  - f) Dust Masks (qty 9)
  - g) Safety Goggles (qty 7)
  - h) pH Test Strips (qty 10, chart)
  - i) Mess-Up Mitts (qty 4)
  - j) Wet Wipe Dispenser (qty 1)

\* Refer to the IMS for current quantities and locations of specific items.

**Table 4.3.2-1 General Hardware Specifications**

Kit and Component List	Mass M(E)	Volume M(E)	Dimensions M(E)	Nominal Stowage Location	Storage Temp °C (°F)	Operating Temp °C (°F)	Operating Pressure mmHg (psia)
CCPK	3.0391kg (6.7 lbs)	10545.19 cm <sup>3</sup> (643.51 in <sup>3</sup> )	30.08 x 25.6 x 18.56 cm (11.8” x 10.1” x 7.3”)	LAB1O5_D2	4 – 32 °C (40 – 90 °F)		Standard Habitable Module Pressure
Eyewash Kit	TBD	TBD	TBD	SM 229A	4 – 32 °C (40 – 90 °F)		Standard Habitable Module Pressure

**4.3.2.1. Eyewash Kit**

The Eyewash Kit contains a Ziploc containing the Eyewash with two Eyewash wastewater bags connected and a Second Ziploc containing the additional four Eyewash Wastewater Bags.

The Eyewash will provide eyewash capability for the crew for treatment of chemical contamination/ toxic irritation from a crewmember’s eye(s). It will flush both eyes of a crewmember with approximately 0.5L/min of water from the Russian potable water source (SVO-ZV). All wastewater will be collected in 1.85 L Teflon Eyewash Wastewater Bags. Two Eyewash Wastewater bags can be connected at a time. When the CCPK is nominally resupplied,

a new Eyewash Kit will also be resupplied. Once on the ISS, the Eyewash Kit will be relocated to near the SVO-ZV, velcroed on the front of panel SM-329.

An issue was identified with the ground training unit. The hoses/tubing come loose from the metal barbs on the goggle lenses. Engineering is applying hose clamps to all units prior to flight to prevent this from happening on-orbit. Prior to 17A, the current on-orbit unit will not have this fix. Hose Clamps are being flown on 17A and an activity will be scheduled to have the crew apply these clamps to each hose.



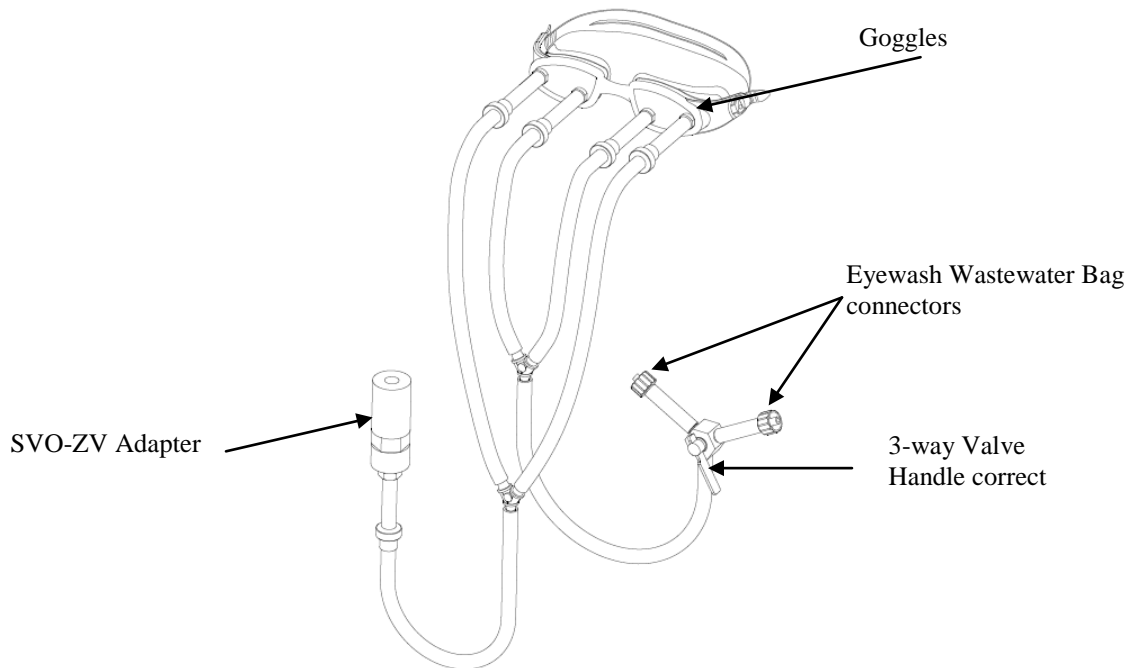
**Figure 4. Hose Clamps applied to Hoses/Tubing**

**Table 4.3.2.1-1 Hardware-Specific Parameters**

Fluid/Gas Description	Eyewash connects with SVO-ZV water port. Fluid flow is approximately 0.5L/min of water
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**Components:**

- SVO-ZV Adapter
- Eye Goggles and Tubing
- 3-way valve
- Eyewash Wastewater Bag connectors
- Eyewash Wastewater Bags (1.85L)



**Figure 5. Eyewash**

**4.3.2.2. CCPK Consumables Description**

- Toxicology Identification Decals: Toxic and non-toxic substances, and biohazard decals are used to mark items contained in bags.
- Ziploc Bags: Sealable bags to be used for containment of tox level 0 and 1 items.
- Nitrile Gloves: Hand protection to be worn for general-purpose cleanup of non-toxic substances.
- Dust Masks: Respiratory system protection against non-toxic particulates no smaller than 5 microns floating in the ISS.
- Safety Goggles: Eye protection to be worn during particulate cleanup procedures.
- pH Test Strips: For determining pH of potable water.
- Yellow Mess-Up Mitts: For cleanup of toxic/biohazard materials.
- Wet Wipes: Pre-moistened wipe dispensers for general-purpose cleanup of non-toxic substances.
- Eyewash Wastewater Bags: Teflon bags used to collect wastewater from the Eyewash during use.
- Silver Shield Gloves: Silver Shield gloves to be worn while handling toxic substances within the cabin.
- Silver Shield Bags: Silver Shield bags to be used for containment of toxic items. See chart below for size and volume information. 85% full is max percentage full to close bag.

<i>% full</i>	<i>length (seam to seam)</i>	<i>width</i>	<i>height (bottom to top)</i>	<i>Liters of water</i>
50%	9"	5"	9"	3.5 L
85%	9"	6"	11"	6 L



#### ***4.3.3. Hardware Interfaces with Vehicle***

Eyewash interfaces with the Russian SVO-ZV port. (This port is located directly opposite the crew galley in the Russian Service Module.)

#### ***4.3.4. Resupply Schedule***

The CCPK is resupplied every 24 months unless determined supplies are adequate. No in-flight maintenance will be performed. Used components will be replaced as needed.

#### ***4.3.5. Data/Commanding Capabilities***

N/A

#### ***4.3.6. Hazard Concerns***

Containment of chemical substances.

## 4.4. Crew Medical Restraint System (CMRS)

### 4.4.1. CMRS Description

The CMRS consists of a resin platform, which folds in half into a rectangular shape for storage. In order to speed deployment of the CMRS, Seat Track Anchors which connect to the rack and interface to the bottom of the unit are deployed at all times. If the CMRS is non-functional, the crew loses the ability to stabilize, transport, and provide electrical isolation for an ill or injured crewmember.

During Inc 19/20, an empty CEVIS Isolator Kit was stowed underneath the CMRS to provide more stability. This was done per crew preference. Future crews may choose to keep the Isolator kit in this place or remove it.

The CMRS is designed to be deployed and set-up in two minutes or less for the following purposes:

1. Patient restraint & transport
2. Spinal stabilization
3. Electrical isolation for defibrillation (to protect the CMOs and ISS from defibrillation energy)

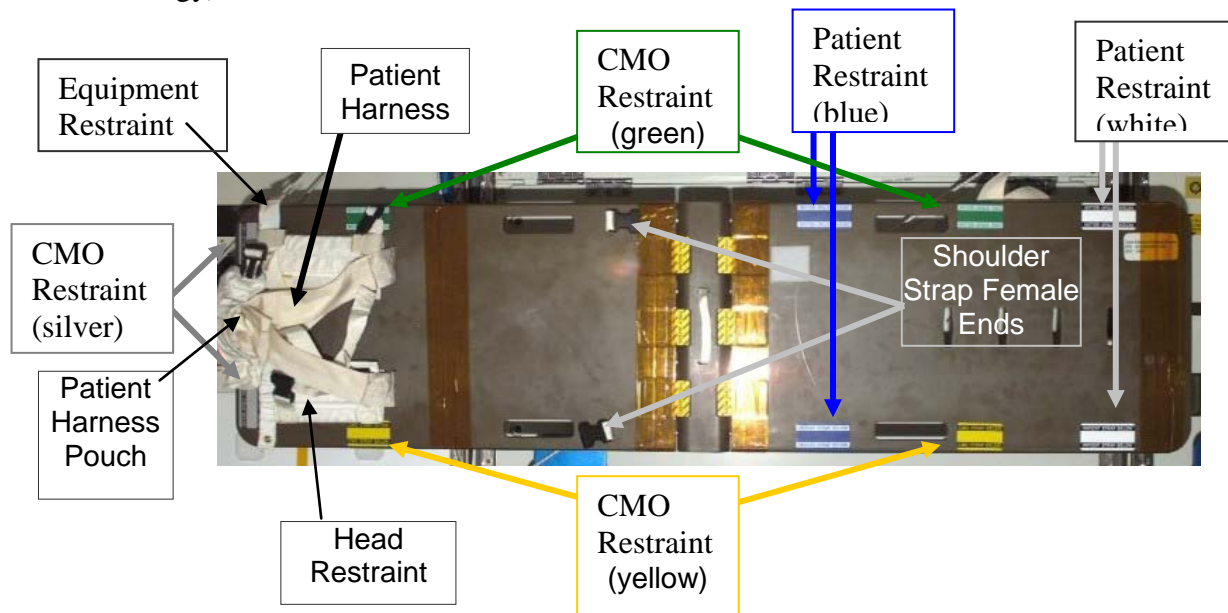
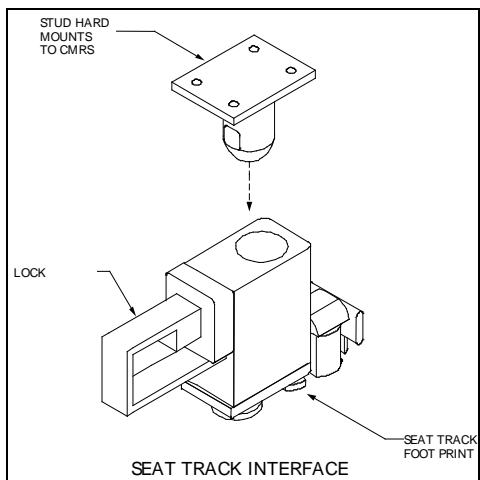


Figure 1. CMRS



**Figure 2. Seat Track Interface**



**Figure 3. Patient on CMRS**

\* Patient restraints not colored correctly in picture.

**4.4.2. CMRS Components List and Description**

- Rigid platform
- Main harness with shoulder straps and wrist strap
- Head restraint
- 2 patient restraints (at waist & legs)
- CMO restraints (one on each side and one at patient’s head, 3 total)

**Table 4.4.2-1 General Hardware Specifications**

Kit and Component List	Mass M(E)	Volume M(E)	Dimensions M(E)	Nominal Stowage Location	Storage Temp °C (°F)	Operating Temp °C (°F)	Operating Pressure mmHg (psia)
CMRS	18.2 kg (36.5 lbs)	29404.5 cm <sup>3</sup> (1794 in <sup>3</sup> )	Deployed: 54" x 14" x 10.5" Stowed: 27.5" x 14.25" x 4." (11.4 x 36.8 x 69.9 cm)	Deployed: LAB1D5 (LAB1S4_D1 stowed)	4 – 46 °C (40 – 115 °F)	4 – 46 °C (40 -115 °F)	Standard habitable module pressure
Patient Harness			67" x 2"				
Patient Restraint			40" x 2"				
CMO Restraint			58" x 2"				
Chin Restraint			19" x 1"				
Forehead Restraint			18.25" x 1"				

**4.4.2.1. Rigid Platform**

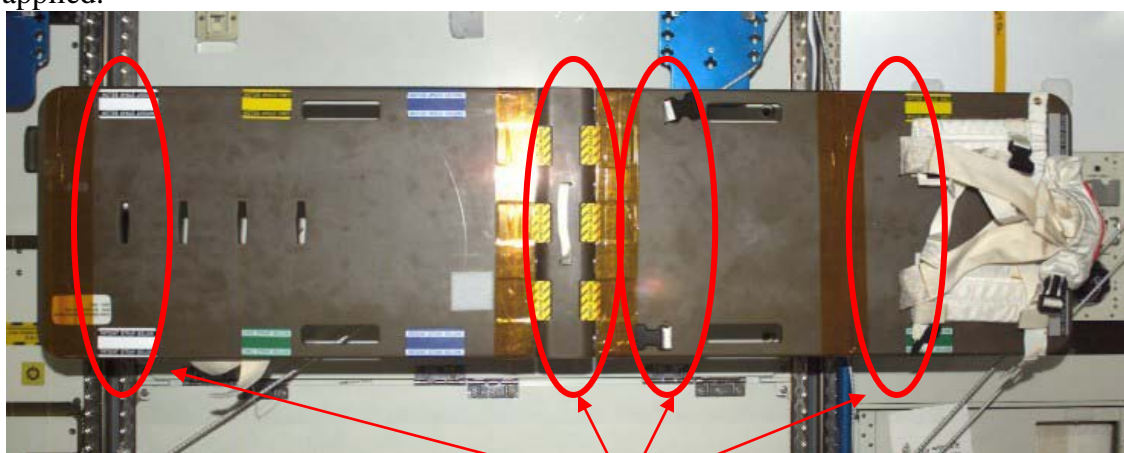
The CMRS Platform is made from Ultem 2300 resin. This material provides high strength, a low dielectric constant, and flame resistance. All edges are rounded to prevent injury.

**4.4.2.2. Harness and Restraints**

The Patient Harness, the CMO Restraints and the Patient restraints consist of 2 inch Nomex webbing. The Forehead, Chin, and Shoulder Restrains consist of 1 inch Nomex webbing.

**4.4.2.3. Electrical Isolation**

In 2002, discolorations indicative of surface and/or subsurface cracks were found at the leg and hinge screw locations. This created a possibility for electrical conduction to the ISS structure during defibrillation of a patient strapped into the CMRS during a medical contingency. A workaround procedure was performed with applied 2 layers of Kapton tape to 4 areas on the topside of the CMRS. These areas are located directly opposite the leg and hinge assembly attach points (underside). Below is a photograph of the on-board CMRS with the Kapton tape applied.



Kapton tape applied in these areas on the on-orbit CMRS.

## Figure 4. CMRS Deployed

### *4.4.3. Hardware Interfaces with Vehicle*

The CMRS interfaces with the USOS ISS seat tracks via the seat track interfaces. The CMRS Seat track interface is not compatible with the Shuttle.

### *4.4.4. Resupply Schedule*

No nominal resupply or maintenance is scheduled; however, a nominal checkout is scheduled at the beginning of each increment.

### *4.4.5. Data/Commanding Capabilities*

N/A

### *4.4.6. Hazard Concerns*

- Pinch hazard (at hinges and with stud insertion)
- Sharp edges
- Flammability (of Nomex webbing, etc.)
- Electrical discharge (if patient is in contact with structure)

## 4.5. Automated External Defibrillator (AED)

### 4.5.1. AED Overview

An Automated External Defibrillator (AED) is a medical device that can provide defibrillation to a patient experiencing cardiac dysrhythmia. Defibrillation is administered via an electrical pulse delivered through electrodes applied to the patient’s skin. The AED is a modified Commercial Off the Shelf (COTS) product, the Medtronic LIFEPAK 1000. This hardware is a replacement for the Health Maintenance System (HMS) defibrillator. The AED software settings are consistent with the 2005 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care and the European Resuscitation Council Guidelines for Resuscitation.

### 4.5.2. AED Components List and Description



Figure 1. AED and Components

Table 4.5.2-1 AED Hardware

Quantity	P/N	Item Name	OpNom
1	SEG52101599-301	Electrodes Pack Assembly (COTS)	AED Electrodes Kit
1	SEG52101600-301	AED Assembly (Modified COTS)	AED
2	SEG52101601-301	Battery Assembly (COTS)	AED Battery

Table 4.5.2-2 General Hardware Specifications

Kit and Component List	Mass	Volume	Dimensions	Nominal Stowage Location	Operating Temp	Storage Temp	Operating Pressure
<b>AED (includes installed battery and electrodes kit)</b>	<b>3.3 kg (7.3 lbs)</b>	7230.5 cm <sup>3</sup> (441.2 in <sup>3</sup> )	<b>11.2 x 23.4 x 27.7 cm (4.4 x 9.2 x 10.9 in)</b>	<b>LAB105_D1*</b>	0 to 50 °C (32 to 122 °F)	-30 to 60°C (-22 to 140°F)	<b>8.34 to 15.34 psi</b>



<b>Spare Battery</b>	<b>0.43 kg (0.94 lb)</b>	1084 cm <sup>3</sup> (66.15 in <sup>3</sup> )	<b>3.56 x 11.4 x 26.7 cm (1.4 x 4.5 x 10.5 in)</b>	<b>LAB105_ D1*</b>	0 to 50 °C (32 to 122 °F)	20 to 30 °C (68 to 86 °F)	<b>8.34 to 15.34 psi</b>
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\* Deployed as needed

**Table 4.5.2-3 Hardware Specific Parameters**

Power Specifications	<ul style="list-style-type: none"> <li>• Battery power only</li> <li>• 12.0 V, 4.5 amp-hours, Lithium Manganese Dioxide (Li/MnO<sub>2</sub>), nonrechargeable</li> <li>• Each battery can produce 440 200-joule shocks, or 1030 minutes of operating time with new battery</li> <li>• Operational battery life is 5 years with new battery and 4 years after 5 years of shelf life</li> <li>• The AED, batteries, and electrodes are scheduled to be replaced every 2 years</li> </ul>
General Specifications	<ul style="list-style-type: none"> <li>• Heart Rate: 20-300 bpm</li> <li>• Charge time after shockable rhythm is detected: &lt;30 sec for three shocks (200, 300, and 360 joules)</li> <li>• Shocks are delivered in the form of a biphasic truncated exponential (BTE) defibrillation waveform</li> </ul>
Waveform Display	<ul style="list-style-type: none"> <li>• Waveform sweep speed – 25mm/sec</li> <li>• Waveform viewing time – minimum 4 sec</li> <li>• Waveform amplitude – 1 cm/mV, nominal</li> </ul>
Shock Advisory System	<ul style="list-style-type: none"> <li>• Good electrode contact is determined through impedance check</li> <li>• ECG analysis is performed</li> <li>• Automatic charging of AED and instructions to caregiver to press the shock button, if a shockable rhythm is detected</li> <li>• SAS is only given for ventricular fibrillation with a peak-to-peak amplitude of at least 0.08 mV and ventricular tachycardia with a heart rate greater than 120 bpm.</li> </ul>

### 4.5.2.1. AED Unit

Figure 2 shows the top of the AED with which the crewmember will interface during patient care. The Advanced Cardiac Life Support (ACLS) Booklet is located at LAB1D4\_D1 and contains AED and ACLS procedures. The AED is a modified COTS item. Modifications are the Kapton tape covering the unit, and the labels applied to the Kapton tape. The battery and electrodes are COTS with no modification.

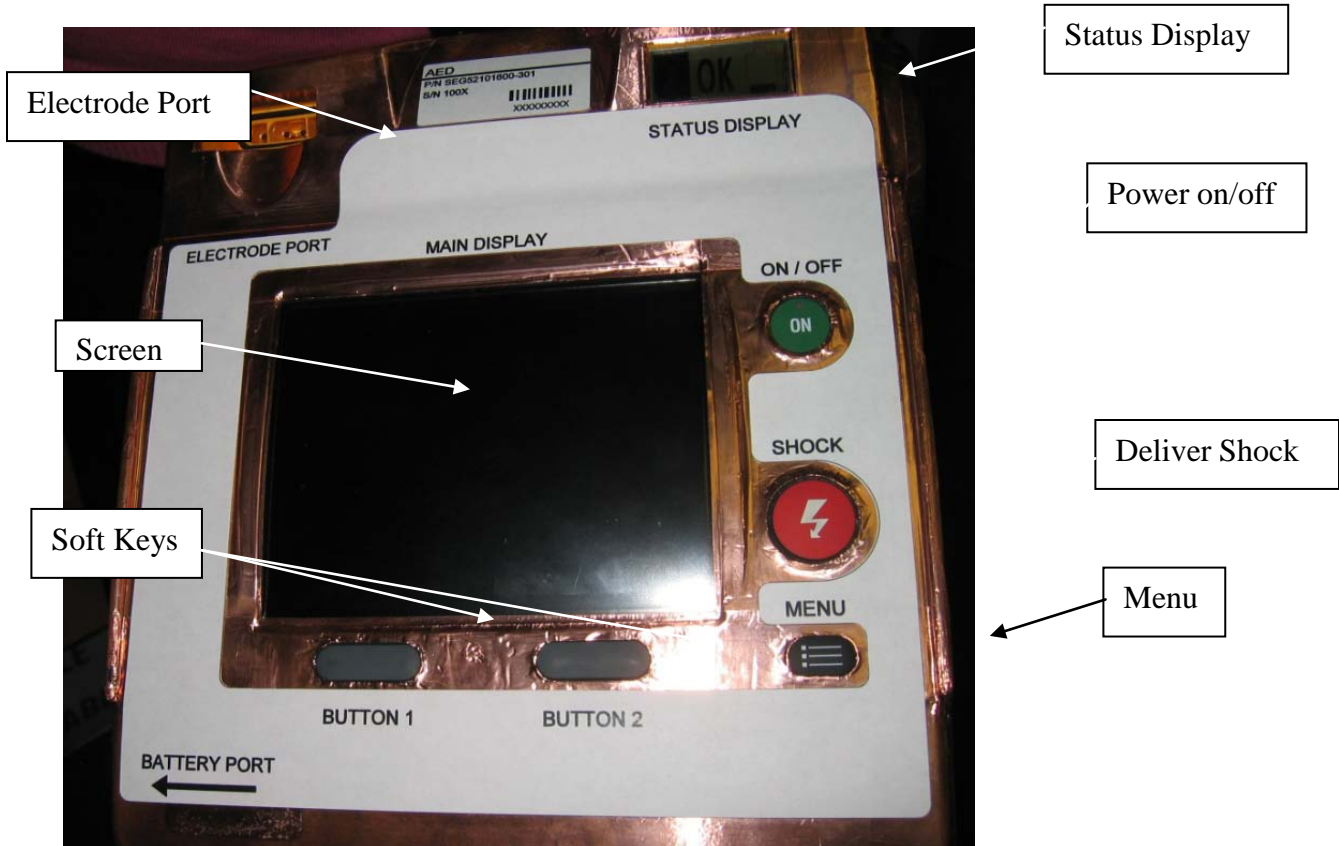


Figure 2. AED Unit

Figure 3 shows the AED, spare battery, and electrodes in the stowed configuration.



**Figure 3. AED Stowage Configuration**

There is one electrode port for the AED electrodes in the upper left corner. A speaker is located on the right side of the unit for verbal commands provided by the device. A battery port is located on the left side. There are also a number of pushbuttons on the AED unit:

1. The ON/OFF button is used to power the unit on or off
2. The shock button is red and flashes when a shock is ready to be delivered.
3. The menu button is used to select the operating mode and to enter information in the setup mode
4. Softkeys (Button 1 and Button 2) under the screen define the function that can be activated (i.e. ANALYZE and DISARM)

The “MAIN DISPLAY” LCD on the AED displays the ECG rhythm, heart rate, shock indicator, elapsed time, battery status, and display messages.

A “STATUS DISPLAY” LCD is located in the upper right corner, and alerts the user of the AED status (battery status and unit status).

#### ***4.5.3. Hardware Interfaces with Vehicle***

Velcro is used to secure the AED to the rack.

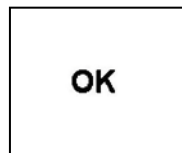
#### ***4.5.4. Data/Commanding Capabilities***

The AED has no data connection and no commanding capabilities on orbit. The LIFEPAK 1000 can store up to two patient records which can be transmitted to a computer after the AED has been returned to ground and the IR port is accessible. The computer used to download the data must have the CODE\_STAT Suite, version 6.0 or later (a Medtronic LIFENET system product).

The LIFEPAK 1000 supports only wireless, infrared communications to transmit data from the AED to a computer.

**4.5.4.1. AED Self Check**

The AED performs automatic self test daily. During these self tests, the AED turns itself on briefly, performs a self-test, stores the results in the test log, and turns itself off. If the unit is operating nominally, the Status Display will display ‘OK’ (Figure 4). If a problem is detected during the test that requires service, or if the internal coin cell battery is low, the service symbol (a wrench) will be displayed in the Status Display in the upper right corner of the unit (Figure 5). Table 4.5.4.1-1 shows the status of the AED as a function of a particular action and the symbols that correspond.













**Figure 4. Nominal Operations Symbol**



**Figure 5. Service Symbol**

**Table 4.5.4.1-1 AED Status**

Action	Status Display	Main Display
No battery installed	 	Blank
Battery inserted, unit runs through a self-check, unit remains off.	 <b>OK</b> 	Blank
Unit is turned on and self-check has found an issue for servicing.	 	
Unit is turned on and self-check has found no issues.	 	

The unit also performs a monthly charge circuitry test in addition to its daily tests. During this self-check, the AED capacitor is automatically charged and dissipated.

#### **4.5.4.2. AED Periodic Checkout**

The AED is scheduled for a periodic inspection by a crewmember every 30 days and includes visual inspection of the AED case, copper and Teflon tape, inspection of the battery, observation of the STATUS DISPLAY, examination of AED electrodes, and testing of the spare battery.

#### ***4.5.5. Hazard Concerns***

Refer to the JSC63799A: AED Risk Assessment Executive Summary Report (RAESR).

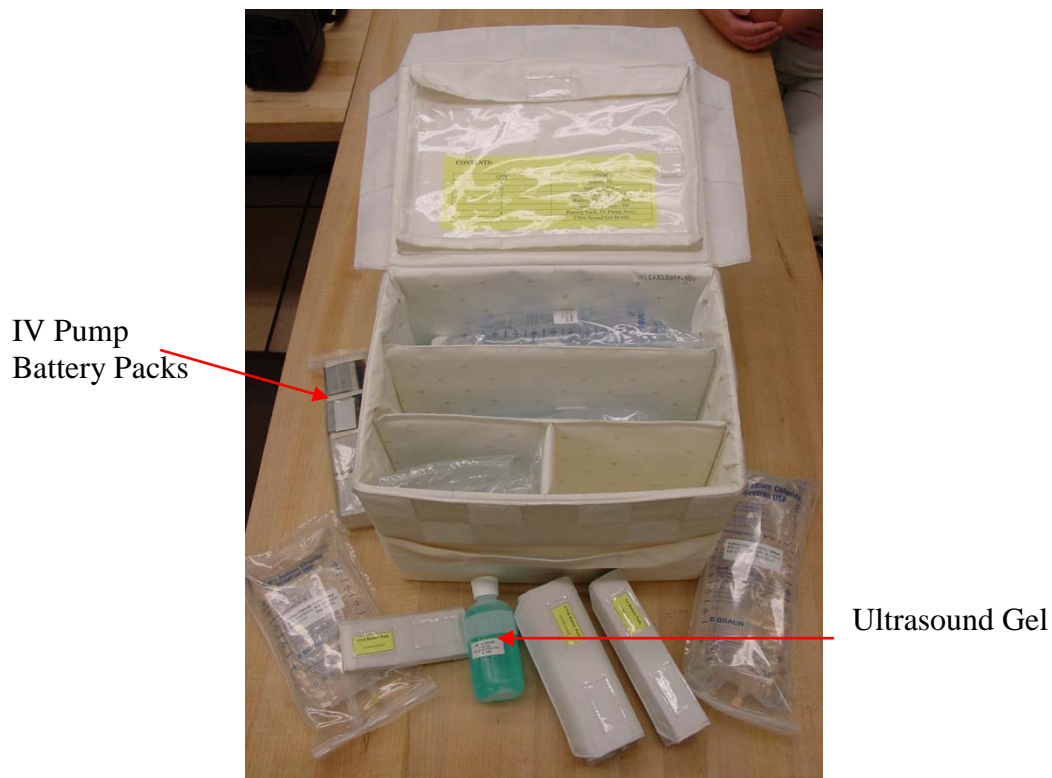
#### ***4.5.6. AED Resupply***

The AED, including batteries (2) and electrodes kits (2 sets of electrodes), will be replaced every 2 years or at the first available opportunity, if used. The old AED may be trashed once the new one has been installed and checked out. The initial unit will be returned, and the batteries and electrodes kit will be trashed. The first resupply will occur in July, 2010. Future units and all consumables will be trashed.

## 4.6. HMS Ancillary Support Pack (HASP)

### 4.6.1. HASP Description

The HASP is used to stow infrequently used items for HMS. The interior of the HASP is designed with absorbent material to absorb any saline leaks.



**Figure 1. HASP**

### 4.6.2. HASP Contents List and Description

- 7.5 L Saline
- IV Pump battery packs (4)
- Ultrasound Gel (2)



**Table 4.6.2-1 General Hardware Specifications**

<b>Kit and Component List</b>	<b>Mass M(E)</b>	<b>Volume M(E)</b>	<b>Dimensions M(E)</b>	<b>Nominal Stowage Location</b>	<b>Storage Temp °C (°F)</b>	<b>Operating Temp °C (°F)</b>	<b>Operating Pressure mmHg (psia)</b>
HASP	Varies; ≤30lbs.	22/22.5 cm <sup>3</sup> (1350 in <sup>3</sup> )	25.4x 25.4 x 34.3 cm (10" x 10" x 13.5")	LAB105_G2			

**4.6.3. Hardware Interfaces with Vehicle**

Velcro

**4.6.4. Resupply Schedule**

Components of the HASP are resupplied as needed.

**4.6.5. Data/Commanding Capabilities**

N/A

**4.6.6. Hazard Concerns**

N/A

## 4.7 ISS Medical Accessory Kit (IMAK)

### 4.7.1. IMAK Description

The IMAK is designed to be a transfer stowage container for crewmember personal medications, piece parted medical or CHeCS items, EC8+ cartridges, hearing protection, and occasionally HRF or other small hardware. The crewmembers, along with the Increment Flight Surgeon, define the contents of the IMAK in an IMAK Content List (ICL), formerly the Flight Surgeon Content List (FSCL). The kit is 'late stow' hardware and is typically manifested on all crew rotation flights. IMAKs may also be manifested on Shuttle or Progress flights. The contents of the IMAK are removed on orbit and stowed with the crewmember's personal items or stowed per instructions provided. The IMAK contents are transferred to a temporary or final location during or shortly after docked ops, and the IMAK is trashed. Crew members may use the IMAK for personal medical item stowage if desired.

The IMAK was redesigned in 2008-2009, and the disposable IMAK is replacing the Nomex IMAK. The new IMAK first flew on 2J/A (July, 2009). The new IMAK is a 12" x 12" grey opaque polyethylene recloseable bag within a Teflon sleeve. The IMAK may contain items for one or more crewmember or kit (such as one crewmember's personal items or an HMS resupply item), or may contain multiple inner Ziploc bags which may have multiple stowage locations (such as one or more crewmembers' items, piece part resupply items and HRF items). Labels are applied to the IMAK, as well as to inner Ziplocs. A Jedi message is prepared whenever IMAKs fly. This message provides unpack and stowage instructions for the crew. An explanation is provided to the crew in the unpack notes if unusual circumstances occur, such as when a medication or brand name is changed during resupply, to avoid questions or confusion. See Figure 1.

The old IMAK consisted of a blue Nomex bag with a Velcro closure which was used for return of crew personal medical items and returning CHeCS hardware. There are still some Nomex IMAKs on orbit, some being used for extra medications and medical supplies, and some listed as 'lost'. As these are emptied or found, they will be trashed. See Figure 2.



**Figure 1. New IMAK**



**Figure 2. Old IMAK**

**4.7.2. IMAK Contents List and Description**

The components of the IMAK will vary on crewmember preference and Increment Flight Surgeon decisions. They will be detailed in a confidential ICL (IMAK Content List).

**Table 4.7.2-1 General Hardware Specifications**

<b>Kit and Component List</b>	<b>Mass M(E)</b>	<b>Volume M(E)</b>	<b>Dimensions M(E)</b>	<b>Nominal Stowage Location</b>	<b>Storage Temp °C (°F)</b>	<b>Operating Temp °C (°F)</b>	<b>Operating Pressure mmHg (psia)</b>
IMAK (new ziplock Teflon bag)	Average content weight 1.5 kg (3.3 lb), max content weight 4.5 kg (10 lb) Weight of IMAK is 0.0039 kg (0.008 lb).	8962 cm <sup>3</sup> (546.9in <sup>3</sup> )	31.8 x31.8 x 8.9 cm (12.5” x 12.5” x 3.5”)	All items transferred to ISS and IMAK container is trashed.	-50 – 80 °C (-58-176°F)		Standard Habitable Module Pressure
IMAK (old Nomex bag)	1.4 kg (3 lbs)	5380.2 cm <sup>3</sup> (328.3in <sup>3</sup> )	19 x 11.4 x 12.6 cm (7.5” x 4.5” x 5.0”)	All items transferred to ISS and trashed	15-30 °C (59-86°F)		Standard Habitable Module Pressure

**4.7.3. Hardware Interfaces with Vehicle**

None.

**4.7.4. Resupply Schedule**

Typically, one to three IMAKs are launched per crew rotation, Shuttle or Progress flight. The IMAK may also be used as a resupply vehicle for medical packs, such as the Ambulatory Medical Pack and Advanced Life Support Pack.

No maintenance required.

***4.7.5. Data/Commanding Capabilities***

N/A

***4.7.6. Hazard Concerns***

N/A

## 4.8. Intubation Kit/Airway (IKA)

### 4.8.1. Intubation Kit/Airway Description

The Intubation Kit/Airway (IKA) stores the Intubating Laryngeal Mask Airway (ILMA), which is used in place of the Endotracheal Intubation tube. It allows the Crew Medical Officer (CMO) a 99% success rate of securing the airway over the 50% success rate with the Endotracheal Intubation Tube. The IKA is a plastic bag attached to the outside of the ALSP.



**Figure 1-2. IKA: Front and Back of Kit**



**Figure 3. IKA: Contents within Kit**

**4.8.2. IKA Contents List and Description**

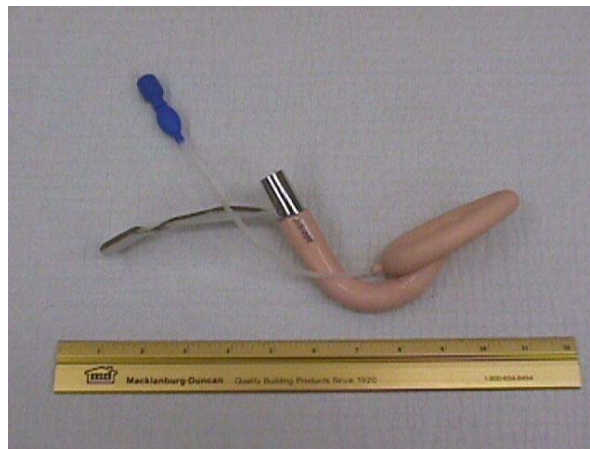
**Contents:**

Intubating Laryngeal Mask Airway (ILMA), 2, size large and small (COTS)	Intubating Laryngeal Mask Airway (ILMA) Stabilizing Rod
Endotracheal Tube (ETT) (COTS)	Surgical Lubricant
Endotracheal Tube connector, 2, size large and small (COTS)	Syringe, 2, one 35cc (for ILMA cuff) and one 10cc (for ETT cuff)
Tape, 1 in	ILMA Cue Card

**Table 4.8.2-1 General Hardware Specifications**

Kit and Component List	Mass M(E)	Volume M(E)	Dimensions M(E)	Nominal Stowage Location	Storage Temp °C (°F)	Operating Temp °C (°F)	Operating Pressure mmHg (psia)
Intubation Kit/Airway	1.3 lb	682.5 in3	15" H x 13" L x 3.5" D	LAB1O5_D1		65-85 °F	Standard Habitable Module Pressure

**4.8.2.1. Intubating Laryngeal Mask Airway (ILMA)**



**Figure 4. ILMA with inflated cuff**



**Figure 5. ILMA with properly deflated cuff**



#### ***4.8.3. Hardware Interfaces with Vehicle***

None

#### ***4.8.4. Resupply Schedule***

There is no resupply schedule at this time.

#### ***4.8.5. Data/Commanding Capabilities***

None

#### ***4.8.6. Hazard Concerns***

- The crew shall know when to deploy and use the IKA based upon the procedures provided on the Instruction Cue Card.
- The crew will be trained for proper use (including insertion, ventilation, intubation, and handling) of the Intubation Kit / Airway (IKA).
- The crew will be trained on the proper location and use of the Intubating Laryngeal Mask Airway (ILMA). The Intubation Kit / Airway (IKA) will be readily accessible at all times in the LAB1O5 rack located in the US Lab.
- The crew will be trained to perform the airway management procedures using the ILMA within 4 minutes, including the time required to transport the patient to the Advanced Life Support Area, deploy the IKA and the ability to perform the airway management procedures.
- The crew will be instructed to notify flight surgeons prior to intubation with the Endotracheal Tube (ETT)
- The crew will be trained on the proper use of the ILMA to include stabilization of the patient during transport and emergency egress.
- The flight surgeons will guide the crewmembers real-time in the treatment of the patient while on-orbit.

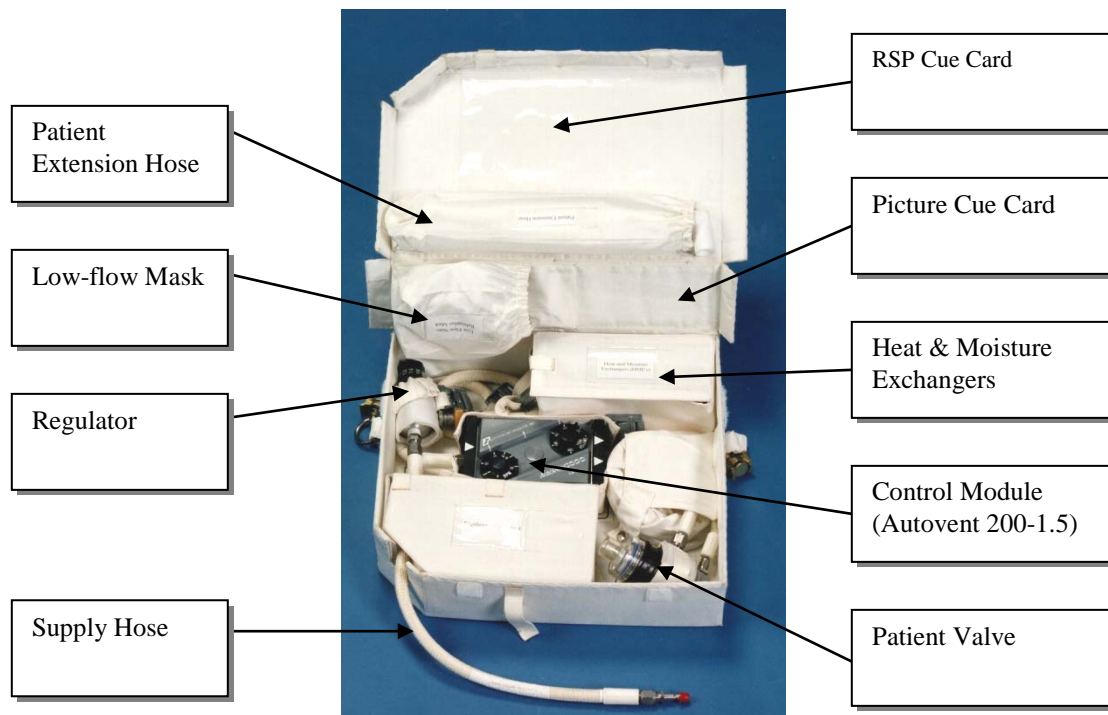
## 4.9. Respiratory Support Pack (RSP) (modified COTS)

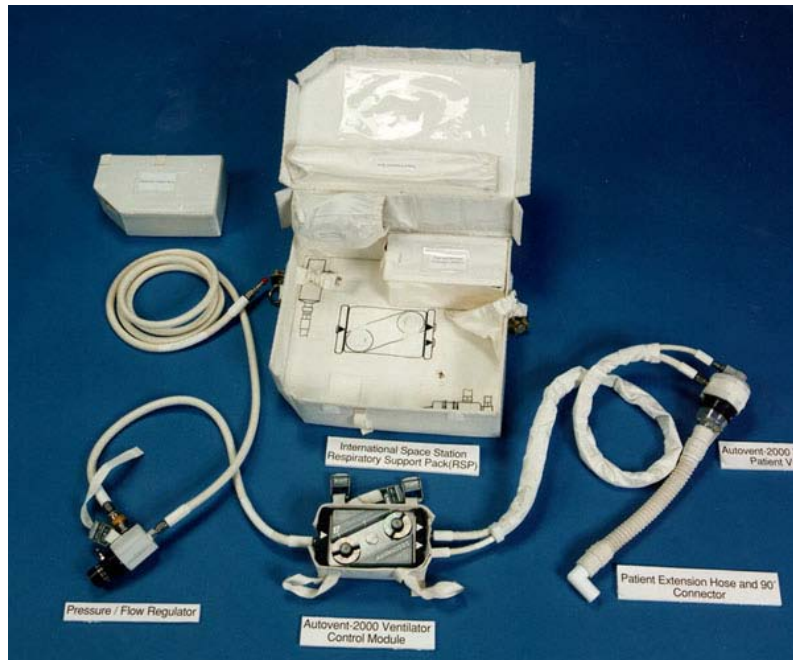
### 4.9.1. RSP Description

The RSP is made up of customized and COTS items making it a modified COTS piece of hardware. Customized items in the RSP include fittings, hose overwraps, the Nomex softpack and restraints as well as the Supply Hose that connects to the ISS O2 port and the Patient Extension Hose. The COTS items include the Control Module (Autovent 2000) which includes the Patient Valve and the Heat & Moisture Exchangers in Figure 1. The Non-Rebreather Face Mask in Figure 3 is also COTS.

The RSP provides the following functions:

1. Low-flow 100% Oxygen to conscious person
2. Manual ventilation via Ambu bag (ALSP)
3. Automatic ventilation for unconscious person





**Figures 1-2. RSP and Contents**

**4.9.2. RSP Components List and Description**

- Dials:
  1. Pressure/Flow Regulator (0–20 Liters/min)
  2. Tidal Volume (400-1200 ml/breath)
  3. BPM (8-20 breaths per minute)
- Patient Interfaces:
  1. Low-flow mask
  2. Patient Valve (for automatic ventilation via ET Tube)
- Hoses:
  1. Supply Hose
  2. Extension Hose

**Table 4.9.2-1 General Hardware Specifications**

Kit and Component List	Mass M(E)	Volume M(E)	Dimensions M(E)	Nominal Stowage Location	Storage Temp °C (°F)	Operating Temp °C (°F)	Operating Pressure mmHg (psia)
RSP	5 kg (11.0 lbs)	11227.2 cm <sup>3</sup> (685.1 in <sup>3</sup> )	36.8 x 34.3 x 8.9 cm (14.5" x 13.5" x 3.5")	LAB1O5_D1	4 – 46 °C (40 – 115 °F)	0 – 45 °C (32 –113 °F)	Standard Habitable Module Pressure

**Table 4.9.2-2 Hardware-Specific Parameters**

Fluid/Gas Description (with design pressures)	Gaseous O2
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Maximum Expected Operating Pressures*	<ul style="list-style-type: none"> <li>• Regulator: 120 psia</li> <li>• Supply Hose: 120 psia</li> <li>• Control Module: 60 psia</li> <li>• Control Module Supply Hose: 60 psia</li> <li>• Patient Valve (Demand Valve): 60 psia</li> <li>• Patient Valve Control Hose: 60 psia</li> <li>• Patient Valve Supply Hose: 60 psia</li> </ul>
Minimum Operating Pressure for Checkout*	<ul style="list-style-type: none"> <li>• Control Module: 43 psia</li> <li>• Patient Module: 43 psia</li> </ul>

\* Values taken from Autovent 2000/3000/ Operating Manual, version 2.0

#### 4.9.2.1. Dials

The Regulator decreases nominal ISS supply pressure of 120 psia to 50 psia for use with the control module and provides low flow oxygen at approximately ambient pressure.

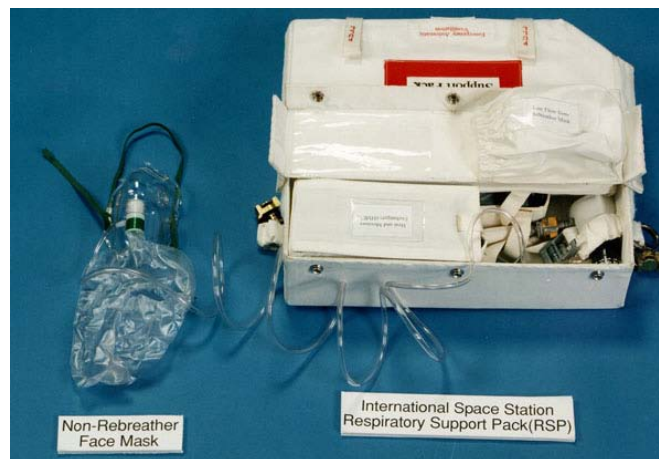
The Control Module is responsible for the timing (BPM Knob) and volume of gas (Tidal Volume Knob) delivered to the patient during automatic ventilation.

#### 4.9.2.2. Patient Interfaces

The Patient Valve interfaces between the control module and the patient endotracheal tube for automatic ventilation.

The Low Flow Rebreather Mask connects to the Regulator at the low flow hosebarb.

The Ambu connects to the Regulator. It can connect to an AMBU mask or to an endotracheal tube.



**Figure 3. Patient Interfaces**

#### 4.9.2.3. Hoses

The Supply Hose (8' 10" length) connects to the ISS O<sub>2</sub> bus (any O<sub>2</sub> source: PBA, PBA extension hose, Shuttle Middeck).

The Extension Hose is used as an extension between the Patient Valve and the Endotracheal Tube.

#### 4.9.3. *Hardware Interfaces with Vehicle*

- ISS ECLSS O<sub>2</sub> bus

- Portable Breathing Apparatus (PBA) bottle
- Portable Breathing Apparatus (PBA) Extension Hose
- Space Shuttle Middeck Oxygen Panel MO32M/MO69M

#### ***4.9.4. Resupply Schedule***

The RSP is resupplied every 2 years or at the first available opportunity, if used. A nominal checkout is scheduled every increment.

#### ***4.9.5. Data/Commanding Capabilities***

None

#### ***4.9.6. Hazard Concerns***

- Fire (due to 100% O<sub>2</sub>)
- Explosion (due to use of pressurized O<sub>2</sub>)
- Sharp edges, corners, or burs can cut crewmembers handling the RSP
- Physiological or biological hazards due to contamination of the RSP, connection to a source other than O<sub>2</sub> thereby resulting in loss of habitable atmosphere for the patient, and over pressurization of lungs
- Impact with crewmembers while free floating
- Entanglement in flex lines during rapid safing
- Elevated ISS O<sub>2</sub> level due to the RSP being left unattended, or failing to cease operation

## 4.10. Variable Oxygen System (VOS) (COTS)

### 4.10.1. VOS Description

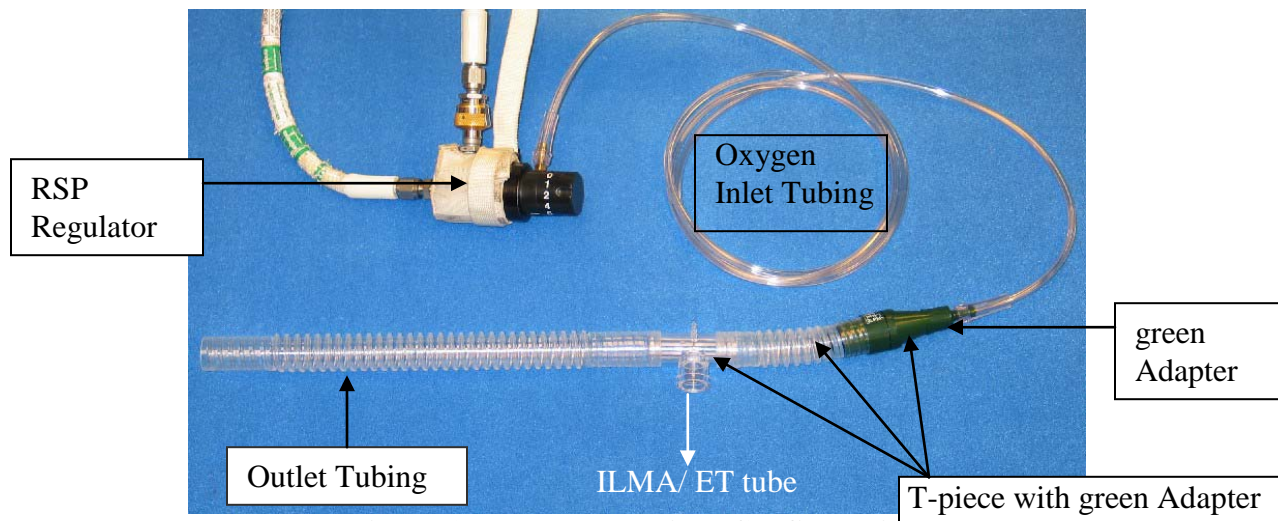
The VOS allows for selectable variable oxygen delivery to a spontaneously breathing patient. This device would be used to wean a patient from 100% Oxygen by mixing cabin air with Oxygen provided by the Respiratory Support Pack.

There are 3 primary reasons to wean a crewmember from oxygen:

1. Prolonged exposure to 100% Oxygen can cause damage to the pulmonary system.
2. The Soyuz cannot interface with the RSP or provide 100% Oxygen to the crewmember. Therefore, before a crewmember can return via Soyuz, they must be weaned from 100% Oxygen.
3. When using the VOS, the RSP regulator will be at a setting of 6 or 4 L/min, thus reducing the amount of Oxygen entering the atmosphere. This will increase the amount of time before reaching the Oxygen Concentration Limit per Flight Rule B17-3.

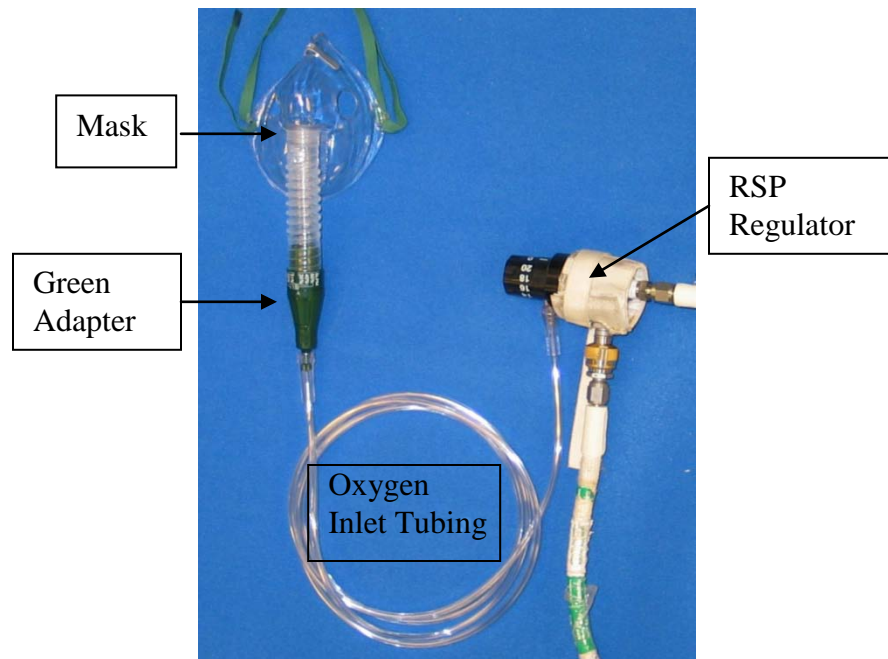
The VOS has 2 configurations:

1. Intubated Patient Configuration
2. Non-Intubated Patient Configuration



**Figure 1. Intubated Patient Configuration**





**Figure 2. Non-Intubated Patient Assembly**

**4.10.2. VOS Components List and Description**

Assemblies:

- Intubated Patient Assembly
  - a. Oxygen Inlet Tubing
  - b. T-piece with green Adapter
  - c. Outlet Tubing
- Non-Intubated Patient Assembly
  - a. Oxygen Inlet Tubing
  - b. Mask
- Spares
  - a. Outlet Tubing
  - b. T-piece
  - c. Mask
  - d. 4” Tubing with green Adapter

**Table 4.10.2-1. General Hardware Specifications**

<b>Kit and Component List</b>	<b>Mass M(E)</b>	<b>Volume M(E)</b>	<b>Dimensions M(E)</b>	<b>Nominal Stowage Location</b>	<b>Storage Temp °C (°F)</b>	<b>Operating Temp °C (°F)</b>	<b>Operating Pressure mmHg (psia)</b>
VOS	0.345 kg (0.76 lbs)	6262.2 cm <sup>3</sup> (366.96 in <sup>3</sup> )	28 x 35.5 x 6.3 cm (11.0”x 13.9” x 2.4”)	LAB1O5_D2	0-60 °C (0 – 140 °F)	0-60 °C (0 – 140 °F)	13.5-15.2 psia

#### 4.10.2.1. Dials

The green adapter has multiple oxygen concentration settings.

Desired Oxygen Percentage:	VOS green Adapter Setting:	RSP Regulator Setting:
50%	50%	6 Liters/minute
40%	40%	6 Liters/minute
35%	35%	6 Liters/minute
31%	31%	4 Liters/minute
28%	28%	4 Liters/minute
26%	26%	4 Liters/minute
24%	24%	4 Liters/minute



**Figure 3. Green Adapter Dial**

*\*NOTE: To change Oxygen concentrations setting pull back sleeve of green Adapter, and rotate sleeve so arrow on sleeve is set **to line** from desired setting.*

#### 4.10.2.2. Patient Interfaces

The T-piece interfaces between the RSP Regulator and the patient ILMA/ endotracheal tube for automatic ventilation.

The Mask connects to the RSP Regulator hosebarb.

#### 4.10.3. *Hardware Interfaces with Vehicle*

The VOS connects to the RSP, which interfaces with:

- ISS ECLSS O2 bus
- Portable Breathing Apparatus (PBA) bottle
- Portable Breathing Apparatus (PBA) extension hose
- Space Shuttle Middeck Oxygen Panel MO32M/MO69M

#### 4.10.4. *Resupply Schedule*

The VOS is resupplied only if used.

***4.10.5. Data/Commanding Capabilities***

None

***4.10.6 Hazard Concerns***

TBD

## 4.11 PanOptic Kit (COTS)

### 4.11.1 PanOptic Overview

The PanOptic kit contains a diagnostic instrument and associated hardware that allows imaging of the posterior portion of the retina. The PanOptic consists of a COTS Welch-Allyn ophthalmoscope and handle with a plastic ‘hood’ that contains a Logitech webcam, enabling the scope to take still and video images. These parts remain assembled on orbit. The kit also contains a spare bulb, eye drops for dilation, a T61p hard drive with the Logitech/PanOptic software, and a DVD containing a backup of the Logitech/PanOptic software. A thumb drive, also temp stowed in the kit, is on loan from CIO which is used to store and transfer the images to a networked SSC.

### 4.11.2 PanOptic Kit Components List and Description



Figure 1. PanOptic Kit and Components

**Table 4.5.2-1 AED Hardware**

Quantity	P/N	Item Name	OpNom
1	11820	Ophthalmoscope	PanOptic (for all three pieces attached together)
1	SEG52102547-801	PanOptic Handle	
1	SEG52102546-301	PanOptic Camera Attachment	
1	03800	PanOptic Ophthalmoscope Bulb	
1	SEG33120738-30	T61p 160GB Hard drive	
1	SEZ39136155-305	Writeable DVD Assembly	
1	24208058564	Tropicamide (Mydriacyl)	Tropicamide (Mydriacyl)

**Table 4.5.2-2 General Hardware Specifications**

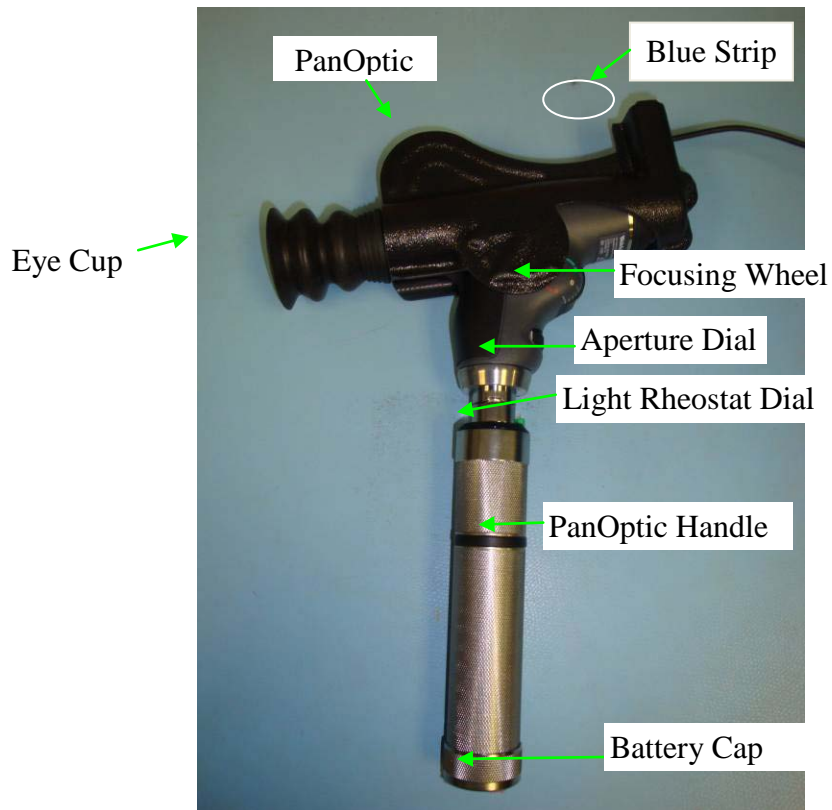
Kit and Component List	Mass	Volume	Dimensions	Nominal Stowage Location	Operating Temp	Storage Temp	Operating Pressure
<b>PanOptic Kit</b>			<b>12x12 Ziplock</b>	<b>LAB105_D2</b>			
<b>PanOptic</b>	<b>0.50 lbs (0.23 kg)</b>		<b>6.575" L (16.7 cm) x 1.4"W (3.6 cm) x 3.75"H (9.5 cm)</b>	<b>LAB105_D2</b>	10-49C (50-120 F), 95% Rh max	-20-49C (-4-120 F), 95% Rh max	<b>500 hPa – 1060 hPa</b>

**Table 4.5.2-3 Hardware Specific Parameters**

Power Specifications	<ul style="list-style-type: none"> <li>• 2 C cells, camera powered by USB port</li> </ul>
General Specifications	<ul style="list-style-type: none"> <li>• COTS Welch-Allyn ophthalmoscope/handle, COTS Logitech webcam in plastic housing</li> </ul>

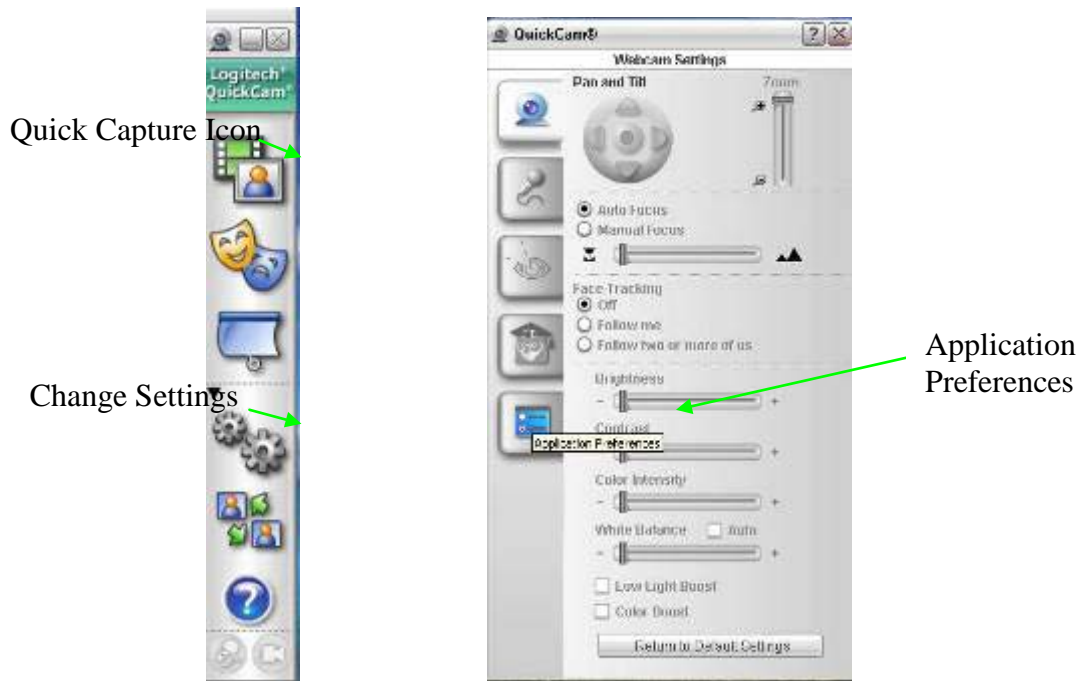
### 4.11.2.1 PanOptic

The assembled PanOptic allows independent or remote guided examination of the posterior portion of the retina to allow visualization of the tissue and blood supply. Refer to Figure. Still and video images are saved to a thumb drive, are downlinked, and provided to eye specialists for review. The plastic housing on the head of the PanOptic contains a Logitech webcam, capable of taking still and video images. The camera has a variety of settings available via the Logitech QuickCam toolbar. Refer to Figure 3.



**Figure 2. PanOptic**





**Figure 3. QuickCam Icons**

### ***4.11.3 Hardware Interfaces with Vehicle***

There are no interfaces to the vehicle.

### ***4.11.4 Data/Commanding Capabilities***

The PanOptic has no data connection and no commanding capabilities on orbit. Still and video images are downloaded via a thumb drive.

### ***4.11.5 Hazard Concerns***

N/A

### ***4.11.6 PanOptic Resupply***

There is currently no resupply planned.