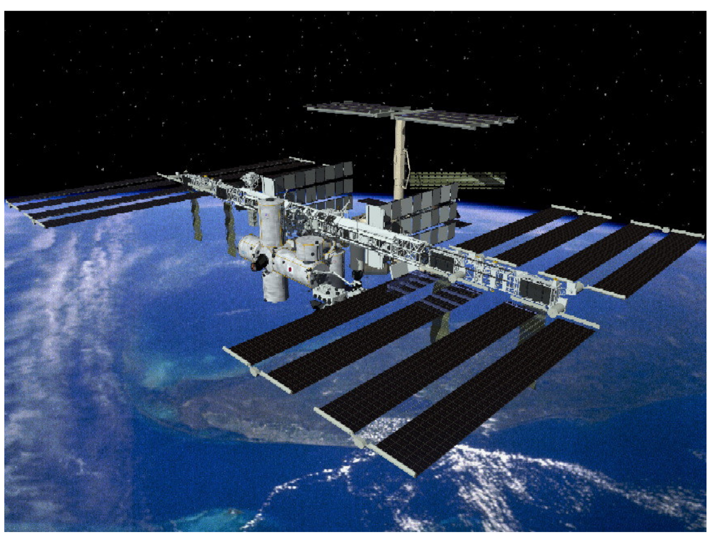
International Space Station

CHeCS

Medical Hardware Catalog



November 2008

Version 8.2

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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. (http://wwwsrqa.jsc.nasa.gov/gfe/CDS/qryCDS.asp)

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: http://sd.jsc.nasa.gov/sd2/issops/checs-issues.aspx

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: http://edcc.jsc.nasa.gov/edccsearch/**

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)

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1.1. CHeCS Systems Integration

1.1.1. 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 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 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	• Nitrogen: USOS ECLSS, ACS subsystem, Lab Nitrogen system
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)

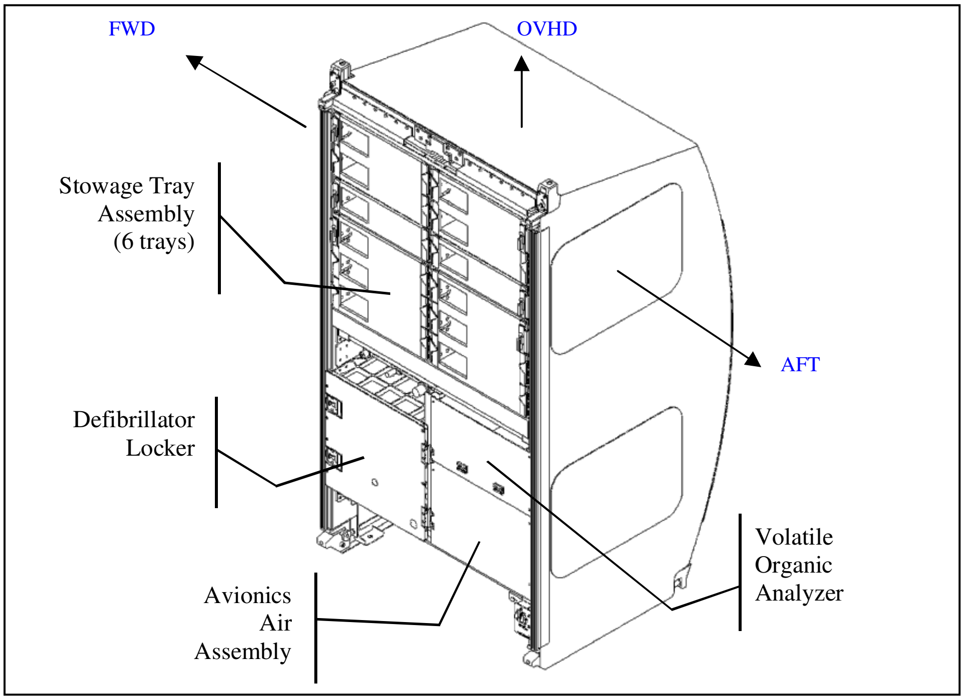

Figure 1. CHeCS Rack

1.1.2. 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_2 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)*

A1 CCPK HRM Resupply HRM Kit 0.5 CTB with Water/Micro Hardware	A2 HASP CDMK PDK SSK VOA Repair Kit
C1 GSC FMK CSA-O2 Resupply Kit	C2 CSA-CP Resupply Kit
D1 IKA ALSP Med Checklist RSP ACLS Flip Book CMRS (when stowed)	D2 AMP VOS WMK
H1 Pwr/N2 Ports J1 (door) AED AED Spare Battery	H2 VOA
Power Distribution Box	AAA
Utility Interface Panel	

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

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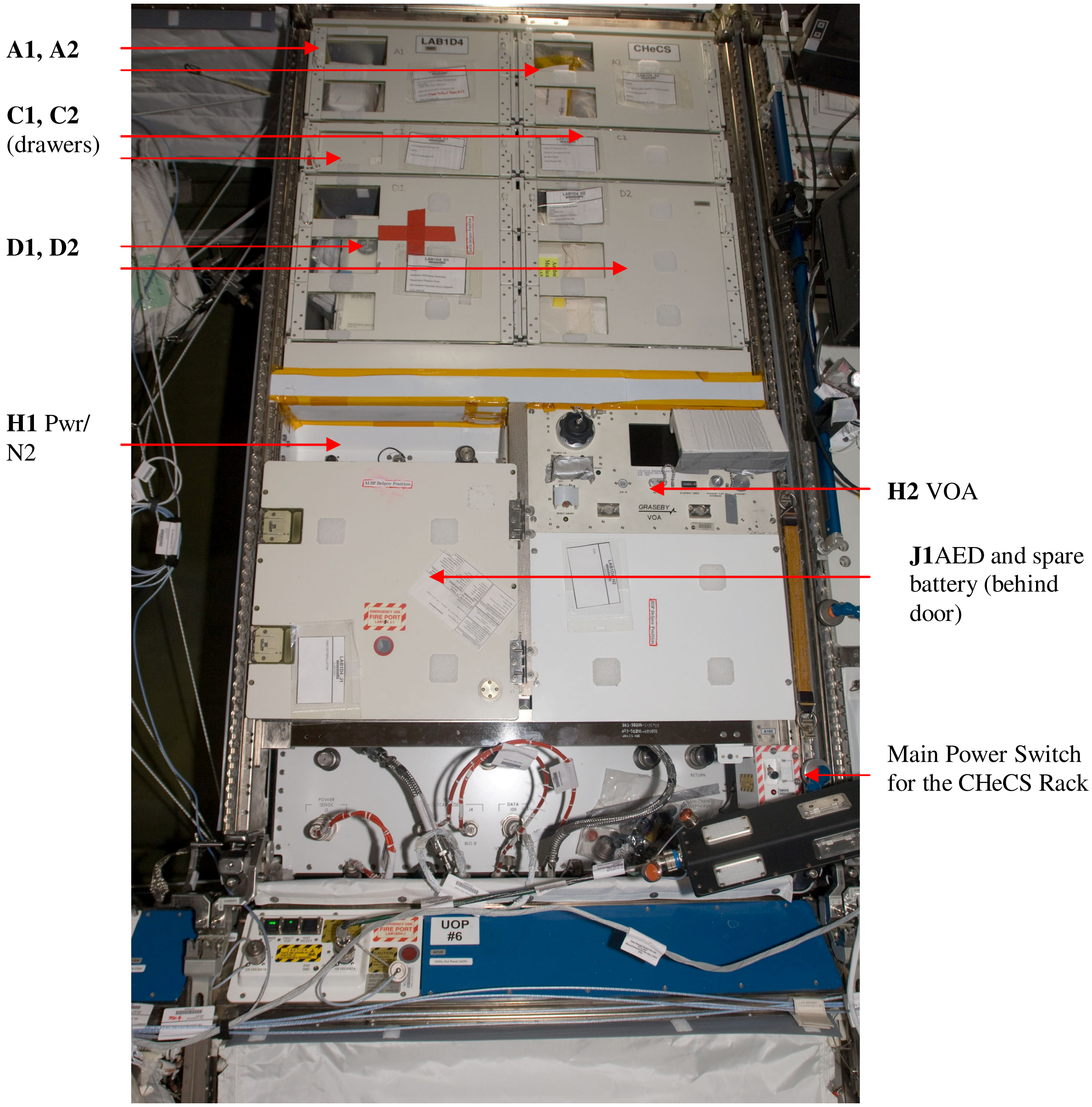

Figure 2. ISS On-Orbit CHeCS Rack (Photo taken during Expedition 17)

1.1.3. 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.

Volatile Organic Analyzer

1.1.3.1. 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.

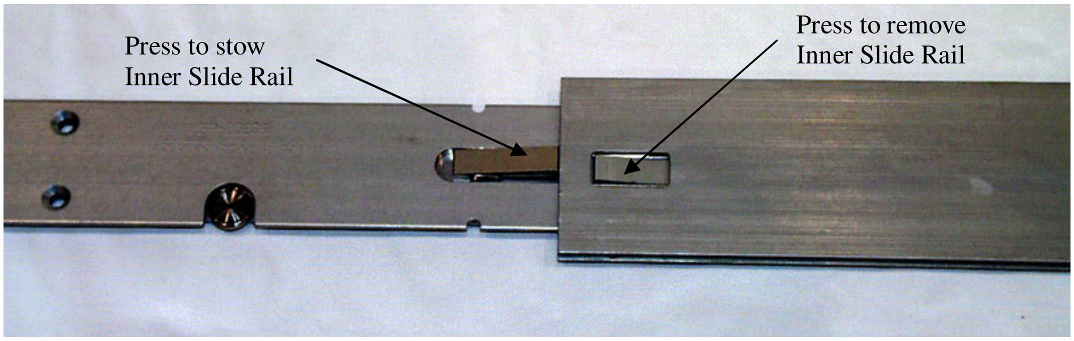

Figure 5. VOA Slide Guide, Inner Guide Rail Release Latch (Exterior View)

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.

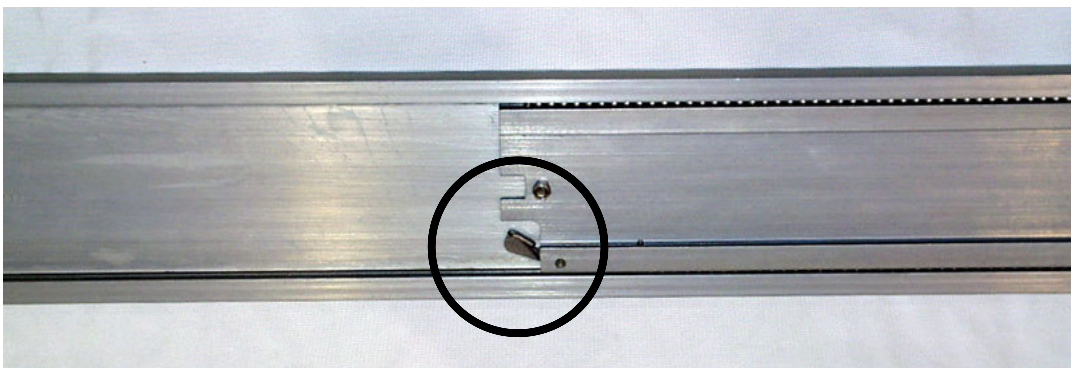

Figure 6. Center Slide Guide Release Latch

1.1.4. 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.

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Figure 7. LAB1S4_H1: CHeCS Utility Panel With Non-Functional Oxygen Port Label

Figure 8. CHeCS Rack: Utility Interface Panel

1.1.4.1. UIP Port Labels

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

Port	Label	Supplies/Returns
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

1.1.4.2. Systems Interface Functional Schematic

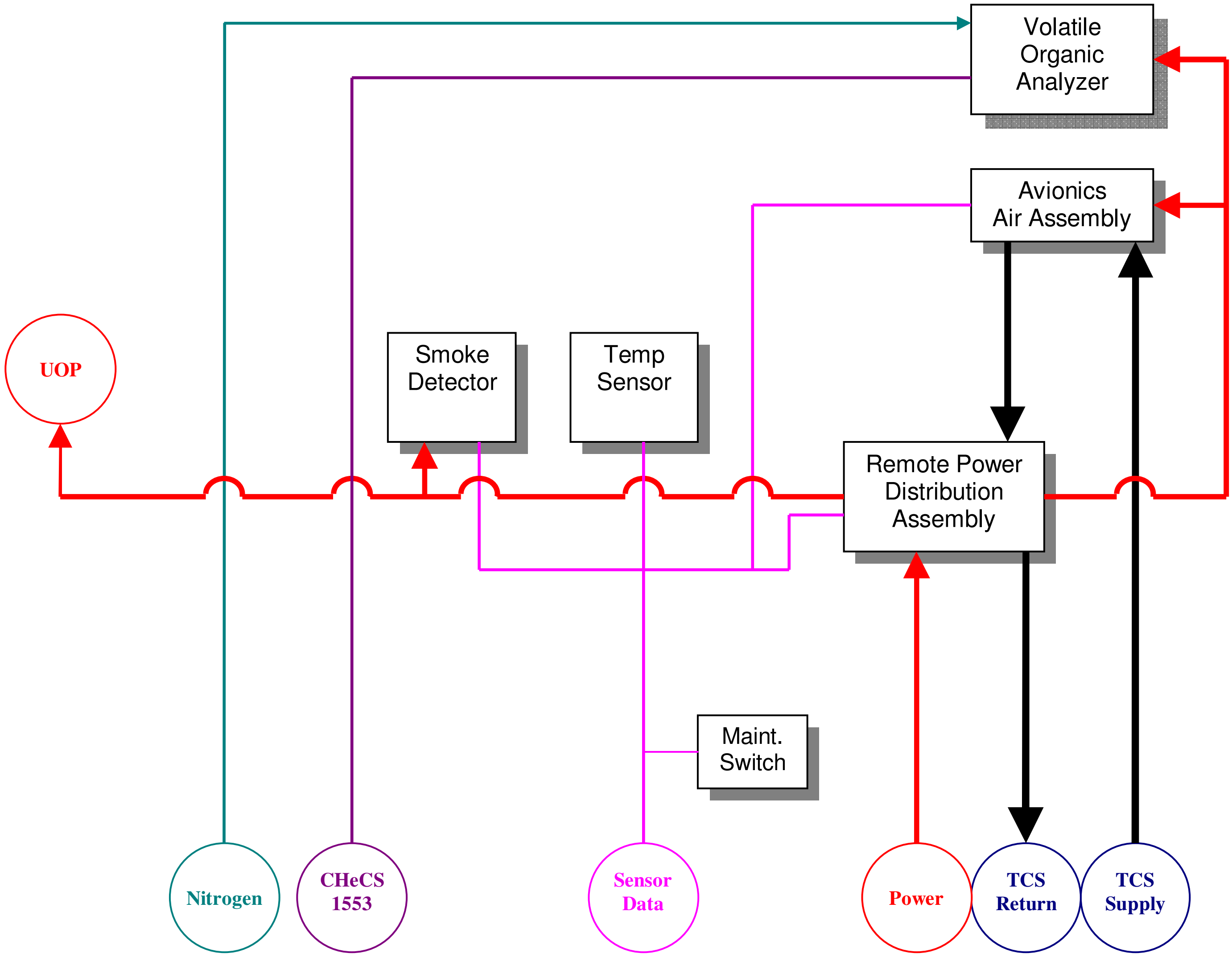

Figure 9. CHeCS Rack Utilities

1.1.5. *Environmental Control & Life Support Systems (ECLSS) Support*

1.1.5.1. 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

1.1.5.2. 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

1.1.6. 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

1.1.7. 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 Volatile Organic Analyzer (VOA), Tissue Equivalent Proportional Counter (TEPC), and the Extravehicular Charged Particle Directional Spectrometer (EVCPDS). 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 EV-CPDS).

In addition to using the 1553 bus architecture, the Medical Equipment Computer (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 (ISSSH)

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

1.1.8. 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.

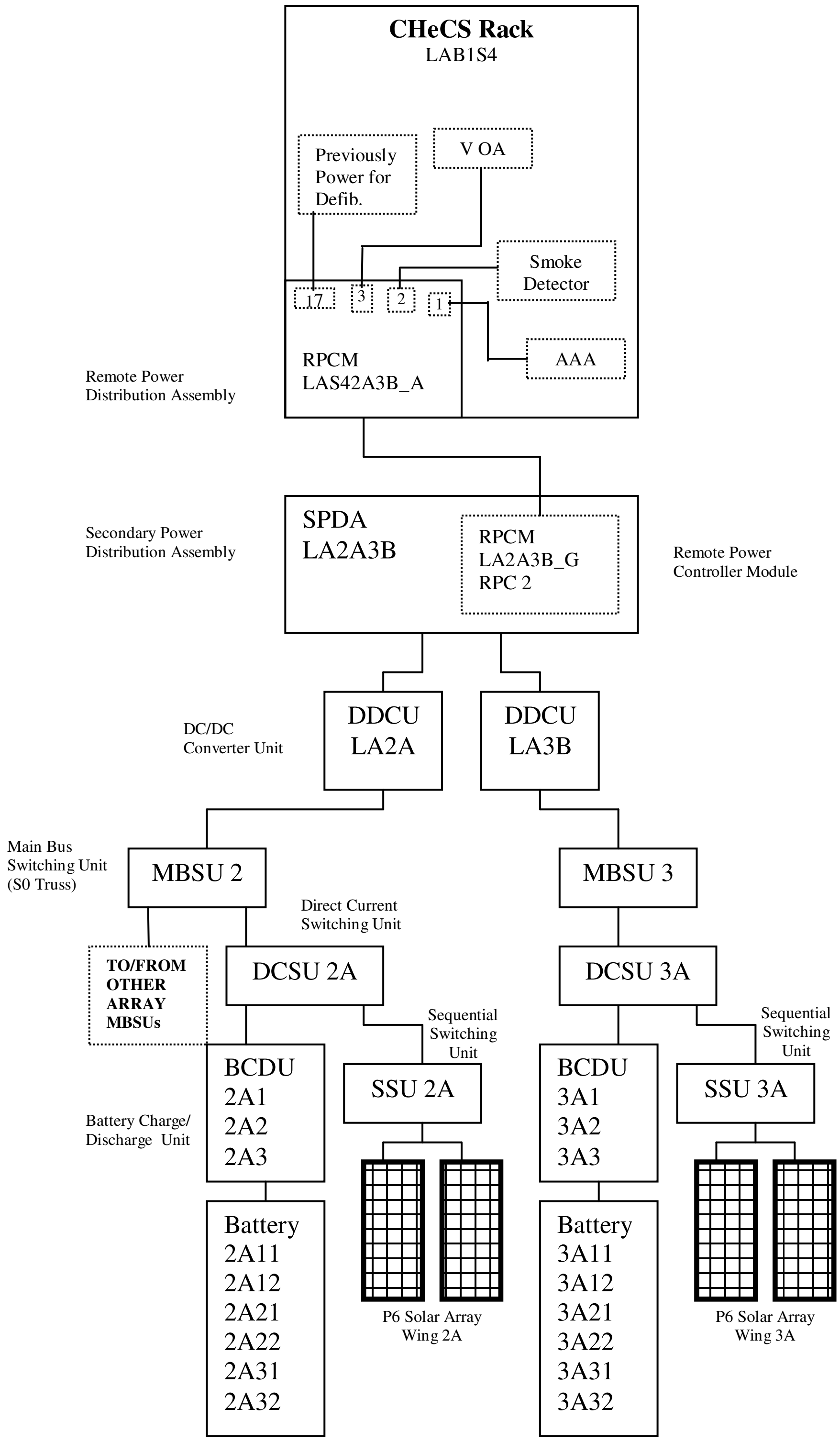

Figure 10. CHeCS Power Supply

1.1.9. 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

1.1.10. Resupply/Maintenance Schedule

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

1.1.11. Data/Commanding Capabilities

N/A

1.1.12. 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.*

1.2. CHeCS 1553 Data Network

1.2.1. 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.

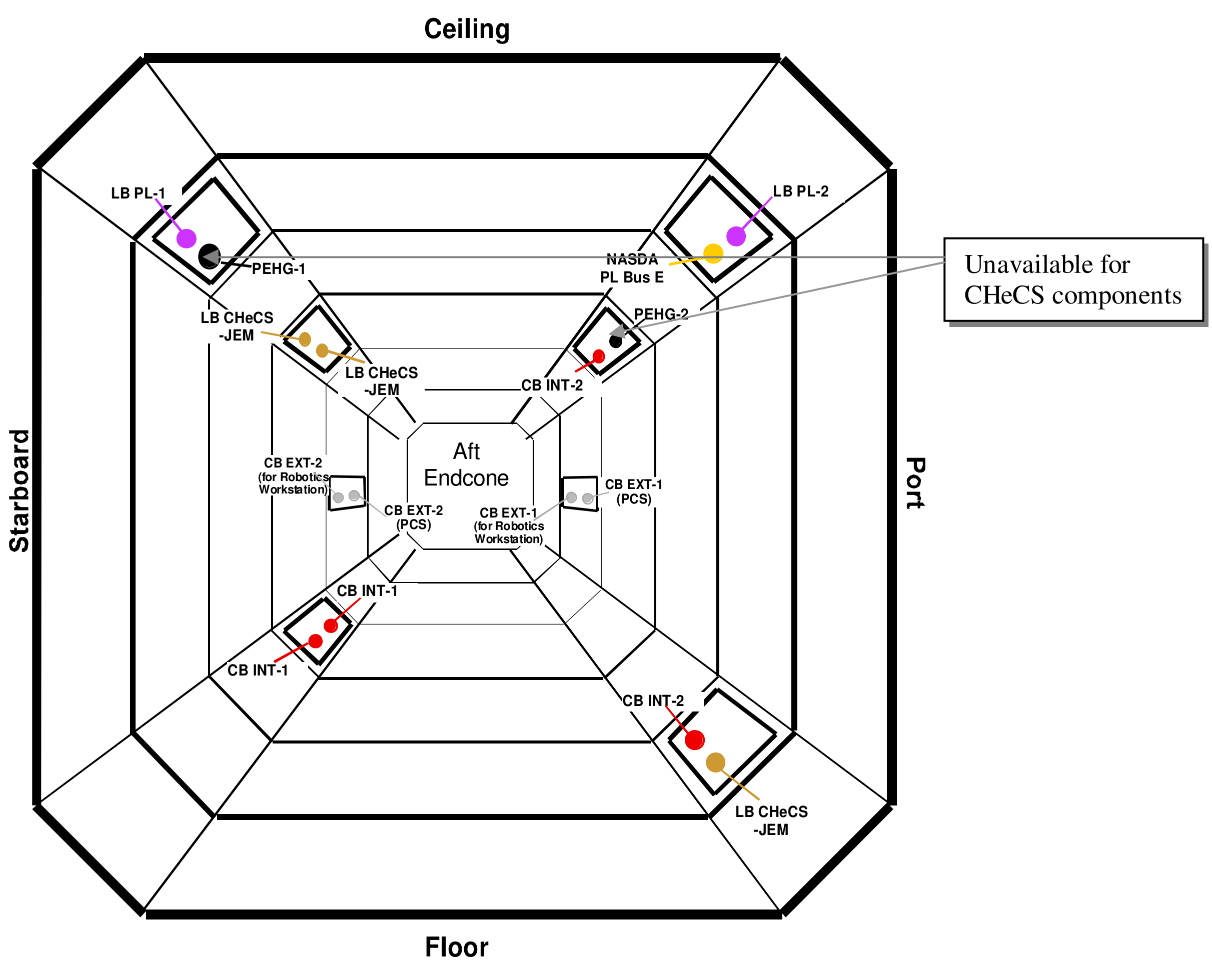

Figure 1. Lab PCR Locations

Table 1.2.1 -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 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
LAB1OS4 J4	Utility Outlet Panel #2		LB CHeCS-JEM
S0 Truss	EV-CPDS #1	USOS EPS Channel 4B DDCU LAP3-4A 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
	EV-CPDS #2		LB CHeCS-COL
	EV-CPDS #3 (EVCPDS External Heaters are powered from RPCM S0-2B_C, RPC 3)		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 1.2.1-2. EPS-Powered CHeCS Devices

CHeCS Device	Power Source
Blood Pressure/Electrocardiogram	USOS 120 V DC ROS 28 V DC
Volatile Organic Analyzer	USOS 120 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

1.3. 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 IDRD, Annex 1: Flight Specific Manifests on the MIDAS database: http://iss-www.jsc.nasa.gov:1532/midasagnt/plsql/midas_home_oas. Select "Integrated Manifest Report", then choose a flight. The CHeCS To/From Lists on the EA-SD folder can also be referenced for transfer information by flight.

2. Countermeasures System (CMS)

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 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 crew member to find and select their 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.

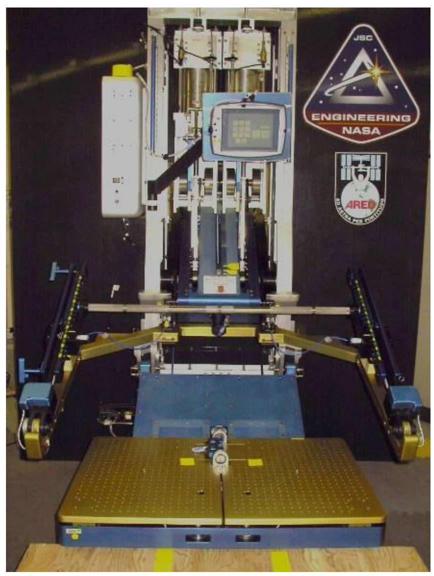

Figure 1. ARED

ARED is located in the zenith alcove of Node 1.

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

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    - 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
- 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 = 65W			
Power Source	16.8 V A31p 120VDC Power Supply			
Measurement Parameters/ Analysis Capabilities:	**Display Parameter**			
		Units	**Range**	**Precision**
	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 1	63 to 87	13.9 - 14.9
Platform	78 lbs.	40.0” x 29.5” x 9.0”	Node 1	63 to 87	13.9 - 14.9
Load Adjustment Unit	94 lbs.	39.8” x 19.8” x 8.7”	Node 1	63 to 87	13.9 - 14.9
Cylinder Flywheels	95 lbs	36.3” x 9.5”x 16.6”	Node 1	63 to 87	13.9 - 14.9
Belt Pulley	71 lbs.	28.0” x 17.7” x 11.5”	Node 1	63 to 87	13.9 - 14.9
Main Arm with Lift Bar	110 lbs	53.8” x 21.0” x 7.6”	Node 1	63 to 87	13.9 - 14.9
VIS (Right)	121 lbs	39.1” x 24.1” x 13.6”	Node 1	63 to 87	13.9 - 14.9
VIS (Left)	129 lbs	39.1” x 25.0” x 13.6”	Node 1	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 aft/zenith side seat tracks of Node 1. The Yoke Beam attaches to these Seat Track Interfaces. The Left VIS attaches to the Yoke Beam and then the Left Seat Track Interface while the Right VIS only attaches to the Yoke Beam. The ARED Frame attaches to the Left and Right VIS via the VIS Rotation Post. 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.

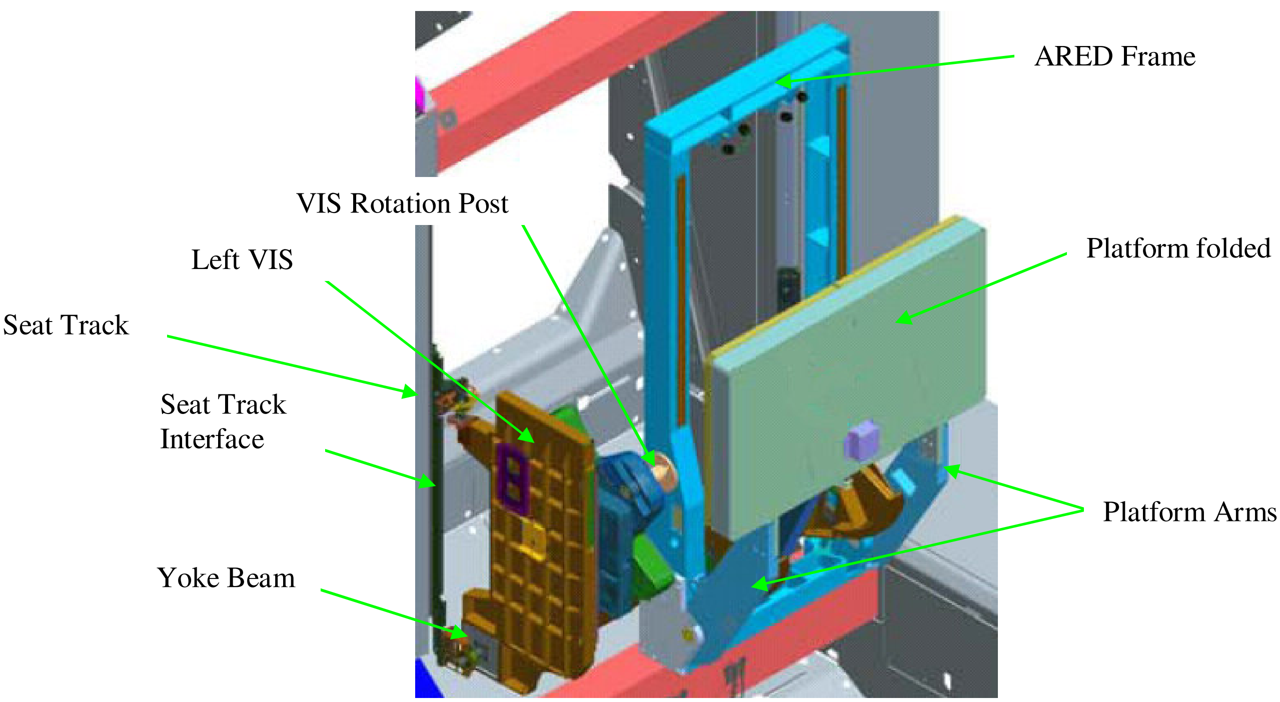

Figure 2. ARED Attachment Points

Load is provided by the vacuum cylinders with flywheels providing an inertial component (when desired) and this 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.

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.

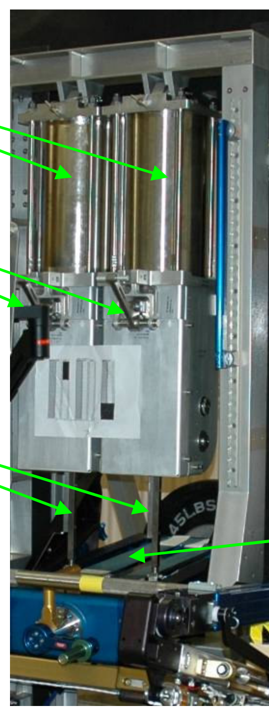

Figure 3. Cylinder Flywheel

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.

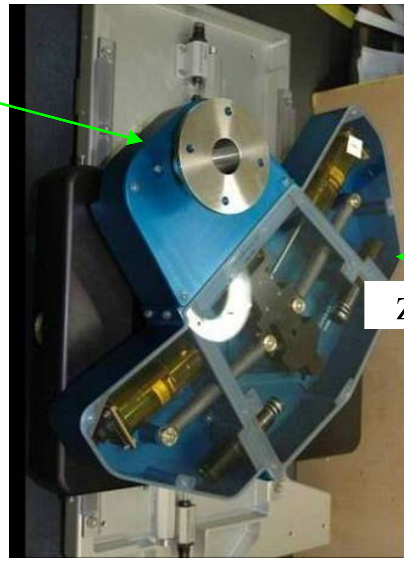

Figure 4. VIS

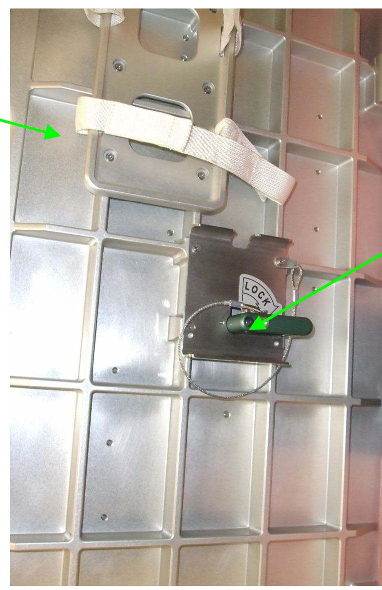

Figure 5. Back of Left VIS

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. A Rack Indicator Window assists the crewmember to know if the Main Arm is racked or un-racked. A racked Arm is indicated by the presence of a while line in the Rack Indicator Window, as shown in Figure 6.

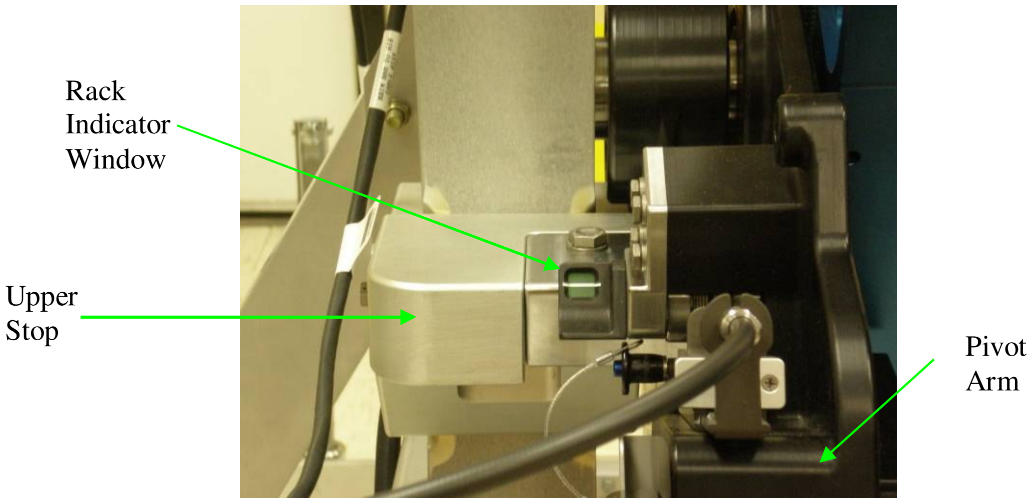

Figure 6. Rack Indicator Window

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.

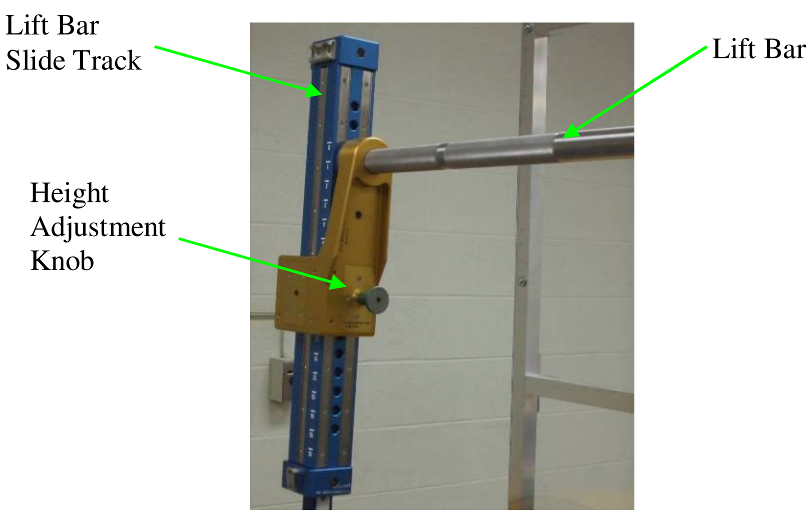

Figure 7. Lift Bar and Lift Bar Slide Tracks

2.1.2.6 Platform

The Platform is located on the port side of Node 1. It attaches to the Platform Arms which attach to the ARED Frame. If stowage or access to the fire port is need, the Platform can be folded up and secured with the Platform PIP Pins (one per side). Platform PIP Pins lock it 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.

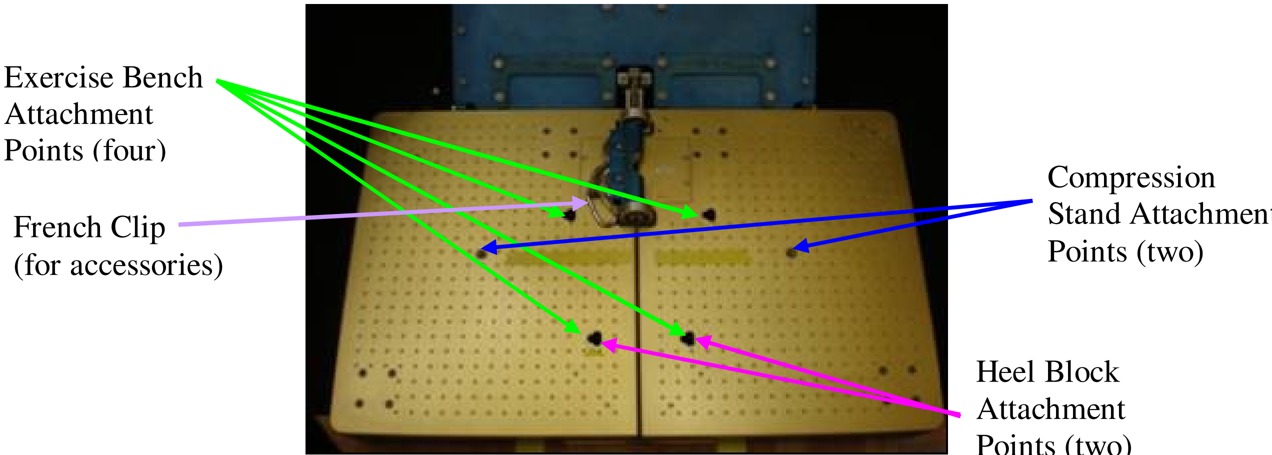

Figure 8. Platform

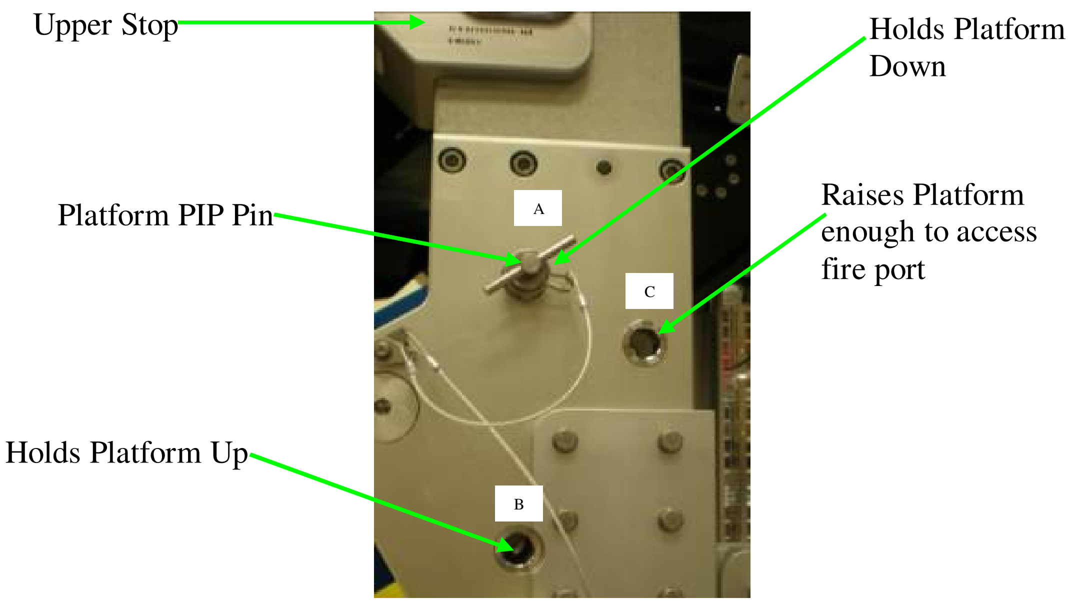

Figure 9. Platform PIP Pin Locations

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.

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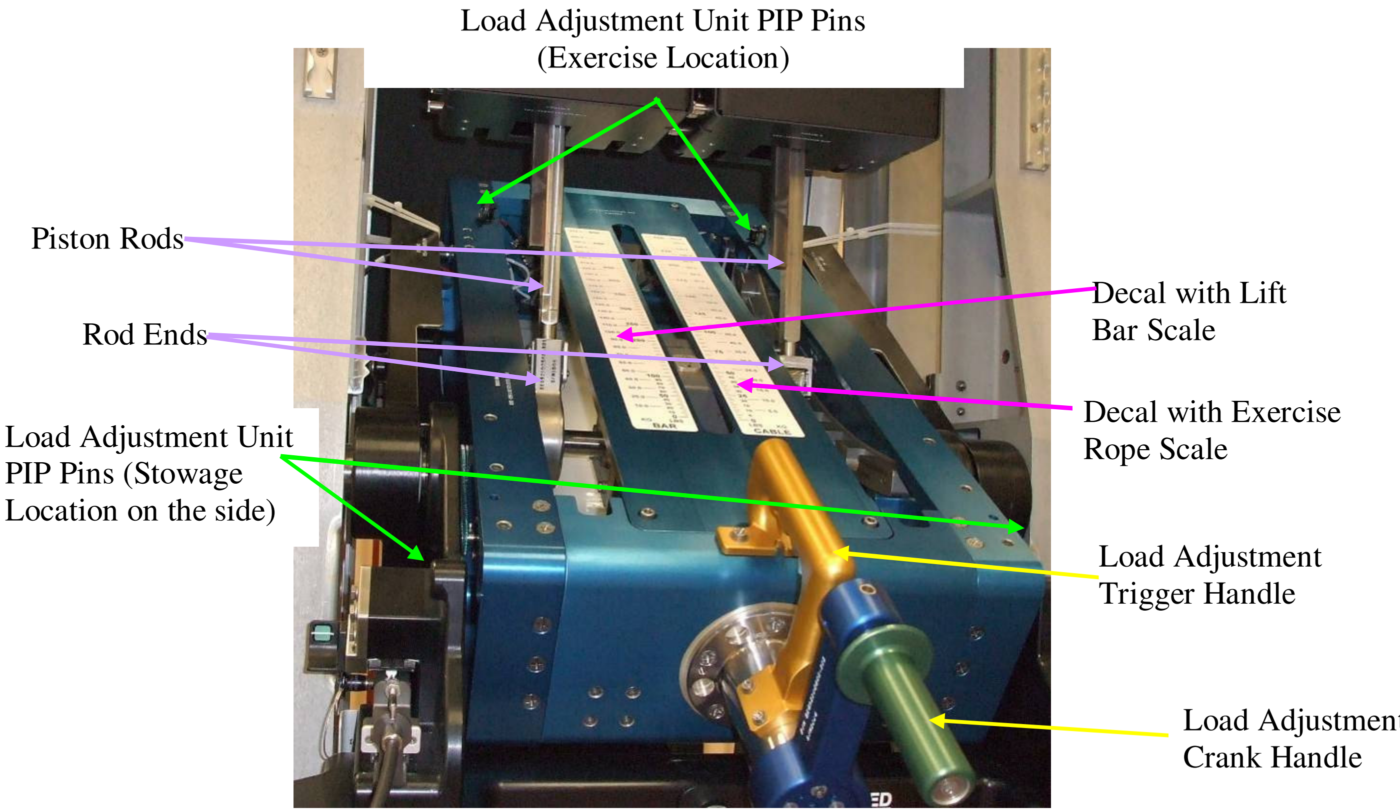

Figure 10. Load Adjustment Unit

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.

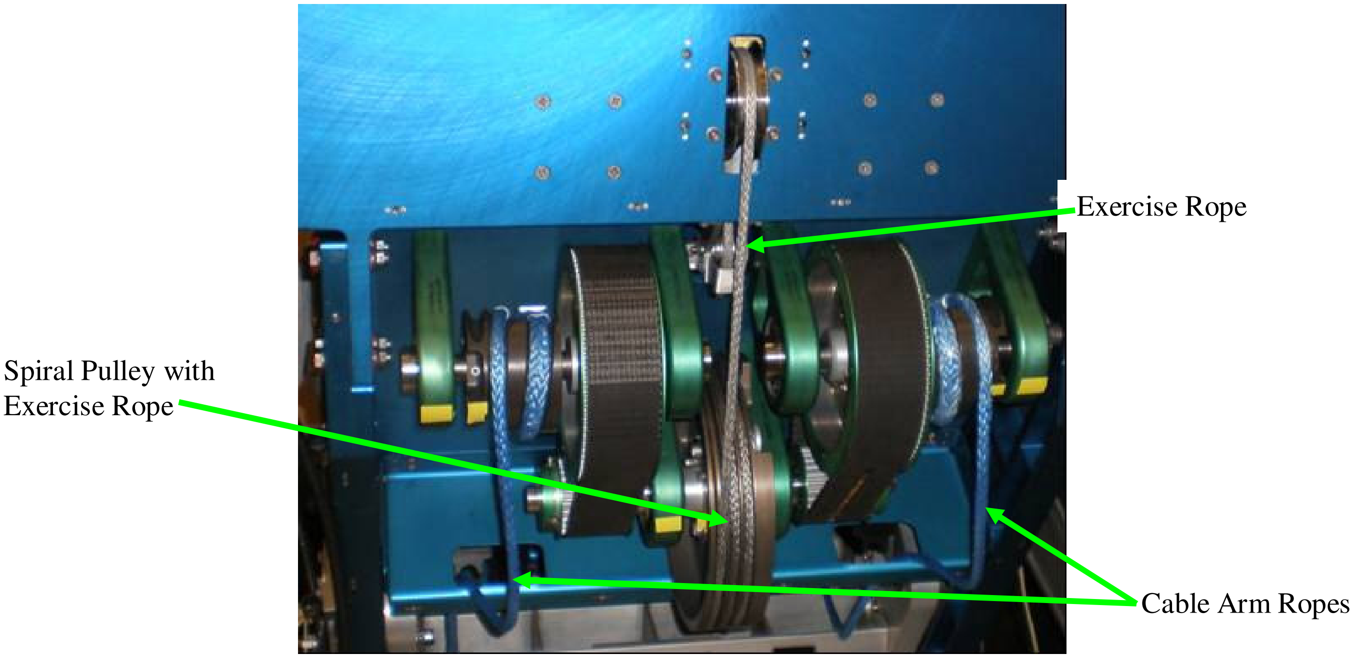

Figure 11. Belt Pulley

2.1.2.9 Exercise Bench

The Exercise Bench supports the crewmember's back. 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. Crewmembers 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.

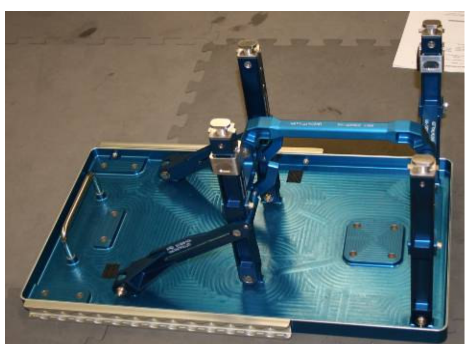

Figure 12. Exercise Bench

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 13. 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.

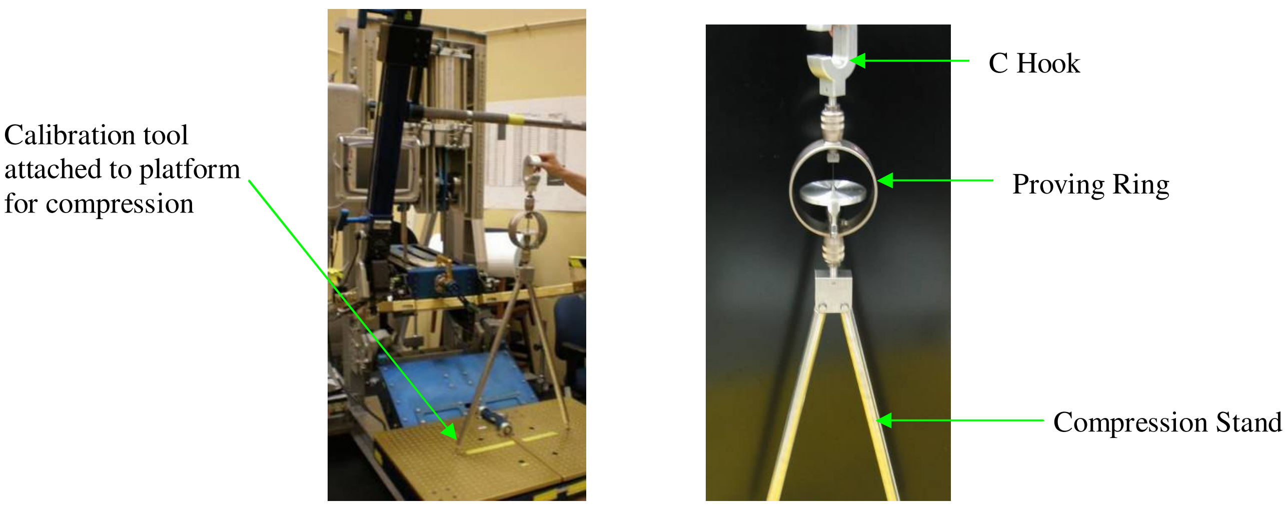

Figure 14. ARED Calibration Tool Installed for Compression Load Cells

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

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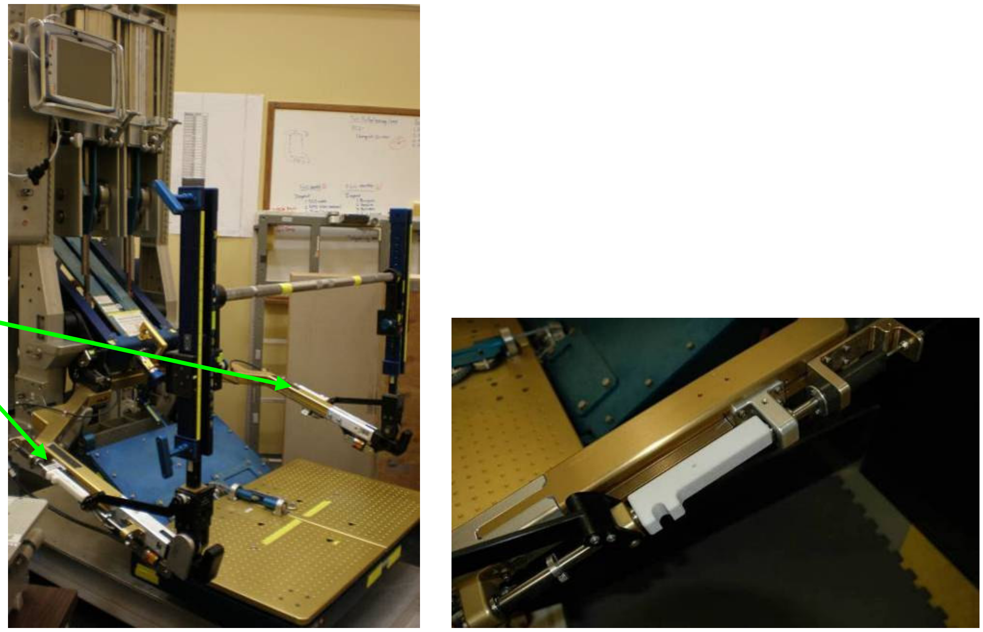

Figure 15. ARED Calibration Block Installed on Main Arm for Rotational Sensors

During calibration of the load cells in tension, the Tension Bracket, C Hook, Proving Ring, and Rope Eye Connecter 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.

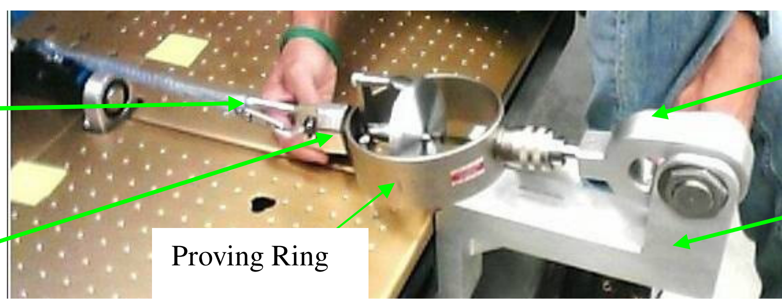

Figure 16. ARED Calibration Tool Installed for Tension Load Cells

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. Crewmembers select the icon with their picture and enter their PIN number keeping the system secure.

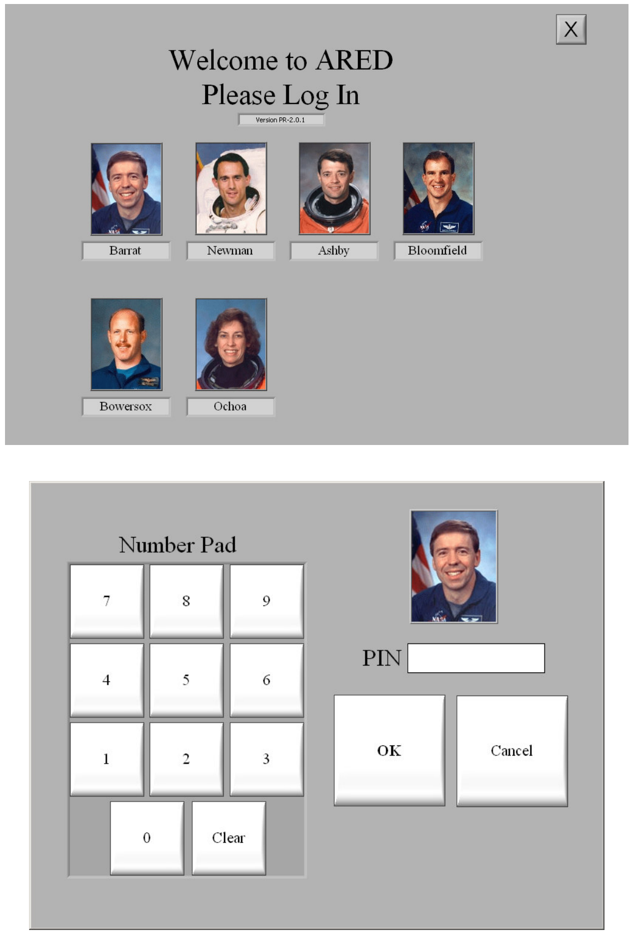

Figure 17. ARED Welcome Screen and Login

The most recent unused prescription file will open and they can begin exercising.

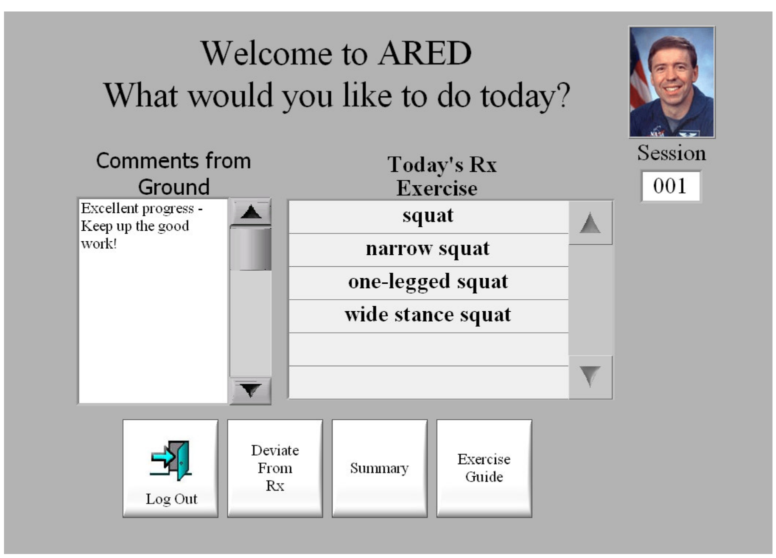

Figure 18. ARED Prescriptions

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

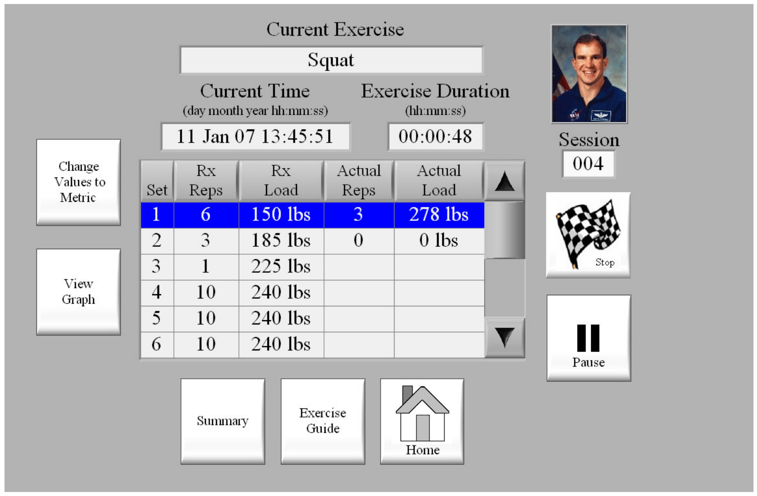

Figure 19. Data Recorded in Prescription File

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.

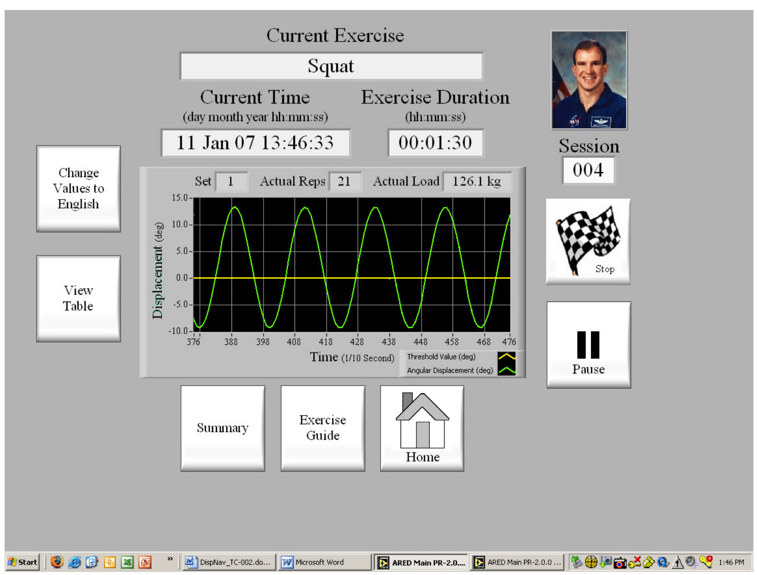

Figure 20. Current Exercise Screen showing Load Data Graph

Crewmembers may also choose to add exercises to their prescriptions. 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.

Power from station is provided through an A31p 120VDC Power Supply connected to a standard Utility Outlet Panel (UOP) in Node 1. 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.

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).

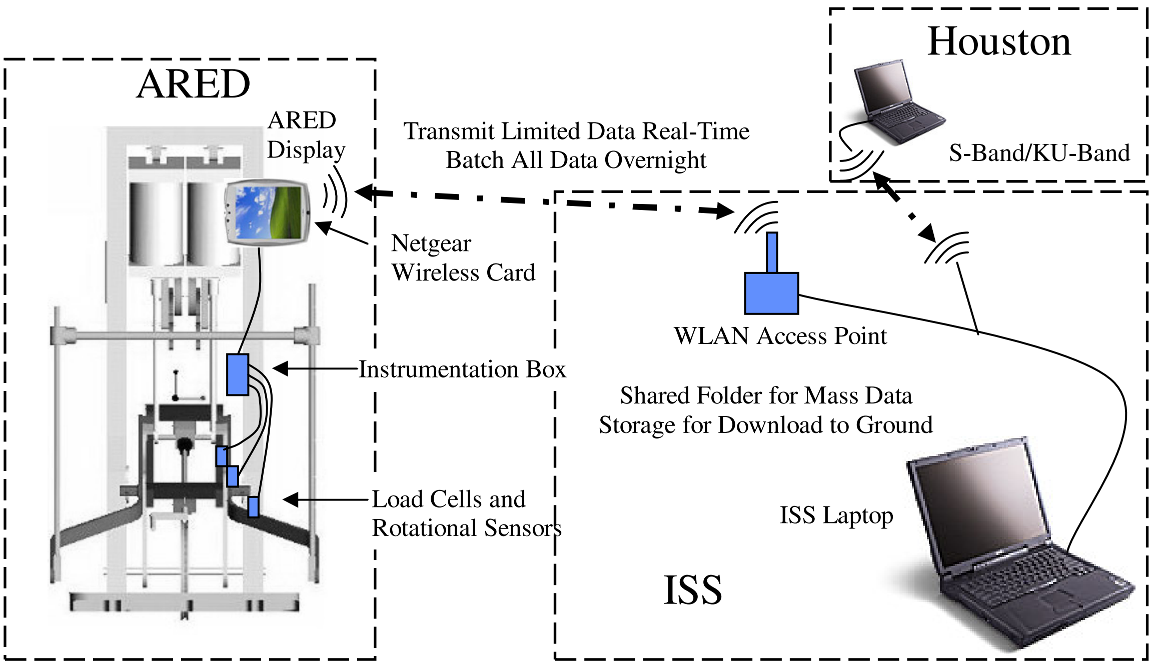

Figure 21. ARED Instrumentation System

2.1.4 Resupply Schedule

New Exercise Ropes, Cable Arm Ropes, and Exercise Bench Covers are flown up as-needed based on crew rotation and ARED cycle counts.

2.1.5 Hazard Concern

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

2.2. Blood Pressure/ Electrocardiograph (BP/ECG)

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.

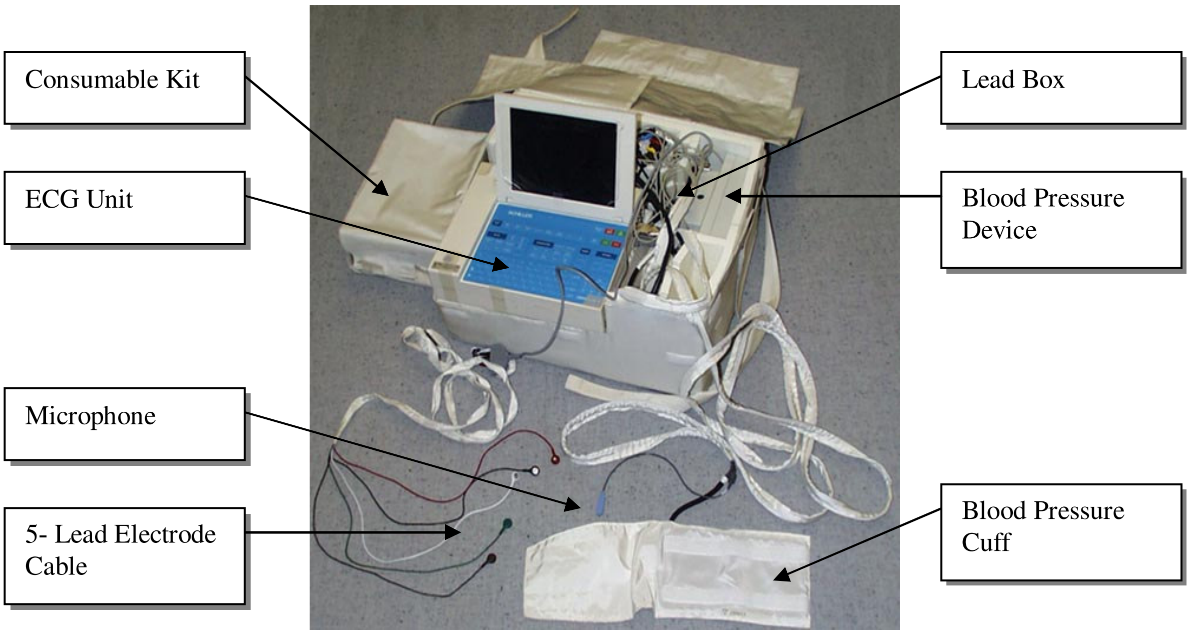

Figure 1. BP/ECG

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^3 (1.62 ft^3)	49.5 cm x 41.9 cm x 22.1 cm (19.5” x 16.5” x 8.7”)	JPM1F6_ E2	-31-52ºC (-25-125 ºF)	10-40º C (50-104 ºF)	13.5 - 15.2 psia
Consumable Kit	6.8 kg (15.0 lbs)	8009.2 cm3 (488.8 in3)	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. **Power cable is 20 feet in length.**
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)

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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.

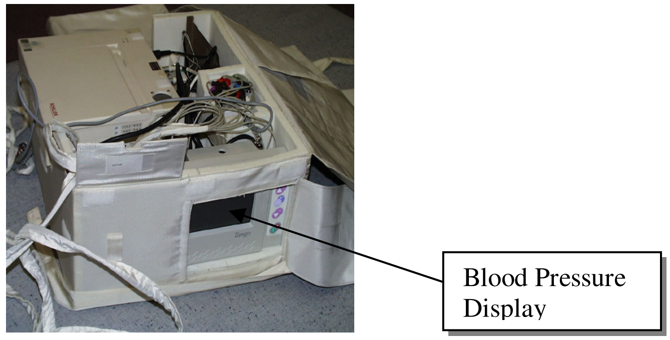

Figure 3. Blood Pressure Unit

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 4. 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

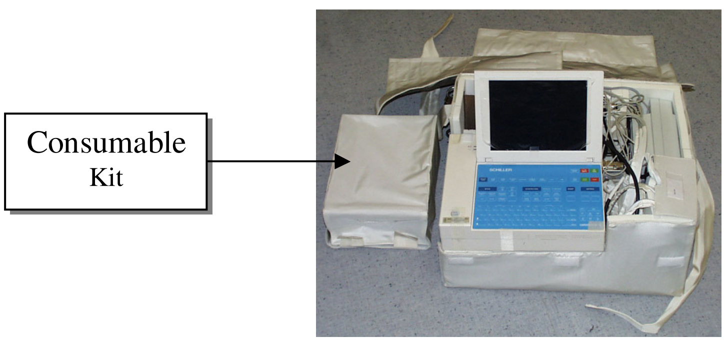

Figure 5. BP/ECG and Consumable Kit

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. 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 Arm Handle and Pedal Crank assemblies are attached with identical interfaces and can be changed out during an exercise session by a crewmember.

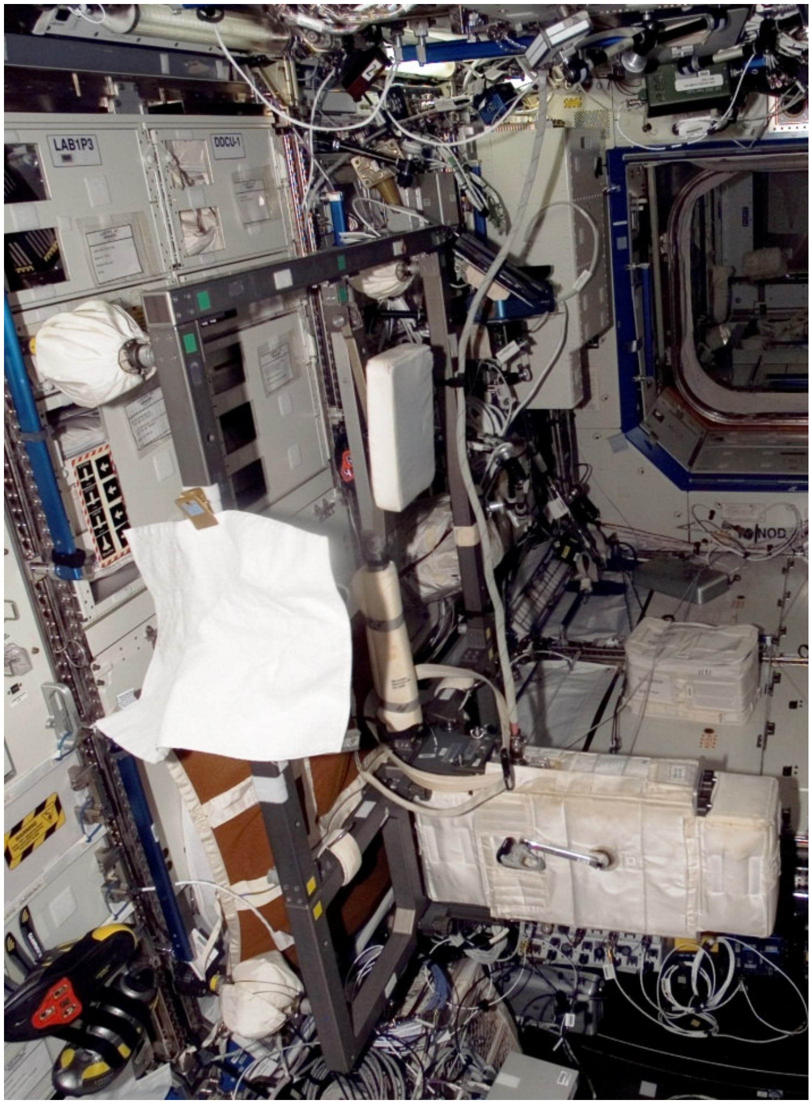

Figure 1. CEVIS side view (left)

2.3.2 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. Display/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 2.3.2-1 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)
CEVIS Assembly	179 lbs (81.19 kg)	Approx. 2.97 ft^3 (0.08 m^3)	N/A	US Lab 1P3	0-49 ºC (32-120 ºF)	0-49 ºC (32-120 ºF)	13.5 - 15.2 psia
CEVIS Ergometer	65 lbs		16.7 in x 7.2 in x 23.0 in	US Lab 1P3			
IVIS Box, red	25.1 lbs		12 in x 6 in x 6 in	US Lab 1P3			
IVIS Box, blue	28.8 lbs		12 in x 6 in x 6 in	US Lab 1P3			
On-orbit Mounting Frame	100.0 lbs		47 in x 18 in x 22 in	US Lab 1P3			
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	US Lab 1P3			
CEVIS Display Cable			78.7 inches long	US Lab 1P3			

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Table 2.3.2-2 Hardware-Specific Parameters

Power Requirements: Source	60 W: 120 VDC or 28 VDC
Measurement Parameters/ Capabilities	• Not to exceed 60 W • Power Usage: 113 – 126 VDC • Display/Control use: 5 VDC and 12 VDC • Workload range: 25 – 350 Watts • Cycling Speeds Range: 30 – 120 rpm for manual controller 50 – 120 rpm for electronic controller • Sensor Error: ± 2%

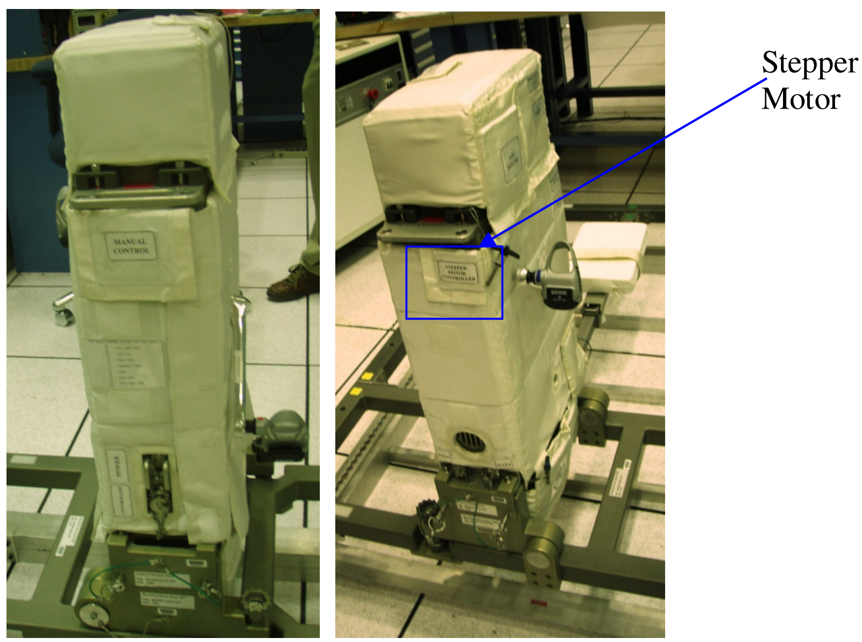

Figure 2. CEVIS Tower (front, back)

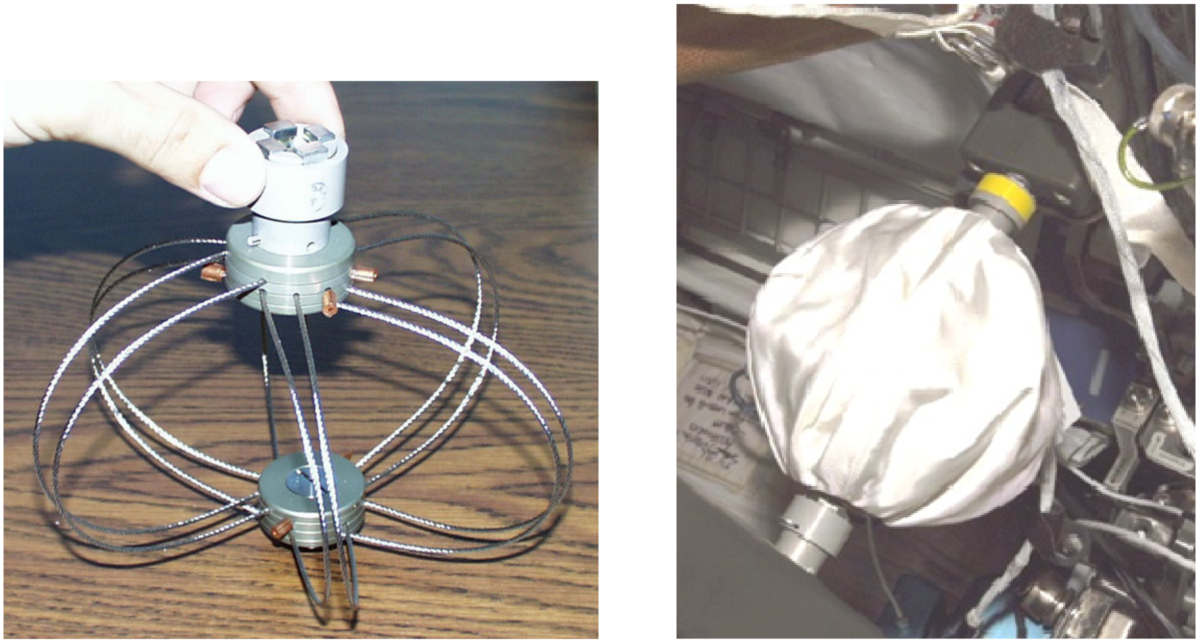

Figure 3-4. CEVIS Isolator Assembly (6" Shown)

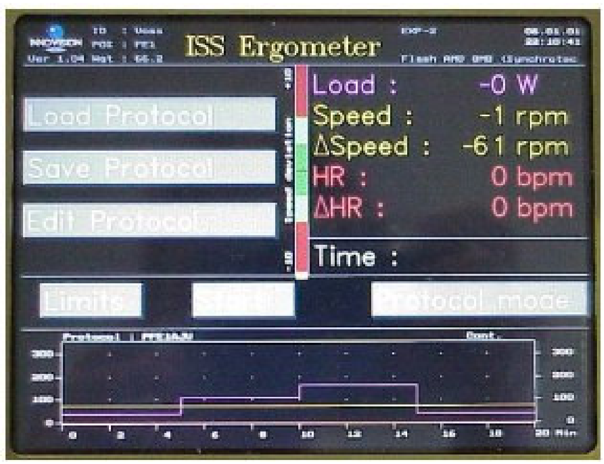

Figure 5. CEVIS Control Panel

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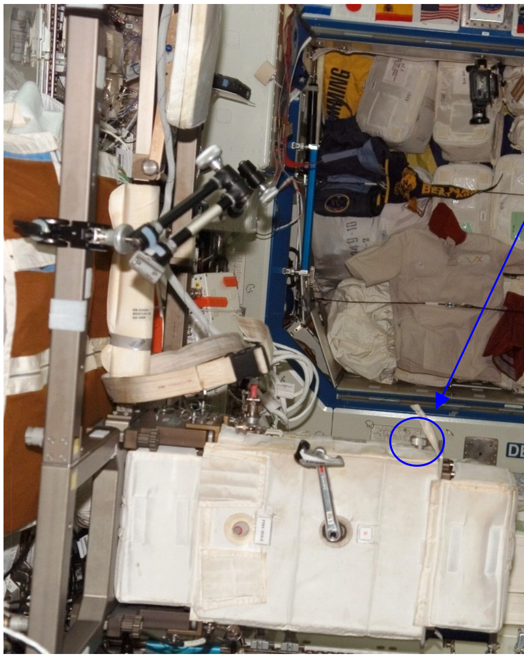

Figure 6. CEVIS Tower (front)

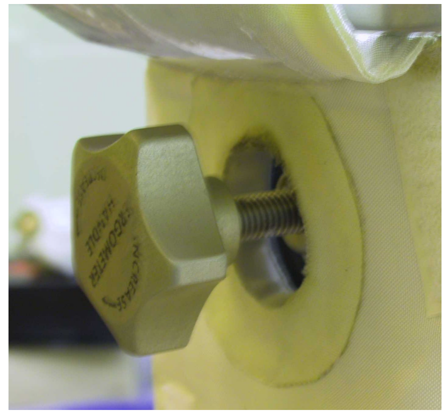

Figure 7. Manual Control Knob

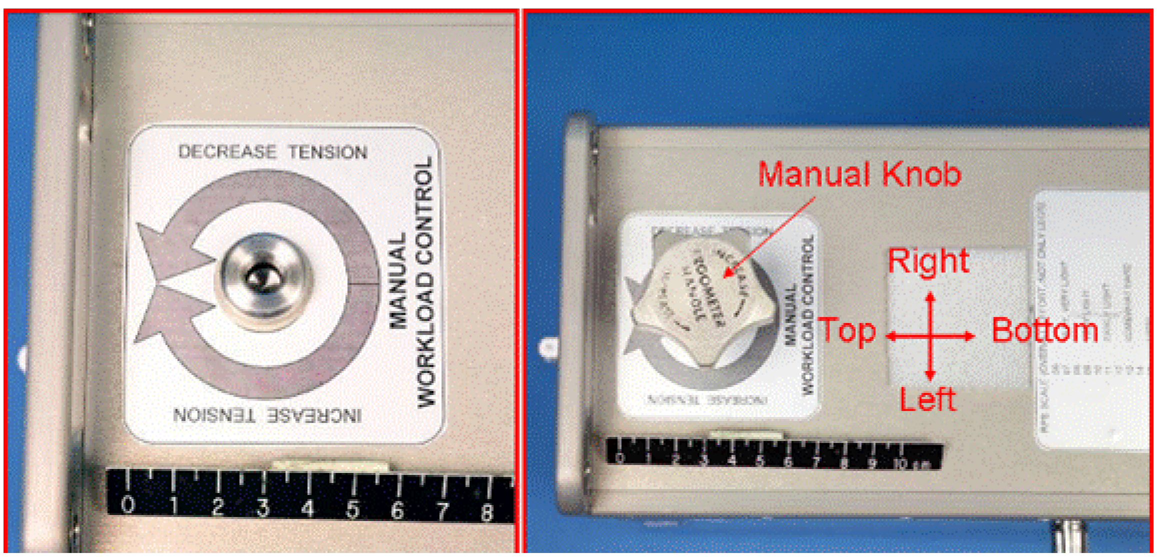

Figure 8. Manual Workload Control with Acoustic Cover removed

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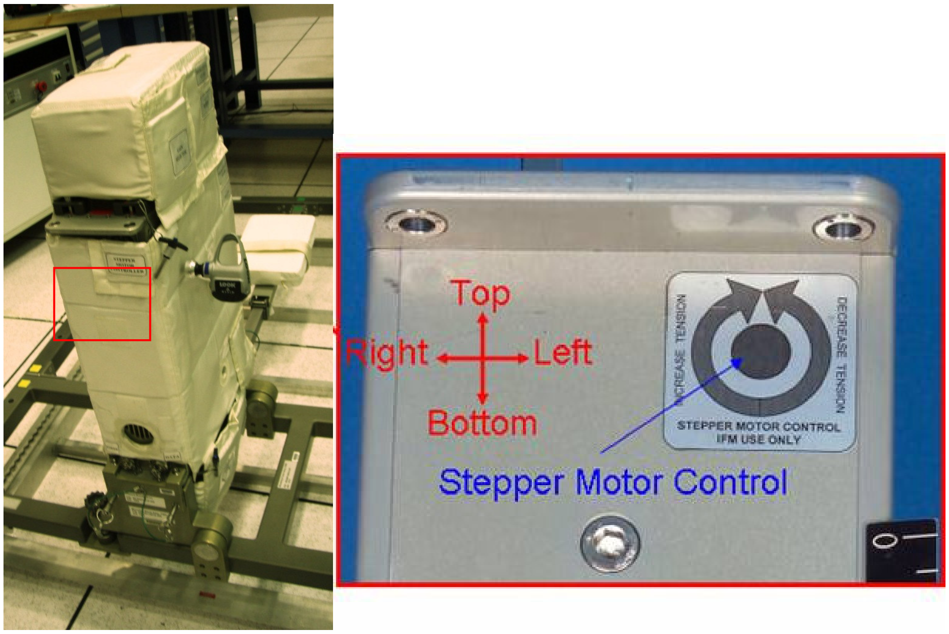

Figure 9. Stepper motor

Figure 10. Stepper Motor punctured

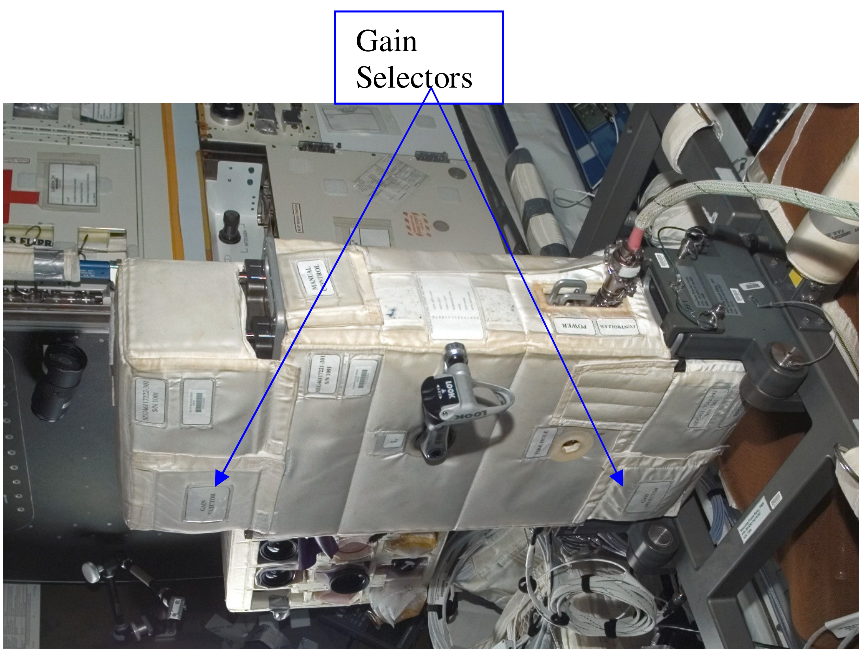

Figure 11. Gain Selectors

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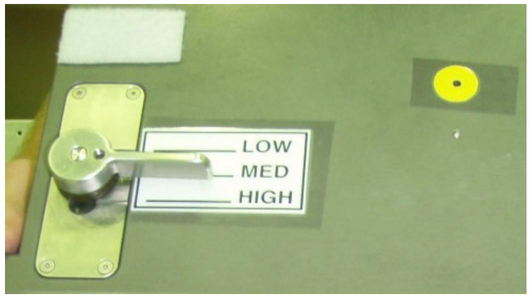

Figure 12. Gain Selector (cover off)

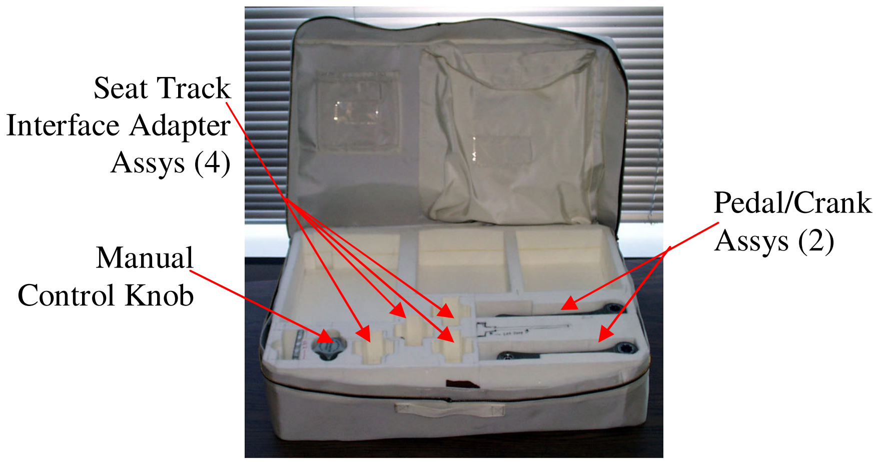

Figure 13. CEVIS Accessory Kit

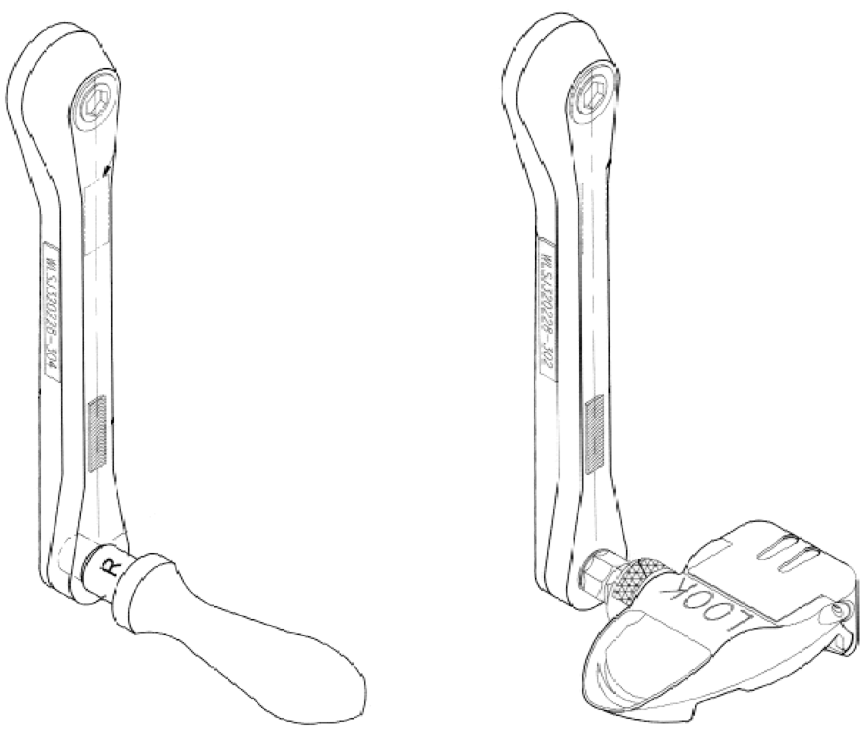

Figure 14. Arm Handle and Pedal Crank Assemblies

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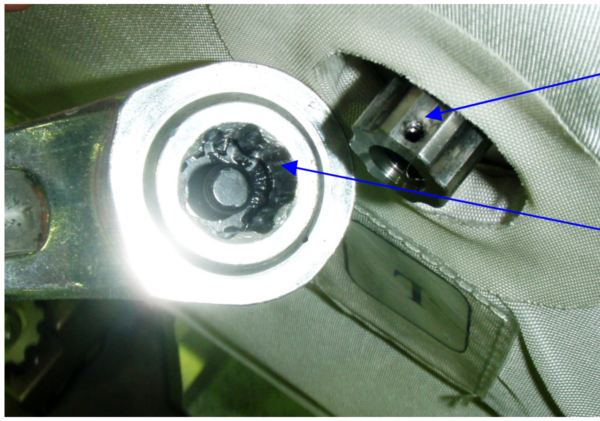

Figure 15. Left Pedal Crank Installation

2.3.3 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 LAB1_P3.

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.

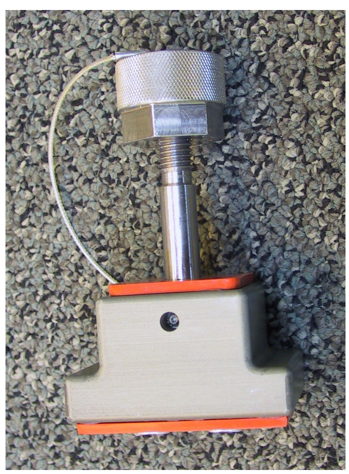

Figure 16. Hard Mount Stud Assembly

2.3.4 Resupply Schedule

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

2.3.5 Data/Commanding Capabilities

Data is downlinked through the MEC.

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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 contingences.
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.

2.3.6. Hazard Concerns

Reference "CEVIS Phase II Safety Review" data packages.

2.3.7. CEVIS Contingency Controller (CCC)

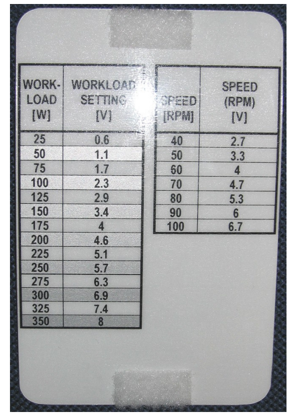
During Expedition 6, the CEVIS Display/Control Panel failed. On 15P, a CEVIS Contingency Controller was flown. The CEVIS Contingency Controller is kept onboard in case of CEVIS Display/Control Panel failure.

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 the Ergometer is providing in 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 (Bogan arm).



WORK-LOAD [W]	WORKLOAD SETTING [V]
25	0.6
50	1.1
75	1.7
100	2.3
125	2.9
150	3.4
175	4
200	4.6
225	5.1
250	5.7
275	6.3
300	6.9
325	7.4
350	8

SPEED [RPM]	SPEED (RPM) [V]
40	2.7
50	3.3
60	4
70	4.7
80	5.3
90	6
100	6.7

Figure 17. CEVIS Contingency Controller and reference Card

Figure 18. CEVIS Contingency Controller Installed On-Orbit

2.4 Heart Rate Monitor 2 (HRM2)

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.

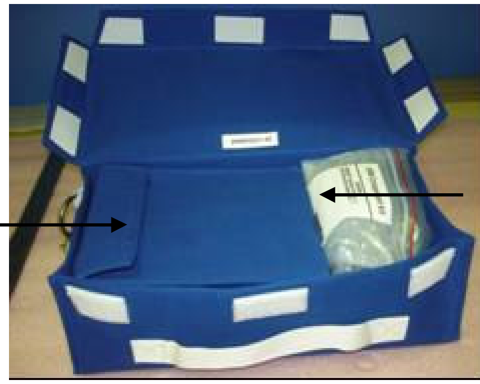


Figure 1. Heart Rate Monitor Kit

2.4.2. Component List and Description

- Heart Rate Monitor Kit contains:

    i. 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)

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ii. 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)

iii. 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^3 (444.4 in^3)	32.8 x 16.5 x 13.5 (cm) (12.9" x 6.5" x 5.3")	LAB1S4_ A1	0-50ºC (32-122 ºF)	0-50º C (32-122 ºF)	13.5 - 15.2 psia
HRM Resupply Kit	0.64 kg (1.42 lbs)	126 in3	15.2 x 7.6 x 17.8 (cm) (3" x 6" x 7")	LAB1S4_ A1			
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")	LAB1S4_ A1			
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")	LAB1S4_ A1			
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")	LAB1S4_ A1			
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	LAB1S4_ A1			

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

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 with watches, transmitters, and chest straps 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, time of day.
- Data downloaded from watch to MEC via HRM/MEC Interface Device.
- 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 or CEVIS control panel.
- Heart rate data 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 or TVIS display.
- 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.*
(http://ea.jsc.nasa.gov/eawebfiles/ea-projects/flightgfe/HRM2/HTML/HRM2.htm)

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 up link/down link 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^3	10.8” x 13” x 2”	Deployed LAB1S4	10 – 35° C (50 – 95 ºF)	10 – 25° C (50 – 95 ºF)	13.5 – 15.2 psia
MEC Kit			Ziploc	NOD1D4_ K1	10 – 35° C (50 – 95 ºF)		
MEC Software Kit				Inside MEC Kit	10 – 35° C (50 – 95 ºF)		

2.5.2.1. MEC Description

Table 2.5.2.1-1 Hardware-Specific Parameters

Power Requirements	20 VDC, <40W
Power Source	• 28 VDC or 120 VDC • Rechargeable Battery (Internal)
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 contain 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
- 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)

2.5.3. 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

2.5.6. *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.

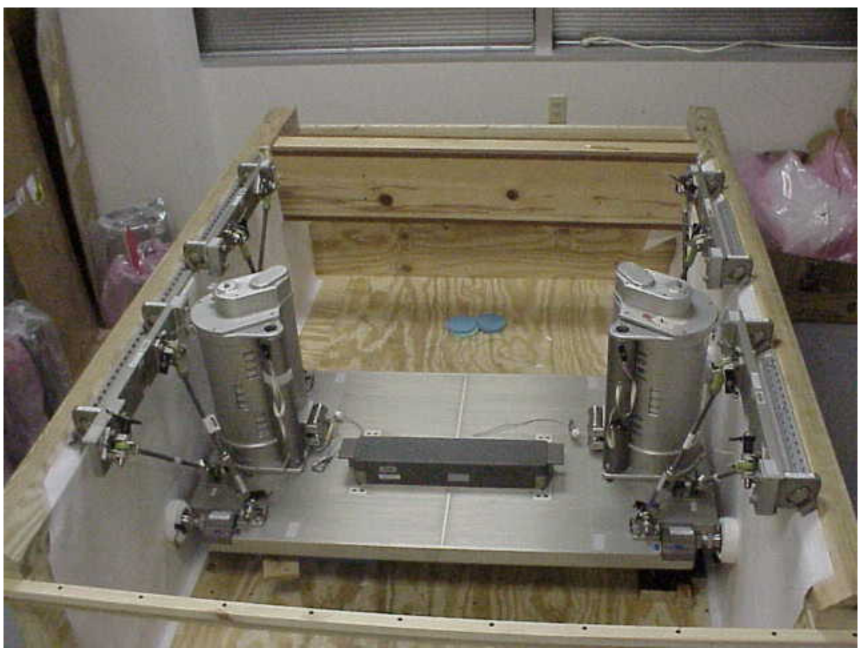

Figure 1. RED Assembled in Wooden Node 1 Mock-up

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)

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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)	Pre-ARED Stowage Location	Storage Temp °C (°F)	Operating Temp °C (°F)	Operating Pressure mmHg (psia)
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^3	51" x 28" x 1.9"	Node 1, Zenith Alcove			
RED Removable Heel Block		~220 in^3	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^3	18.5" x 11.5" x 8.38"	NOD1D4			
RED Accessory Kit		1.54 ft^3	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) ± 2 lbs. (4.5 – 113.5 Kg ± 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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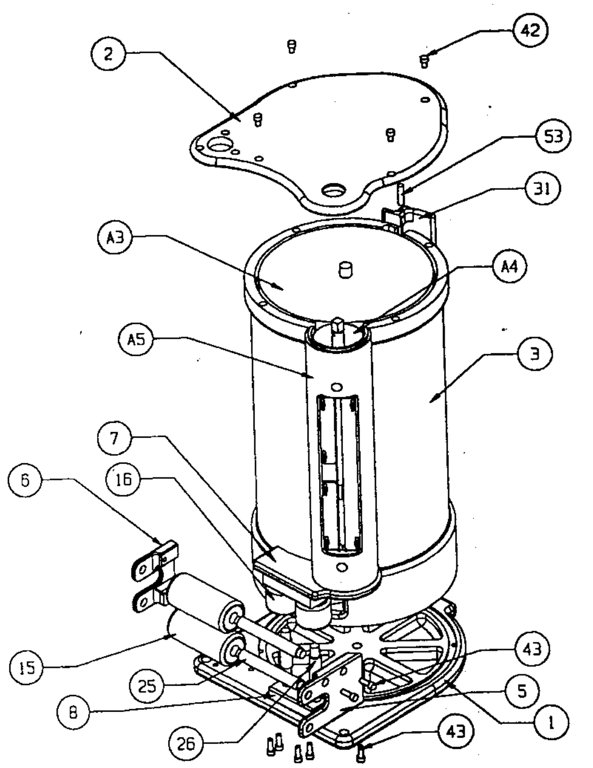

Figure 2. RED Assembly and its external components

Figure 3. RED Assembly Internal Stack

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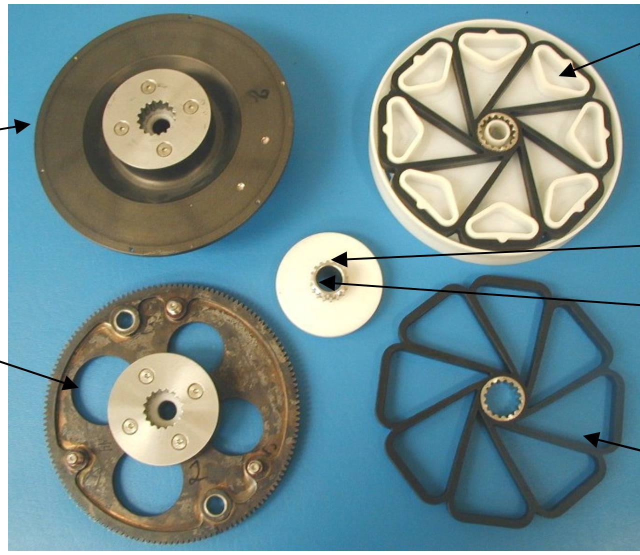

Figure 4. Flexpack Assembly Components

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.

Item	Quantity	Notes
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

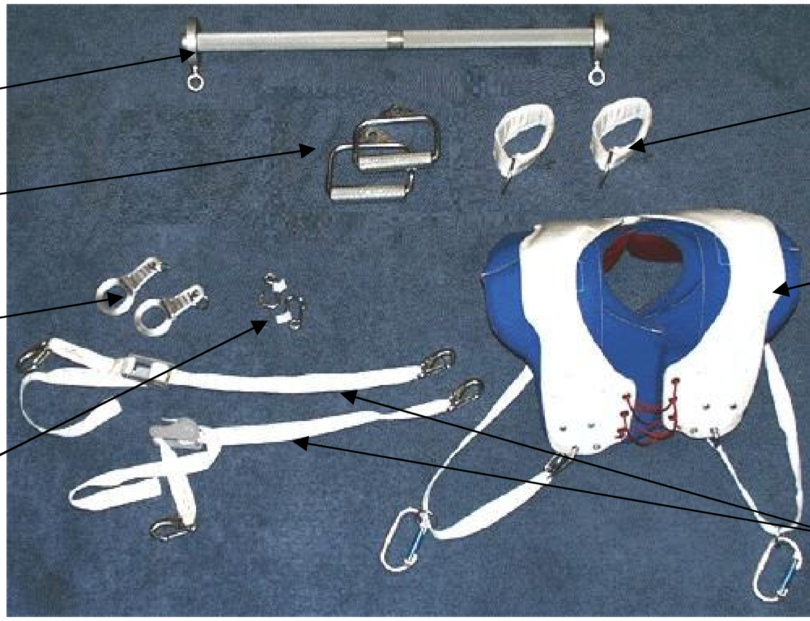

Figure 6. RED Accessories

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.

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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).

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 or Y-Straps to the Harness. They then connect the Subject Load Devices (SLDs) - if in use - to the SBSs, and the Subject Positioning Devices (SPDs) – if in use - to the harness, and begin exercise. 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 Operations

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 2.7.2-1 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:	**Display Parameter**	**Units**	**Range**	**Precision**
	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
	Control Parameter	**Units**	**Range**	**Precision**
	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).

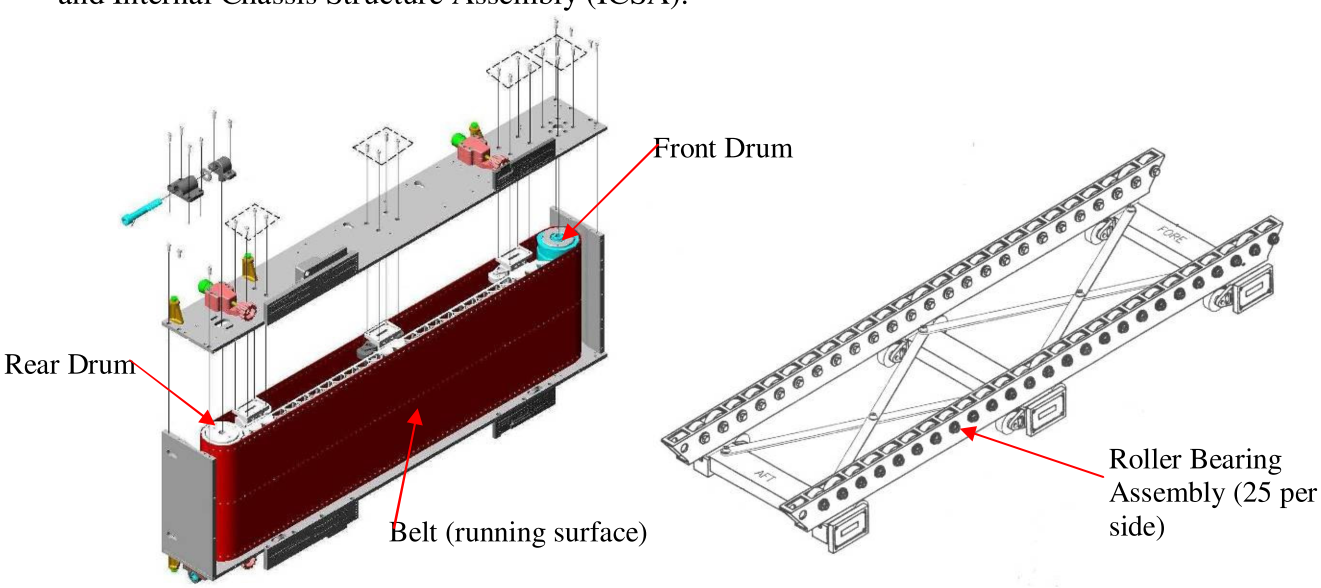

Figure 2. Treadmill Assembly and ICSA

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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.

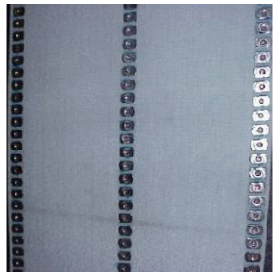

Figure 3. Belt Underside with Weld Nuts

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. Bearings are considered consumables and life is tracked in treadmill usage (duration, loading and speed) hours to determine when bearings must be swapped. Only 10 center-most bearings on each side, which receive the majority of loading, are replaced via center of truss structure.

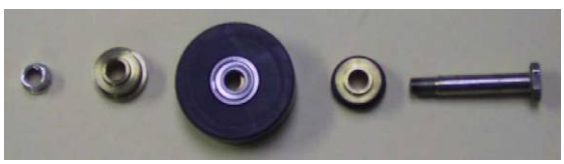

Figure 4. Roller Bearing Assembly

2.7.2.2. Closeout Panels

There are 4 Closeout Panels, two Forward and (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 only has 2 out of 3 fasteners present.

Figure 5. Forward Closeout Panel

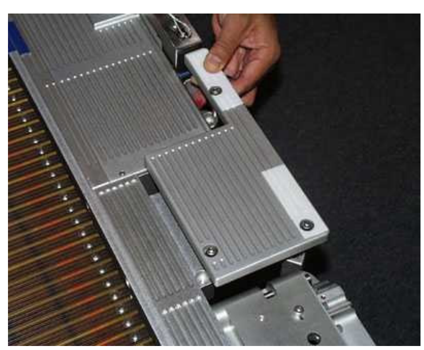

Figure 6. Aft Closeout Panel

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2.7.2.3. 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.

2.7.2.4. Control Panel

The Control Panel is suspended in front of TVIS from SM 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.

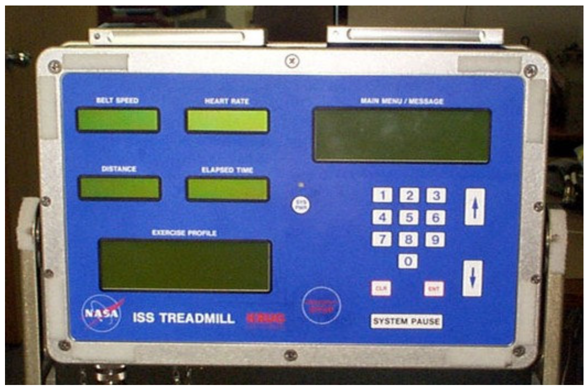

Figure 7. TVIS Control Panel

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.

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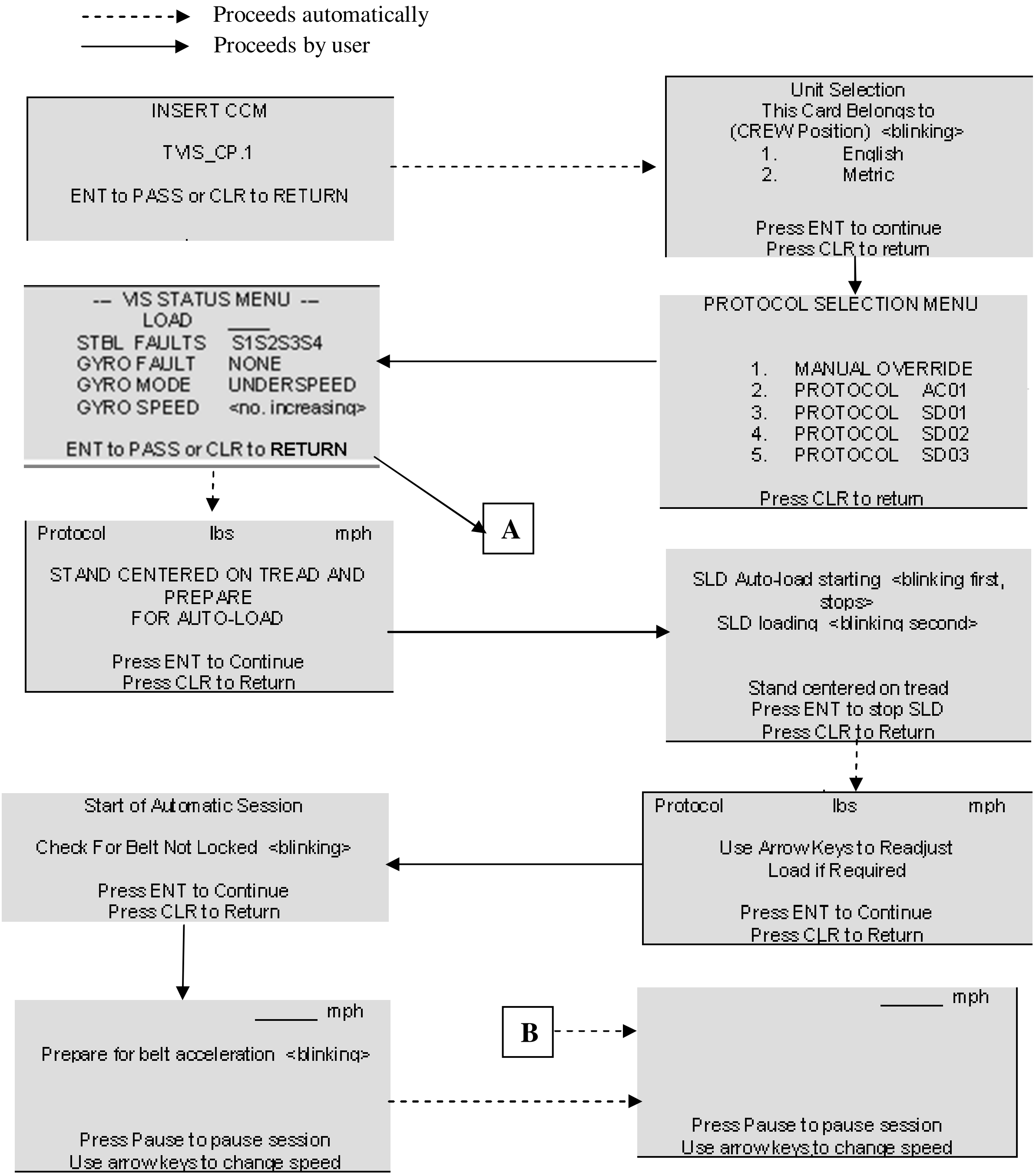
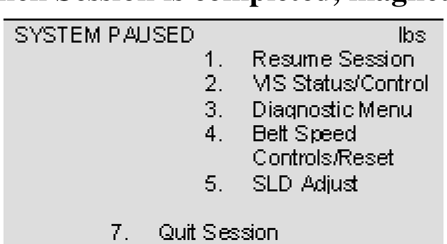
2.7.2.4.1. *Control Panel Flowchart*



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



From SYSTEM PAUSED menu:

Trainer: Bob Tweedy (281) 212-1400 robert.tweedy-1@nasa.gov
Ops Rep: Katy Sproule (281) 244-2376 katy.m.sproule@nasa.gov
HW Engr: Melissa Murray (281) 483-2419 melissa.m.murray@nasa.gov & Pat Bevill (281)244-7348 pat.bevill-1@nasa.gov
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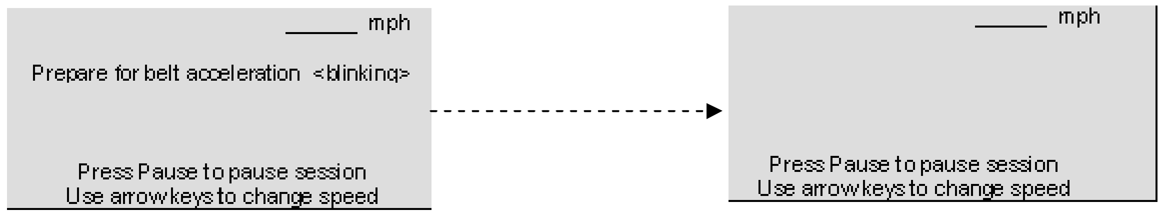
PB 1, ENT:



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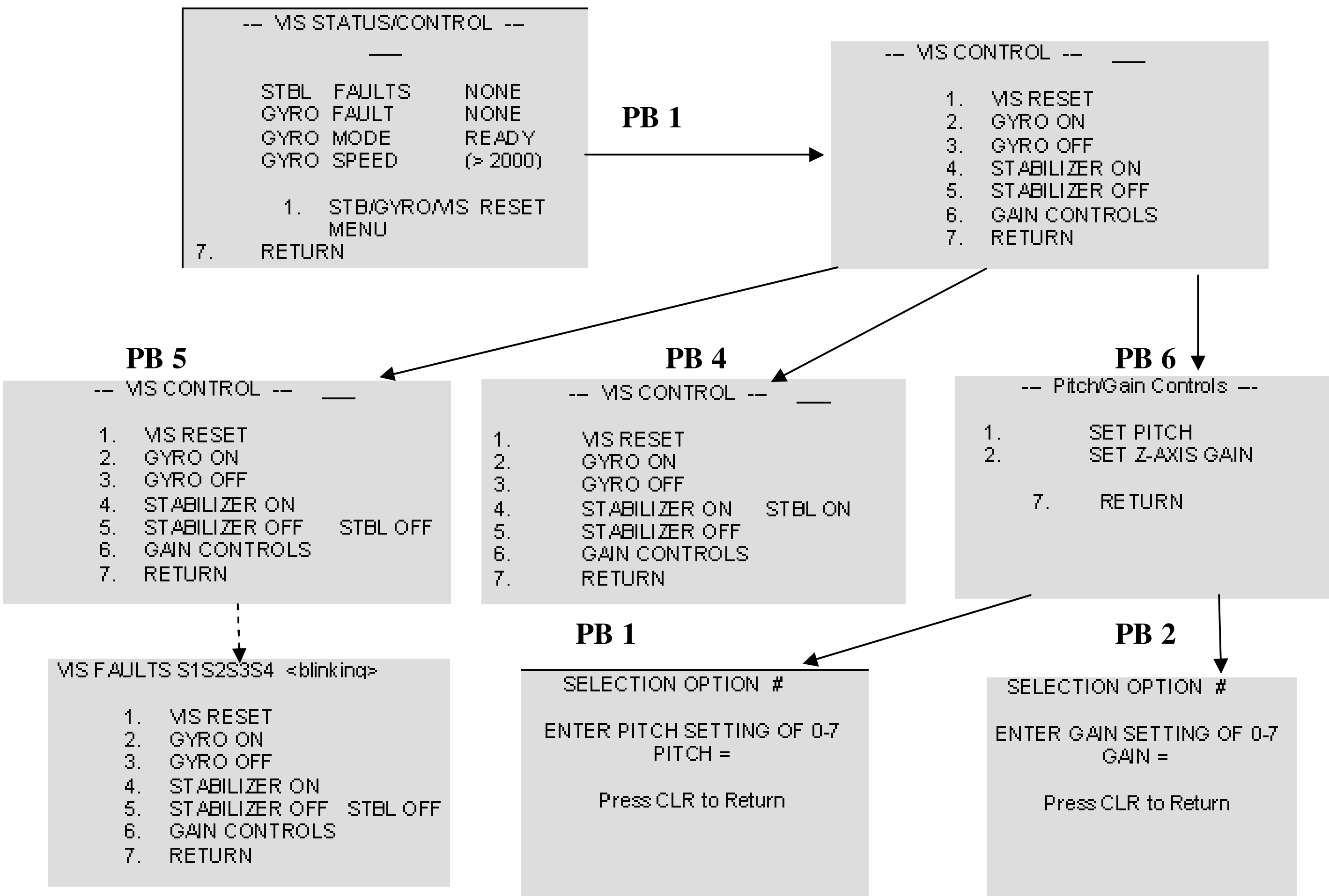

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PB 3, ENT:

SELECTION OPTION # ___

1. SYSTEM STATUS =
2. GET DATE/TIME = XX:XX:XX
3. SLD LOAD = ##
4. ELE BOX REV =
5. TREAD VOLTS = ##
6. TREAD AMPS = ##
7. NEXT MENU

PB 1, ENT

SELECTION OPTION # ___

1. SYSTEM STATUS = **Mot Stb Gyro**
2. GET DATE/TIME = XX:XX:XX
3. SLD LOAD = ##
4. ELE BOX REV =
5. TREAD VOLTS = ##
6. TREAD AMPS = ##
7. NEXT MENU

PB 4, ENT

SELECTION OPTION # ___

1. SYSTEM STATUS =
2. GET DATE/TIME = XX:XX:XX
3. SLD LOAD = ##
4. ELE BOX REV = **TVIS EB.1**
5. TREAD VOLTS = ##
6. TREAD AMPS = ##
7. NEXT MENU

PB 7, ENT

SELECTION OPTION #

1. VIS VOLTS = ##
2. STBL AMPS = ##
3. GYRO AMPS = ##
4. ELEC BOX TEMP = ##
5. MOTOR TEMP = ##
6. SET SYS TIME
7. EXIT

PB 6, ENT

hh mm ss

ENTER NEW TIME

Press Down Arrowto Skip
Press ENT to continue
Press CLR to return

Da Mo Dt Yr

ENTER NEW DATE

Press Down Arrowto Skip
Press ENT to continue
Press CLR to return

PB 4, ENT:

BELT SPEED CONTROL/RESET

NOTE: Selecting 1 will reset the values in the 'Elapsed Time' and 'Distance' windows of the Control Panel.

1. Reset Time & Distance
2. Motorized Session
3. Passive Session

7. Return

PB 2

Protocol ____ lbs ____ mph

Enter desired belt speed
Enter 0.0 if Passive Session

Check For Belt Not Locked <blinking>

Press ENT to Continue
Press CLR to Return

Prepare for belt acceleration <blinking>

Press Pause to pause session
Use arrow keys to change speed

Press Pause to pause session
Use arrow keys to change speed

PB 3

Start Passive Session <blinking>

Press Pause to pause session
PASSIVE SESSION <blinking>

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PB 5, ENT:

Protocol lbs

STAND CENTERED ON TREAD
ENTER DESIRED SUBJECT LOAD

Press ENT to Continue
Press CLR to Return

Protocol lbs mph

Prepare for SLD loading <blinking>

Press ENT to Continue
Press CLR to Return

Protocol lbs mph

SLDs loading <blinking>

Press ENT to Continue
Press CLR to Return

Protocol lbs mph

Use arrow keys to readjust
load if required

Press ENT to Continue
Press CLR to Return

PB 7, ENT:

Protocol Selected

STAND CENTERED ON TREAD
FOR FINAL SUBJECT LOAD
DETERMINATION

Press ENT to Continue
Press CLR to Return

Please Remove CCM Card

EXERCISE COMPLETE

INSERT CCM

TVIS CP.1

ENT to Pass or CLR to Return

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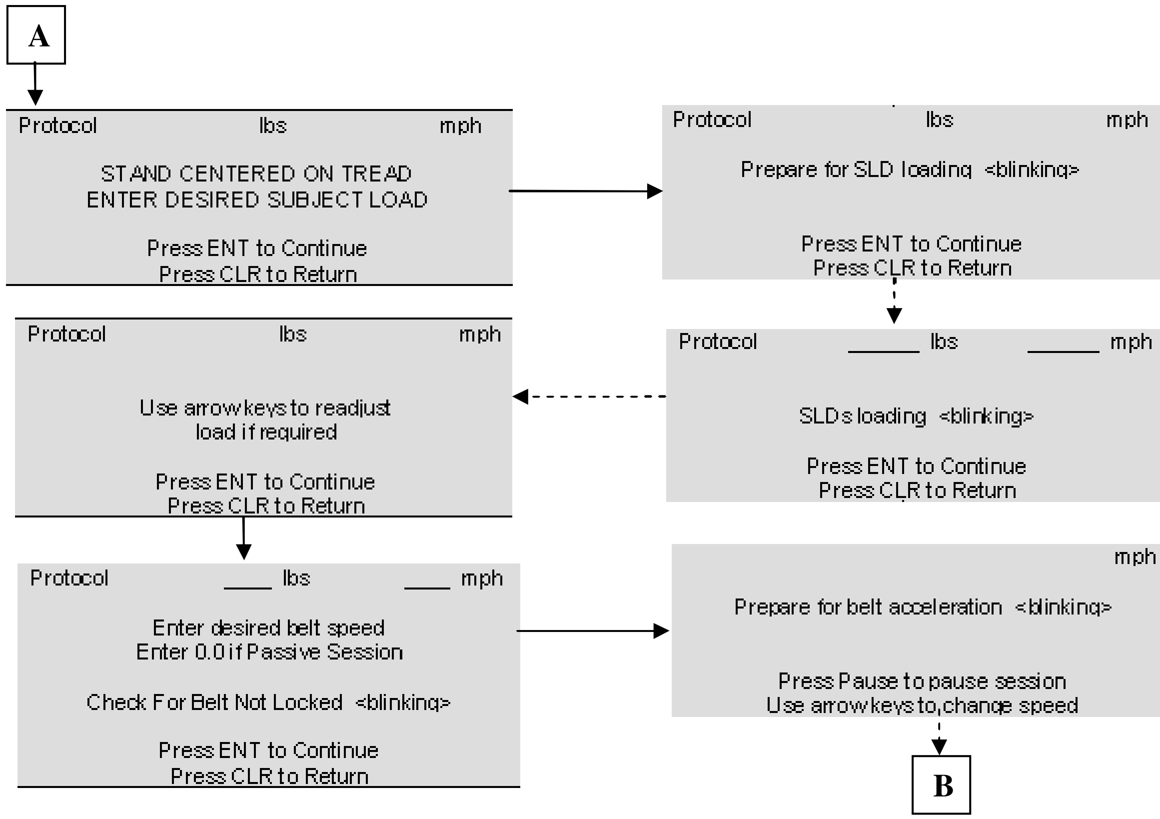


2.7.2.5. Electronics Box

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 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)

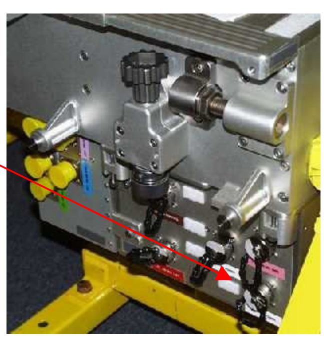


Figure 8. Treadmill Aft, Left

Battery Door

Re-settable Circuit Breakers

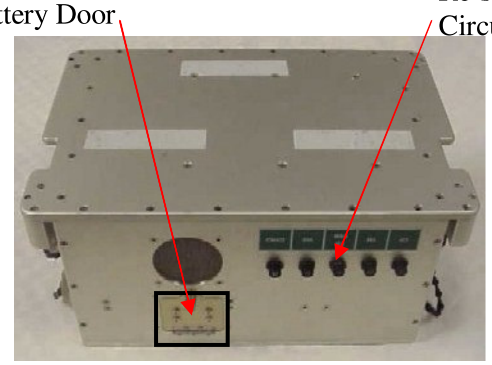
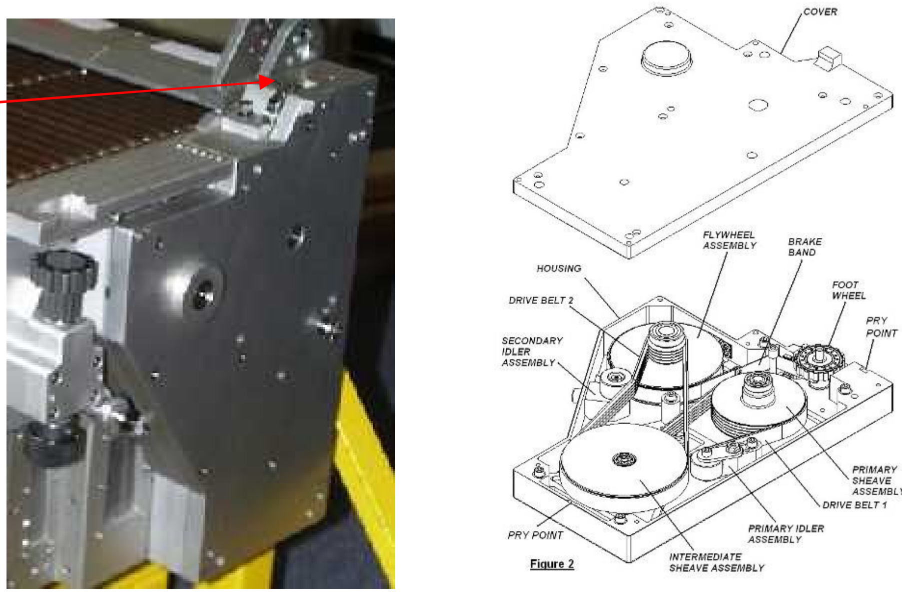


Figure 9. Electronics Box

Figure 10. Battery

2.7.2.6. 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.

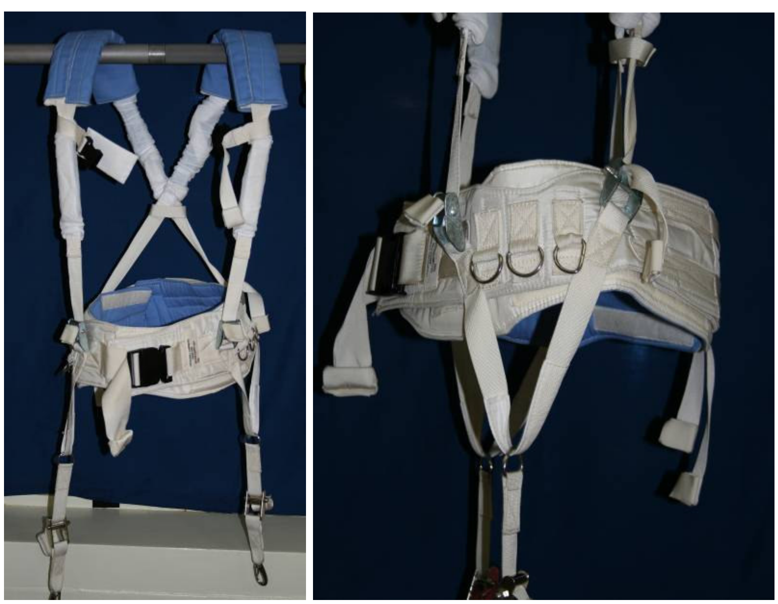


Figures 11-12. Flywheel Case

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

2.7.2.7. Treadmill Harness

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



Figures 13-14. Treadmill Harness – Front View and Side View

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2.7.2.8. 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.

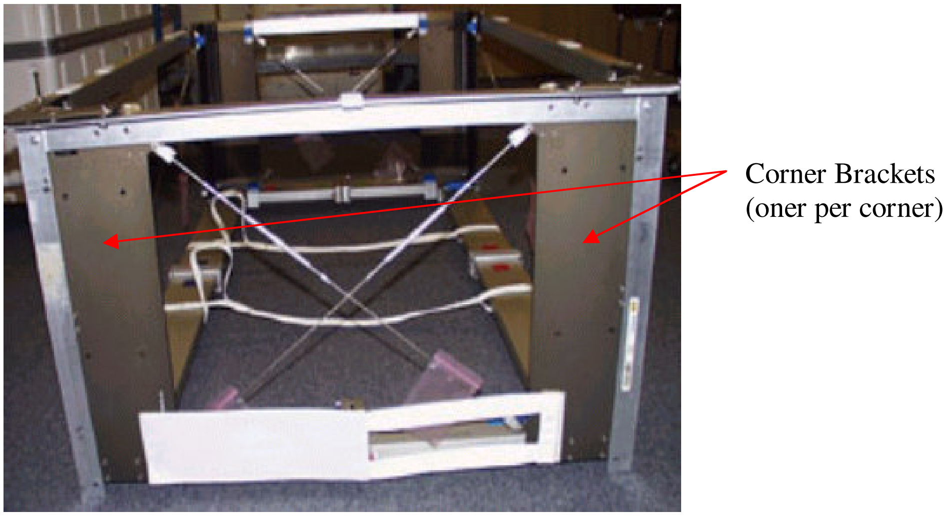


Figure 15. TVIS Isolation Cage

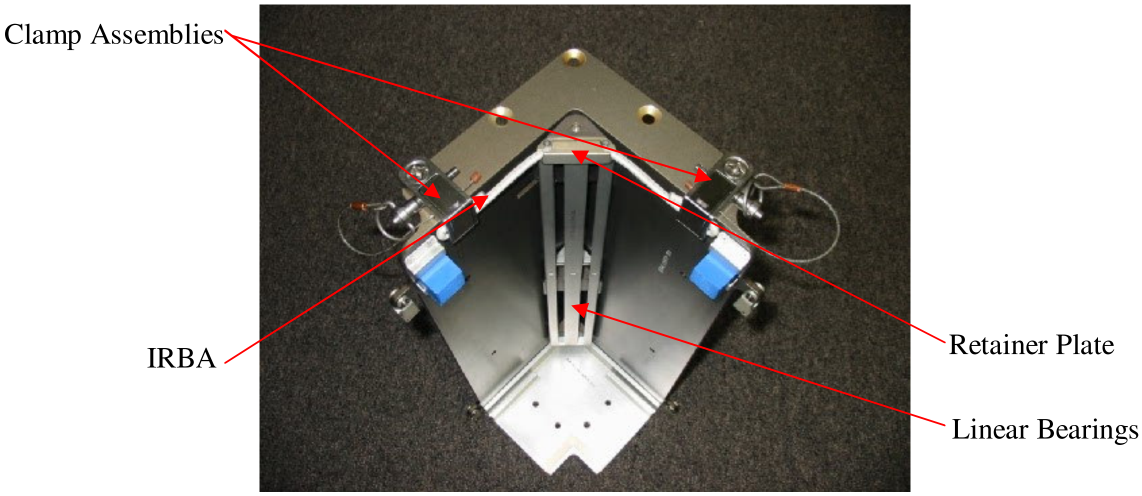


Figure 16. Corner Bracket

2.7.2.9. 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, or in series with Series Bungee System (SBS) Assemblies to achieve smoother loading. The SLDs are changed out periodically and calibrated for use with each individual Electronics Box.

Figure 17. 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.

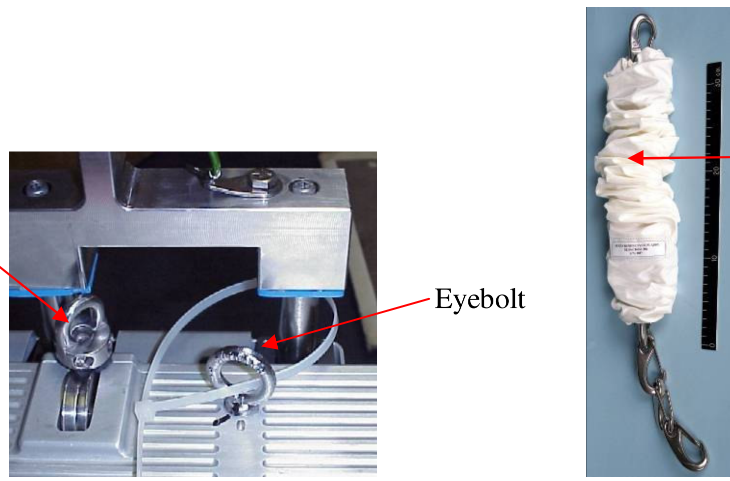


Figure 18. SLD Eyebolt

2.7.2.10. 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).

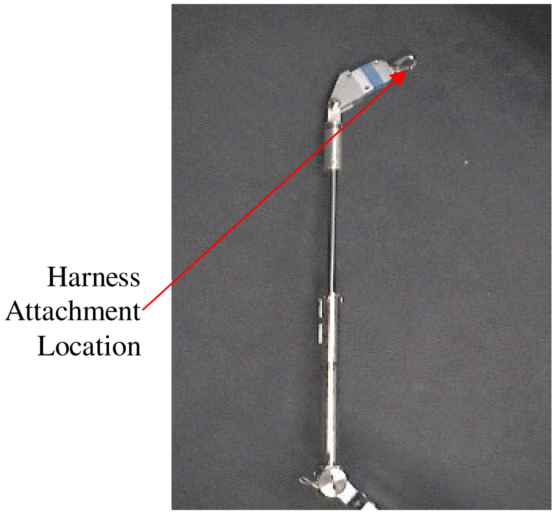


Figure 19. SPD Top

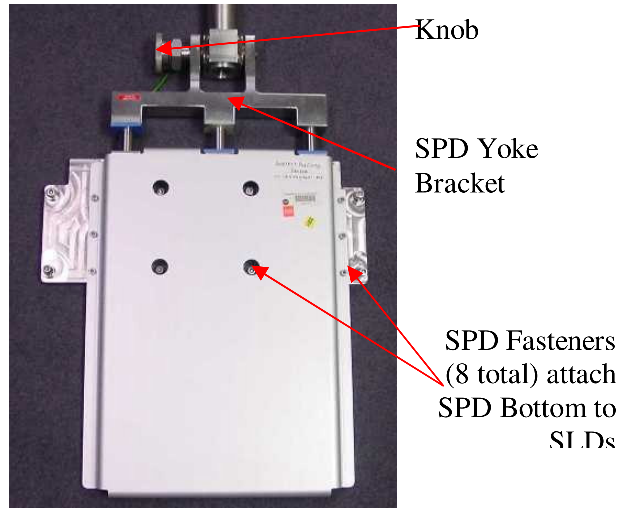
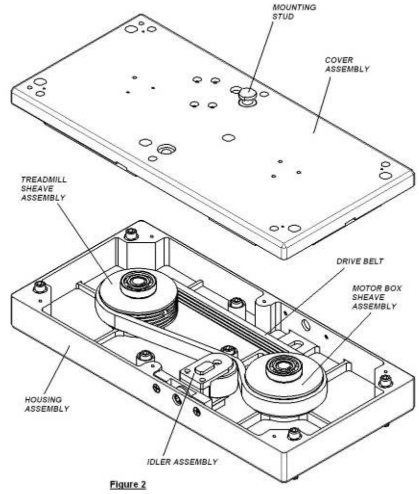


Figure 20. SPD Bottom

Figure 21. SPD Extension Assembly

2.7.2.11. Transfer Case

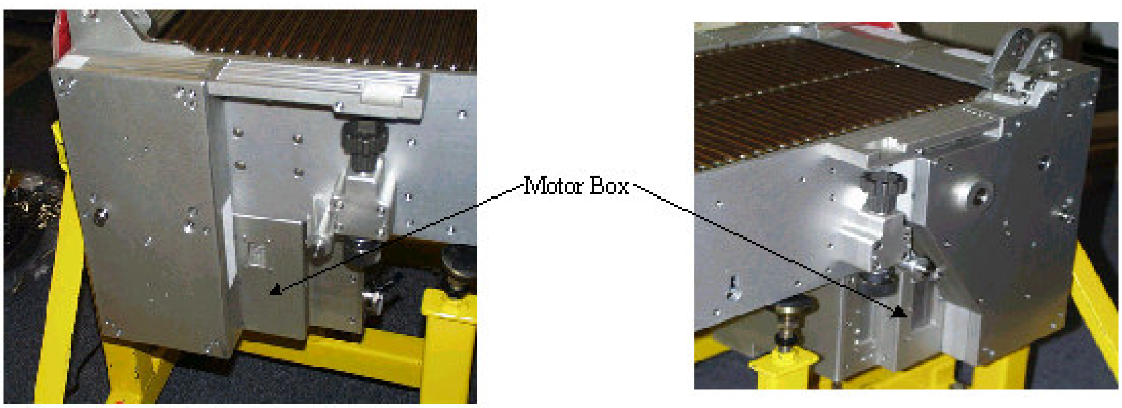
The Transfer Case is at the forward, left end of Treadmill Assembly and interfaces with the Motor Box and Treadmill Belt Front Drum via spline shafts. The transfer case transmits torque output from the motor to the front drum of the Treadmill to turn the belt.



Figures 22-23. Transfer Case

2.7.2.12. 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 24-25. Treadmill Motor Box (view of both sides)

2.7.2.13. 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 control internal throw masses. The four stabilizers can each be installed on any corner.

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.

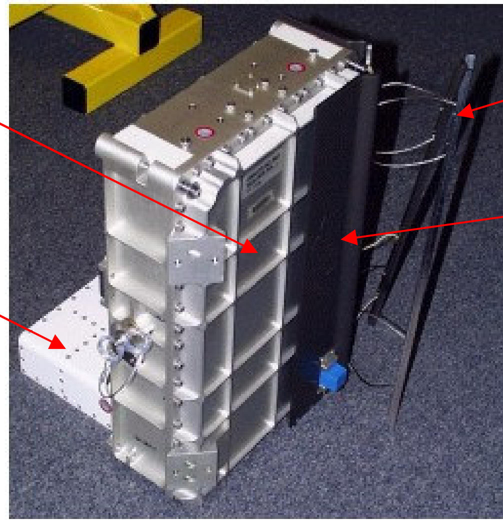


Figure 26. Stabilizer with Corner Bracket Ropes

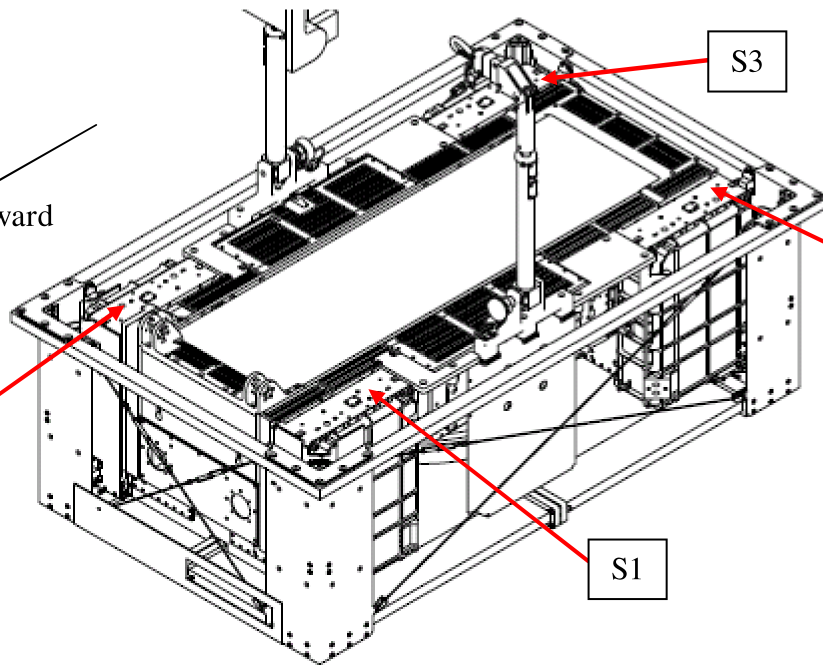


Figure 27. Stabilizers labeled according to software

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. VIS Controller processes the Gyroscope RPM.

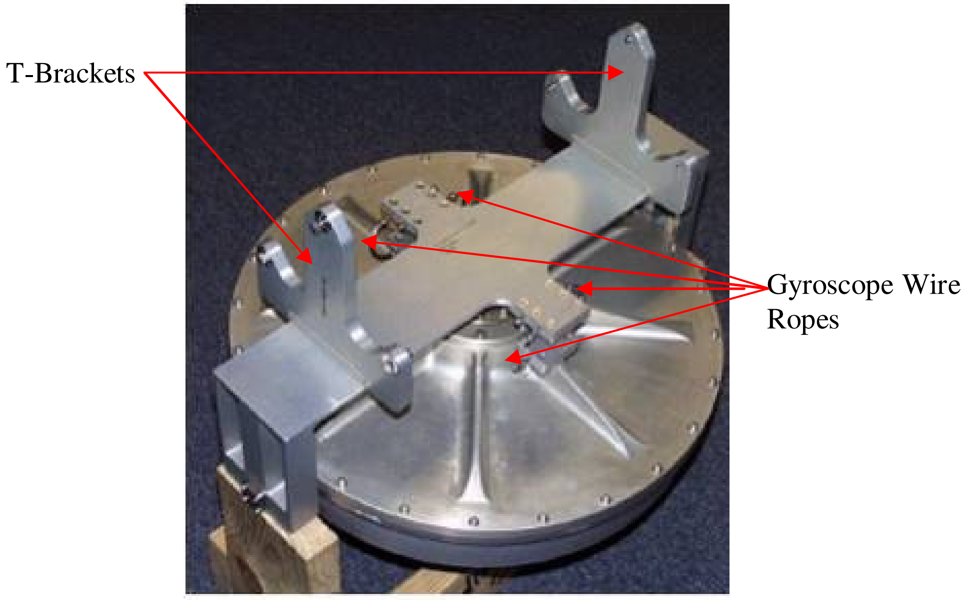


Figure 28. TVIS Gyroscope

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. 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 **БВП -20**
  - CB with barcode 002976R is for Treadmill (TM)
  - CB with barcode 001877R is for VIS

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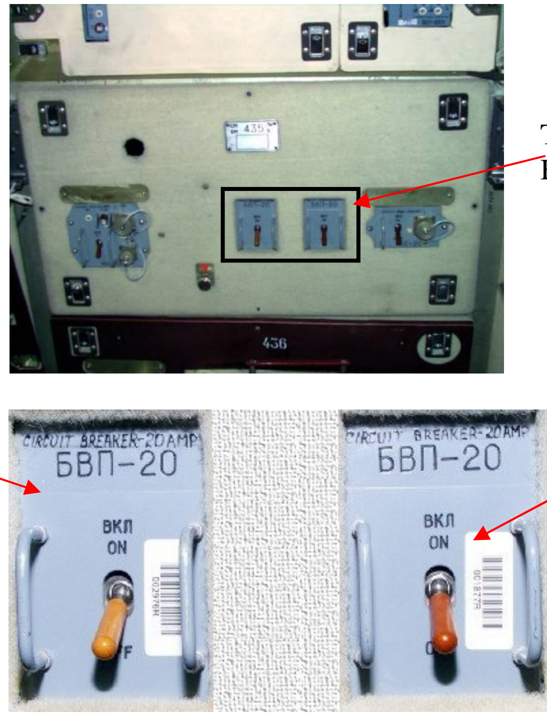

Figure 29-30. SM_435 Treadmill and VIS Circuit Breakers

- 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.

2.7.4. 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.

2.7.5. 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. 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.

2.7.6. Hazard Concerns

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

2.7.7. Contingency Hardware

2.7.7.1. 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 Stabilizaton 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 16 P) 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.

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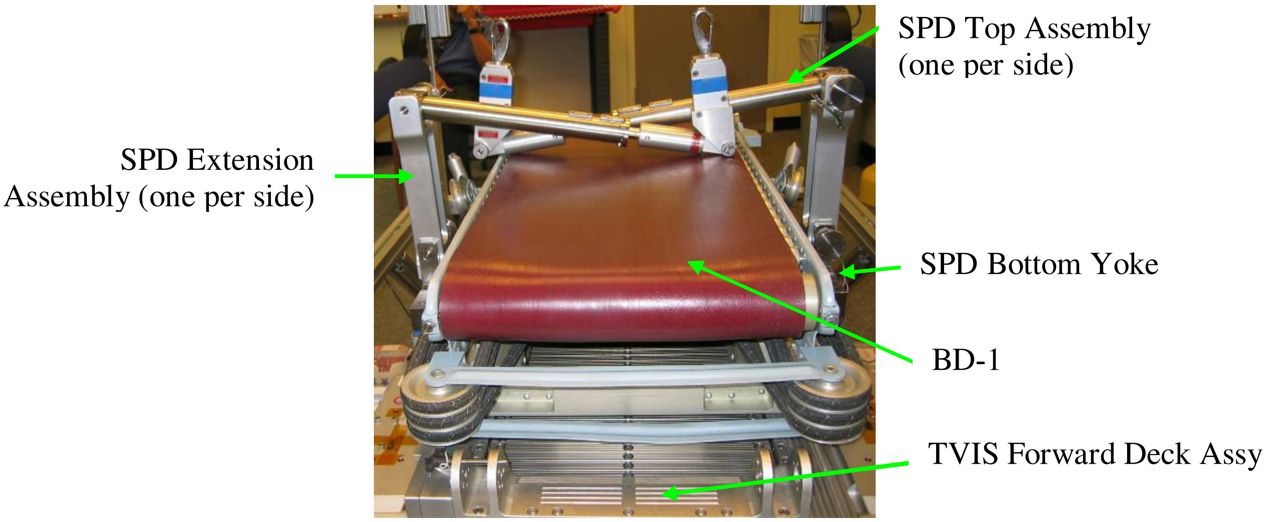

Figure 31. BD-1 Mounted on TVIS with SPD Extension Assemblies

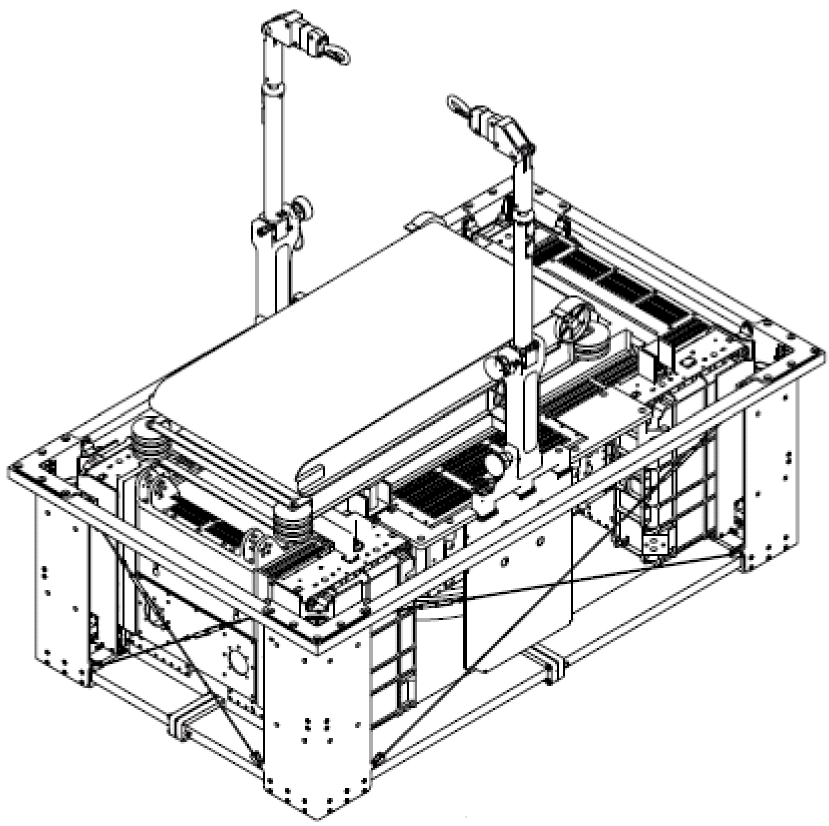

Figure 32. Drawing of BD-1 Mounted on TVIS with SPD Extension Assemblies

3. Environmental Health System (EHS)

3.1. Acoustics Countermeasures

Acoustic countermeasures consist of two, half cargo transfer bags (0.5 CTBs)–the Sound Measurement Kit and Active Noise Reduction (ANR) Headset Kit–that contain all of the hardware for measuring the noise level onboard the ISS and an assortment of hearing protection devices.

3.1.1. Sound Measurement Kit

This kit consists of a half cargo transfer bag (0.5 CTB) containing all of the hardware for measuring the noise level onboard the ISS and the ear plugs (Figures 1-2).

Figures 1-2. Sound Measurement Kit (0.5 CTB)

3.1.1.1. Sound Measurement Kit Contents List

Items contained in the lid pocket:

- Earplug Subpack (1)
- Molded Earplug Subpack, Etymotic (2 pairs per crewmember) *
- Molded Earplug Subpack, Prophonics (2 pairs per crewmember) *
- Tie Wraps (20)

Items contained in the foam assembly (Figures 3-4):

- BZK (Benzalkonymium Chloride) Disinfectant Wipes (60) (**C**)
- Bose Foam Earpads (8)
- Acoustics Dosimeter (3)
- ISS Sound Level Meter Assembly (1)
- RS-232 Cable for Sound Level Meter (1)
- Foam Windscreen for Sound Level Meter (1)

* These items are delivered in the IMAKs, then stowed in this kit after arrival.

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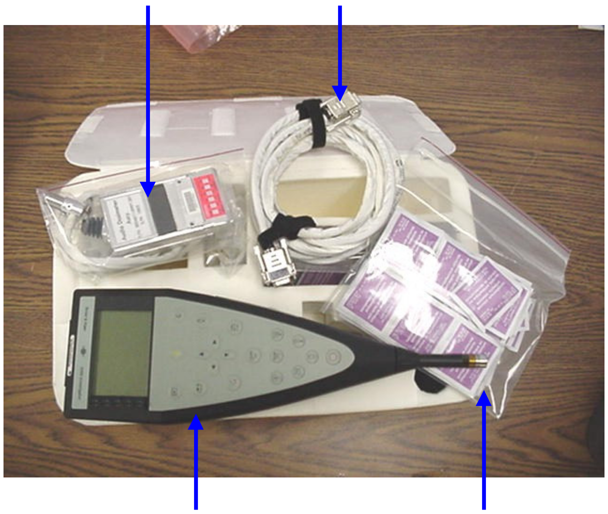
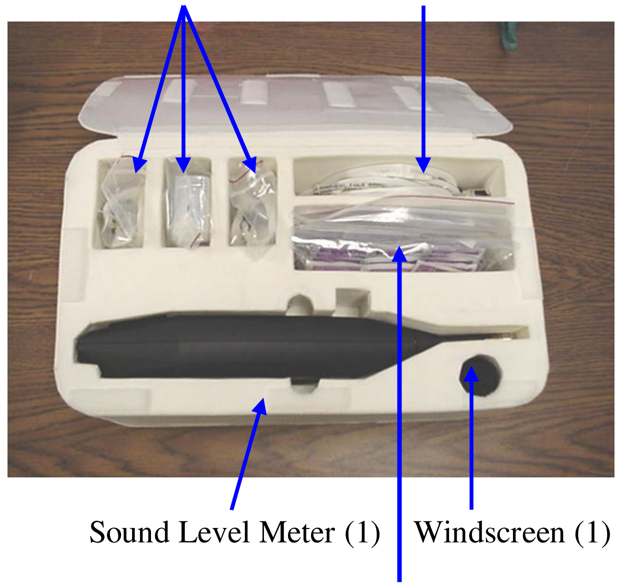
Tech Writer: Kimberlee Jadwick (281) 461-2611 kimberlee.j.jadwick@nasa.gov





Figures 3-4. Sound Measurement Kit Foam Assembly

Table 3.1.1.1.-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 Measurement Kit	5.27 kg (11.62 lbs)	28100.2 cm^3 (1714.78 in^3)	42.5 cm x 24.8 cm x 6.7 cm (16.75" x 9.75" x 10.50")	JPM1F6_F2	7 ºC – 38 ºC (45ºF -100° F)		

3.1.1.1.1 Earplug Subpack

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

Figure 5. Howard Leight Quiet Ear Plug

Figure 6. 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 not only are 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.

3.1.1.1.2 Molded Earplug Subpack, Etymotic

- 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 crew members x 2 sets w/ 2 ear plugs per set)

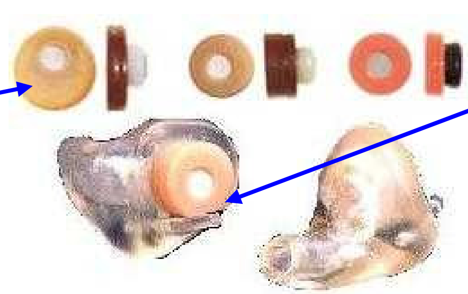


Figure 7. Etymotics Custom Molded Earplug

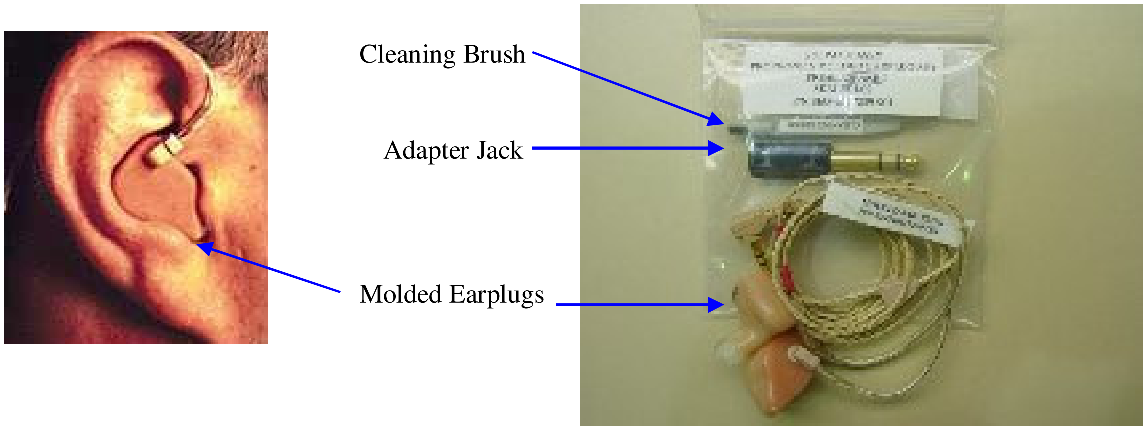
The Etymotic earplugs are packed such that they already have a filter inserted in each ear mold based on each crewmember's preference. The crewmember may switch out the filters by squeezing the silicon earplugs and popping the filters out, then replacing with the desired filter.

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.

3.1.1.1.3 Molded Earplug Subpack, Prophonics

- 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)



Figures 8-9. 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).

3.1.1.1.4 Tie Wraps

The Tie Wraps provide restraint for the microphone on the previous Acoustic Noise Reduction Bose Headsets (P/N SEG16103501-801) and allow for restraint of extended interface cord. The Tie wrap is 0.184” in width and 3.62” in length. The wire bundle range is between 1/16” to 5/8” diameter. The minimum unlocking tensile strength is 18 lbs.

3.1.1.1.5 BZK Disinfectant Wipes

The Benzalkonium Chloride Wipes are used to disinfect the reusable earplugs.

3.1.1.1.6 Bose Foam Earpads

The Bose Foam Earpads are used to replace the earpads on the previous ANR Bose Headset (P/N SEG16103501-801). They cannot be used with the new headsets (P/N SEG46121651-301).

3.1.1.1.7 Acoustic Dosimeter

The Acoustic Dosimeter is a Quest NoisePro DLX-1 dosimeter that will be 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.

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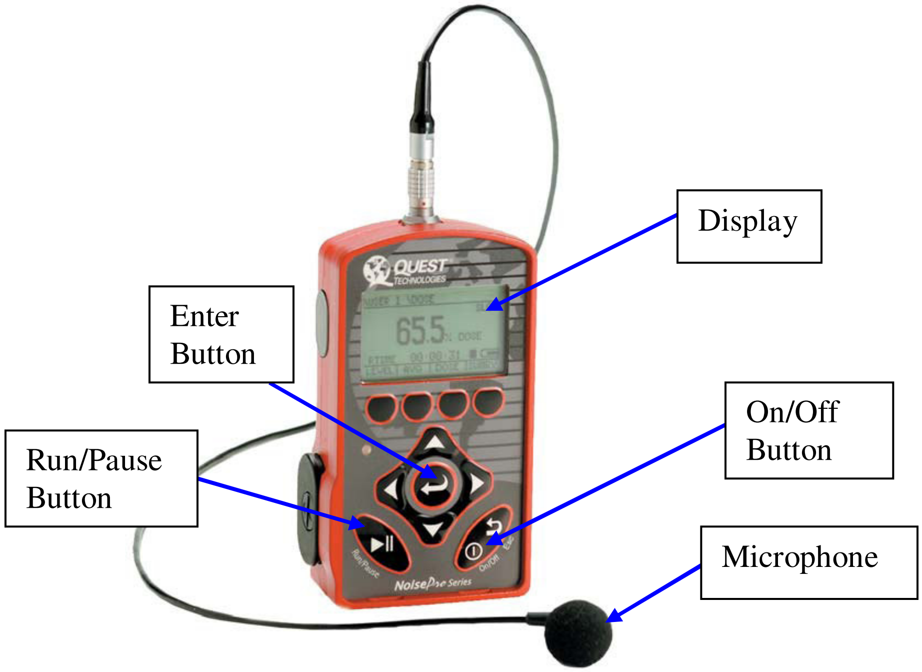

Figure 10. Acoustic Dosimeter

The Acoustic Dosimeter has a backlit 128 x 64 graphical Liquid Crystal Display. It is battery powered by two AA alkaline batteries, which will run the unit for 60 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. With the instrument 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 40 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 an infrared serial interface; however, the download capability is not yet available on orbit.

The Acoustic Dosimer is supplied with a protective cover that protects the entire face of the Acoustic Dosimeter. This cover will utilitze hook and loop as hinge points and be attached to the face of the Acoustic Dosimeter with hook and loop (Figure 11).

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Figure 11. - Protective Cover on Acoustic Dosimeter

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)

Table 3.1.1.1.7-1 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)
Acoustic Dosimeter	0.4 Kg (0.875 lbs)	331.8 cm^3 (20.25 in^3)	6.9 cm x 12.7 cm x 3.8 cm (2.7" x 5" x 1.5")	In the Sound Measure-ment Kit	-25 – 60 ºC (-13 – 140 ºF)	-10ºC-50ºC (14 - 122ºF)	13.5-15.2 psia

Table 3.1.1.1.7-2 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_L - the signal was too large and an overload occurred. U_R - the signal was too small to be separated from instrument noise.

3.1.1.1.7.1 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 is it in close proximity to the crewmember's ear. The Acoustic Dosimeter will also be attached at specific locations in the ISS via Velcro to collect data on noise levels in static locations onboard.

3.1.1.1.7.2 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.

3.1.1.1.7.3 Data/Commanding Capabilities

The crewmember manually logs the readings and calls the data down to MCC-H. Internal data stowage exists; however the software to download the data to the computer via the IR port is not yet certified. There are no commanding capabilities.

3.1.1.1.8 Sound Level Meter

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

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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

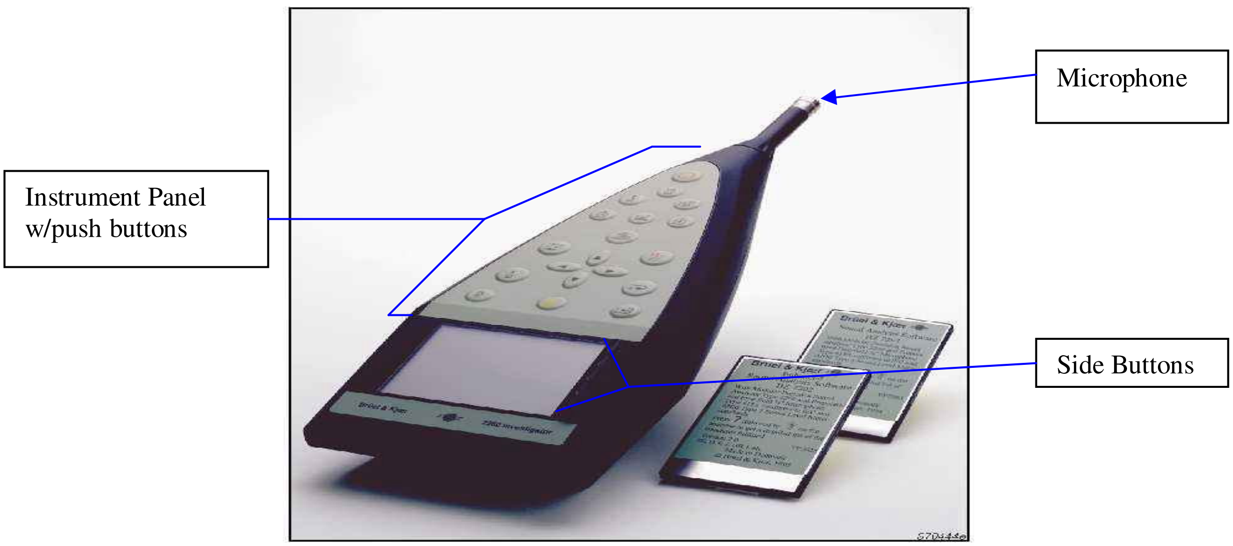


Figure 12. Sound Level Meter

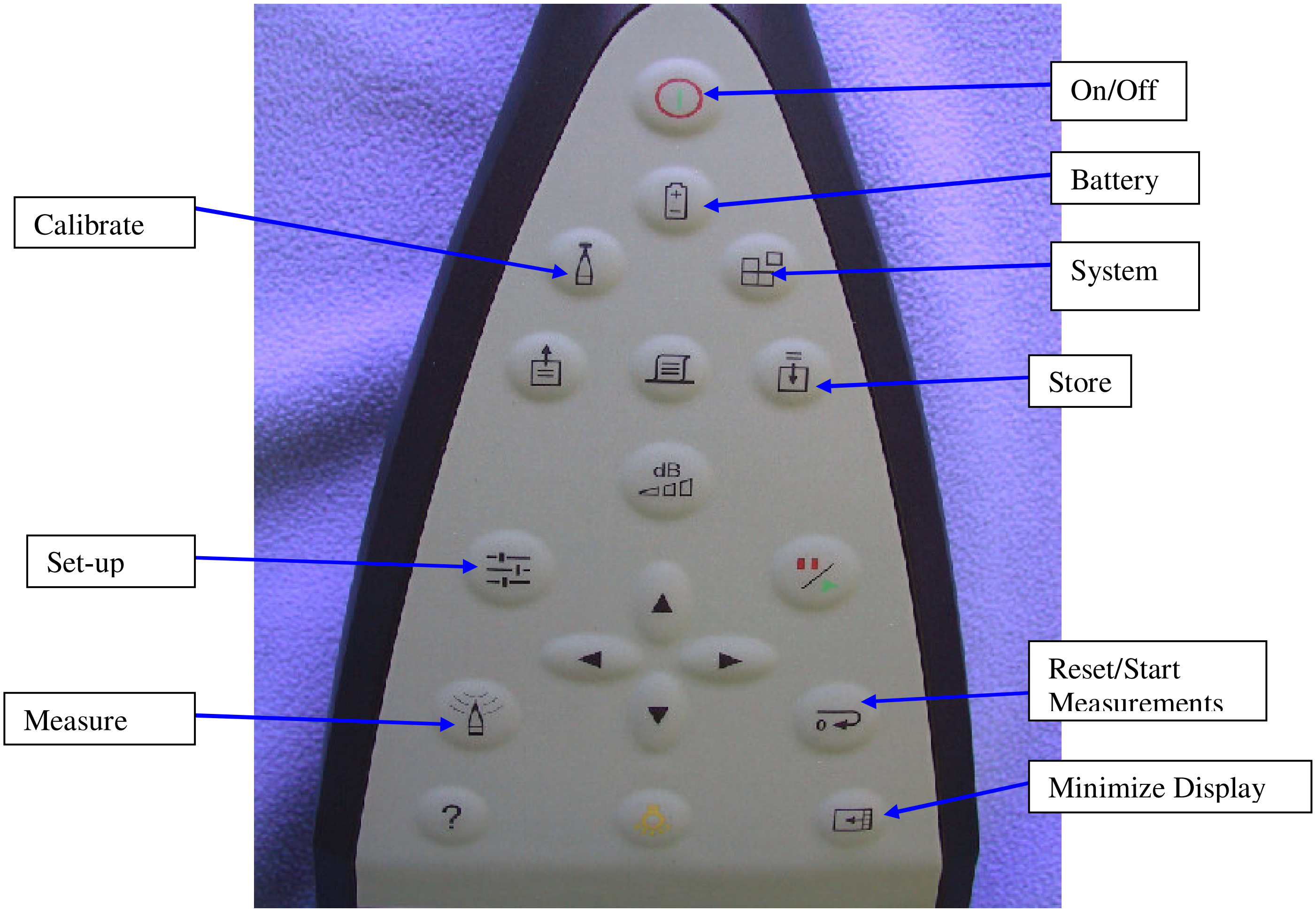


Figure 13. SLM Front Panel Pushbuttons

3.1.1.1.8.1 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 3.1.1.1.8.1-1 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^3 (110.4 in^3)	29 cm x 12 cm x 5.2 cm (11.4" x 4.7" x 2")	In the Sound Measure-ment Kit	-10 – 50° C (14-122° F)	-10 - 50º C (14 -122º F) (For a ±0.5 dB error margin)	No sealed compartments; no pressure issues

Table 3.1.1.1.8.1-2 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)

3.1.1.1.8.2 Hardware Interfaces with Vehicle

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

3.1.1.1.8.3 Resupply Schedule

The Sound Level Meter is resupplied each year. Sound Level Meter calibration is performed during the first usage of the Sound Level Meter at the beginning of each increment.

3.1.1.1.8.4 Data/Commanding Capabilities

The Sound Level Meter stores data internally, which is downloaded to the MEC via an RS-232 cable found in the Sound Measurement Kit. There are no commanding capabilities.

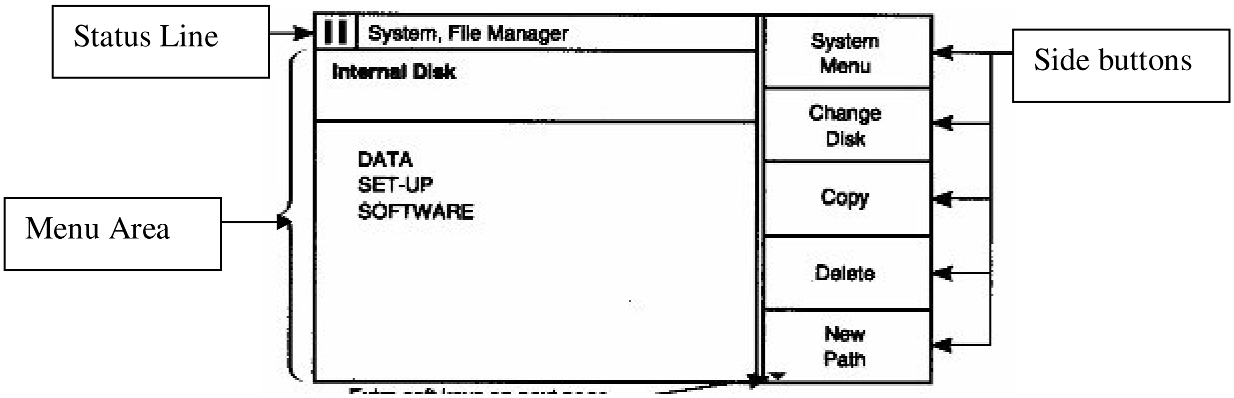
3.1.1.1.8.5 Hazard Concerns

None.

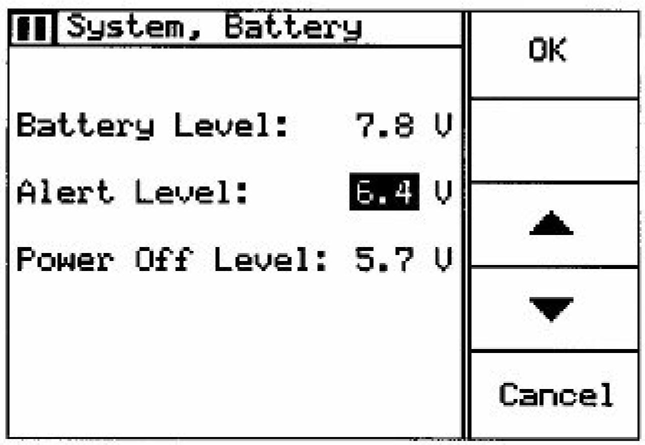
3.1.1.1.8.6 Displays

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.

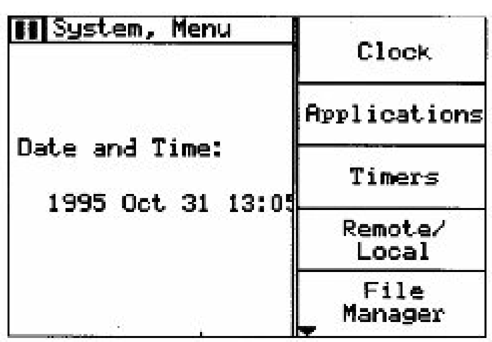
General Menu Structure:



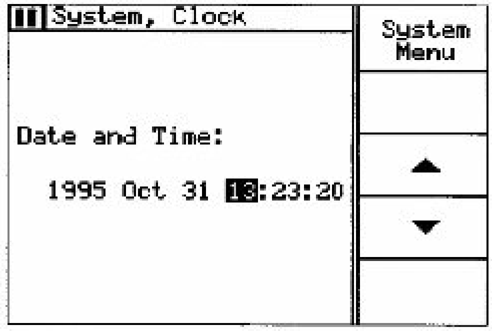
Battery  : Displays the battery voltage screen to check the status of the batteries.



System  : Displays the system menu for configuring the analyzer.

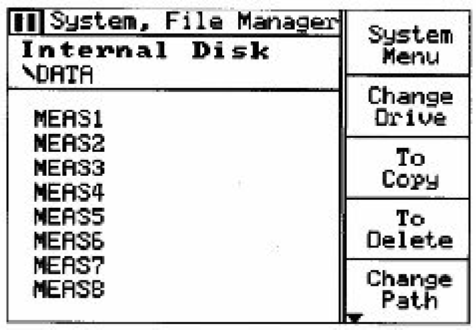


Press Clock (side button): This display allows you to set the measurement activity date and time.



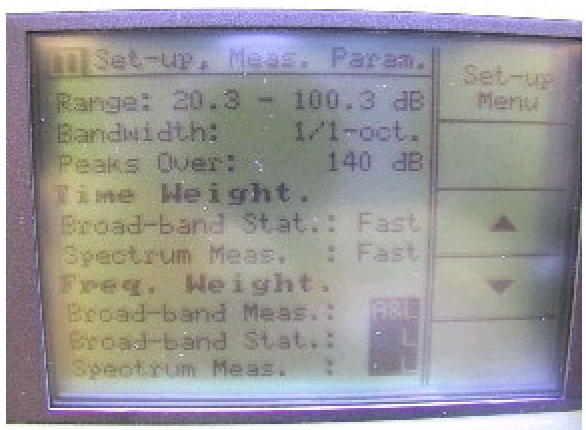
Press System Menu (side button) to return to System display.

Press File Manager (side button).

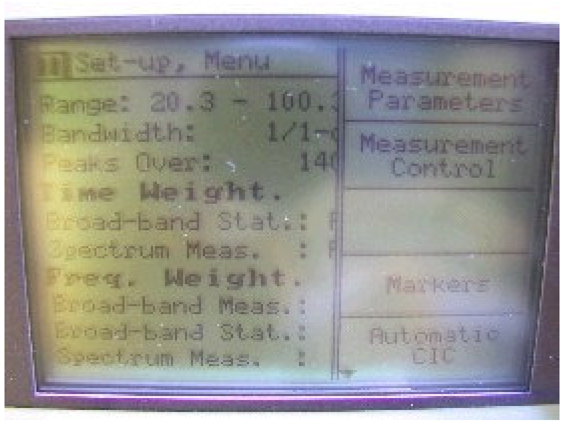


The Sound Level Meter from the factory is set with MEAS1→ directories. The Acoustics engineer deleted this directory to avoid crew confusion with saving data in the wrong directory.

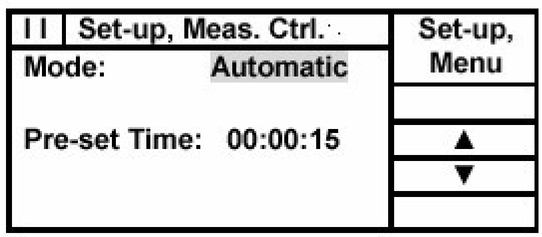
Set-up  : Displays the set-up menu for changing the analyzer's set-up parameters.



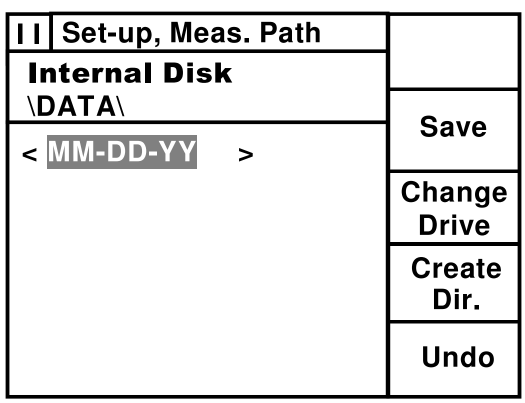
Press Set-up Menu (side button): This takes you to a display for changing measurement parameters and control.



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



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



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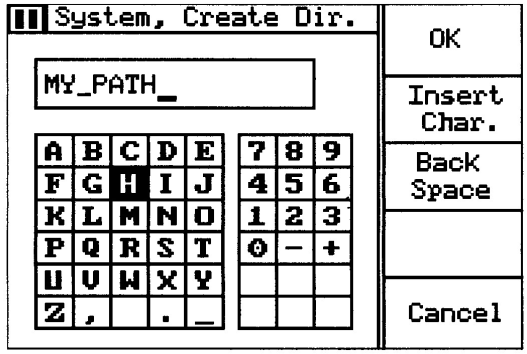
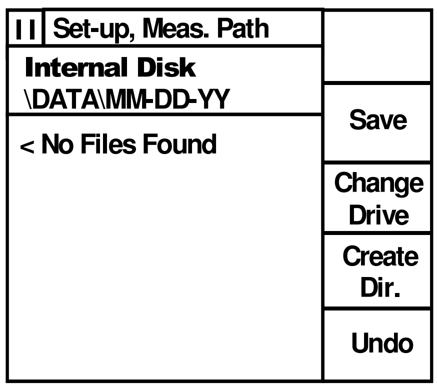
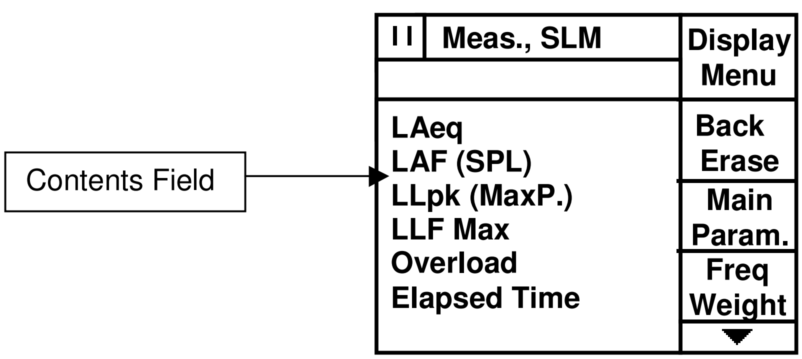
Press Create Dir (side button).



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.



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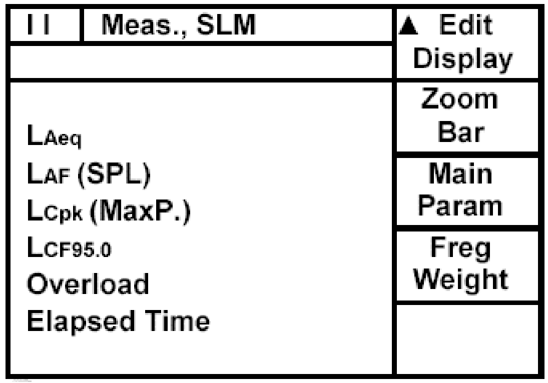
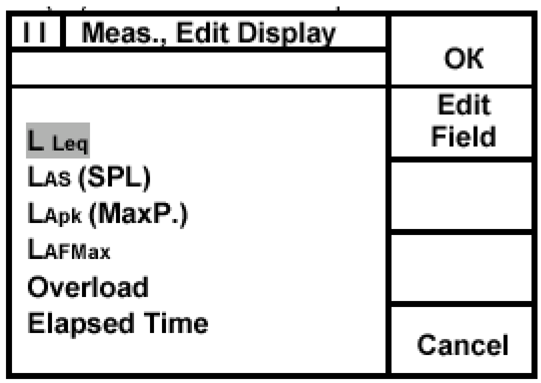
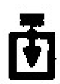
If Laeq or Lleq is not displayed on the top line, press down arrow and see display below.

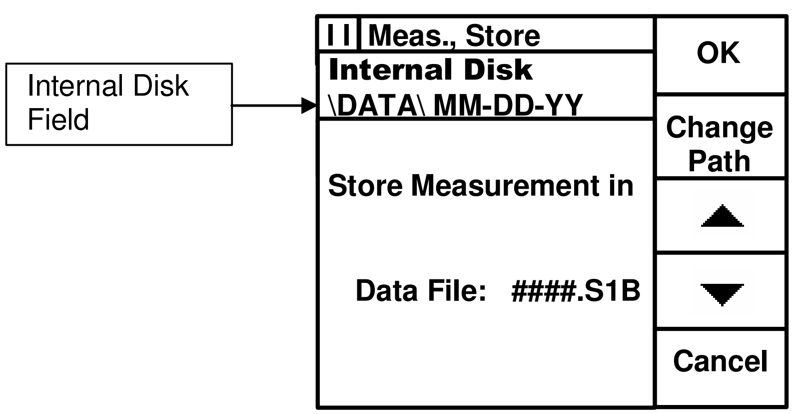


Press Edit Display (side button) to see display below.

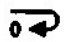


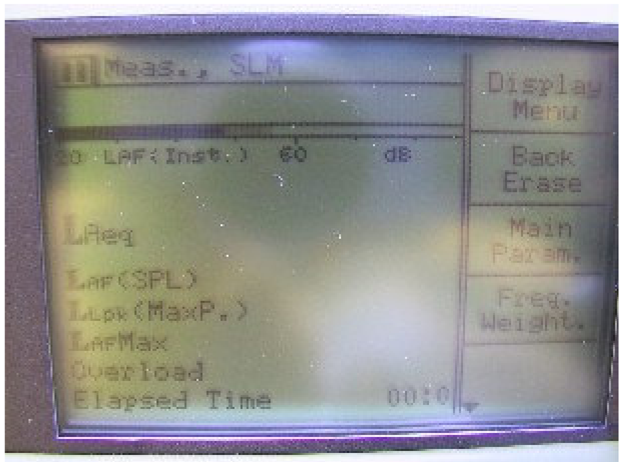
Laeq or Lleq (1st line) can be edited by pressing Edit Field (side button).

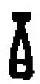
Store  : Displays the store menu for storing data on the analyzer's internal disk.

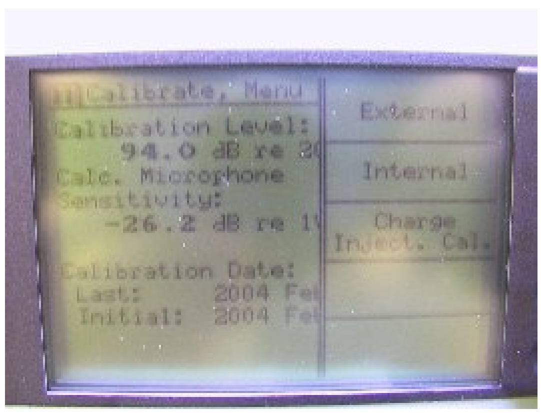


If folder name (mm-dd-yy) is incorrect, press change path (side button). Use left arrow to scroll until the internal disk field only shows \DATA. Then use the up and down arrow to find the correct date (mm-dd-yy).

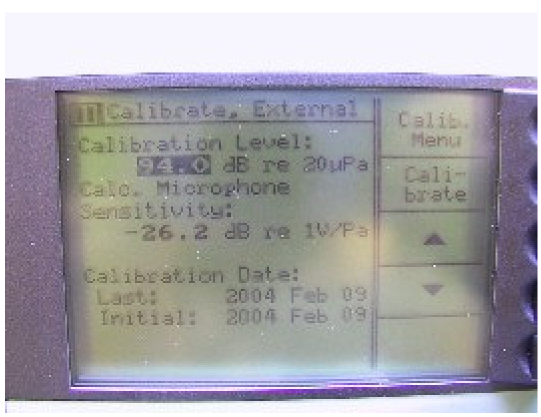
Reset/Start  : Deletes the current measurement data, sets the analyzer's internal buffer to zero and, restarts the measurement.



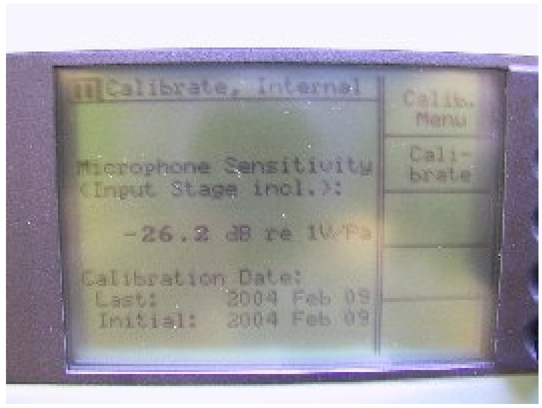
Calibrate  : Displays the calibration menu for calibrating the analyzer.



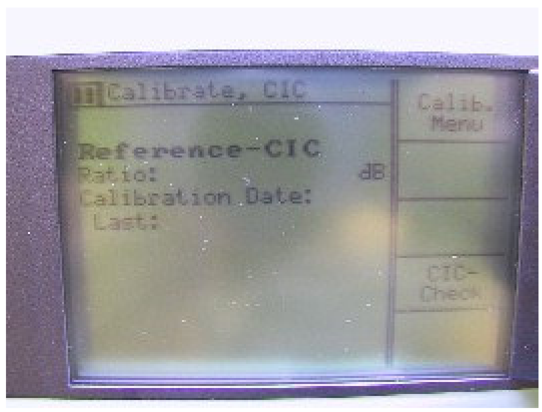
Press External (side button).



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



Press Charge Inject. Cal. (side button)



3.1.1.2. Hardware Interfaces with Vehicle

The Sound Measurement Kit itself has no interfaces with the ISS. Refer to individual hardware sections for interfaces between acoustic hardware and the ISS.

3.1.1.3. Resupply Schedule

The Sound Measurement Kit will be resupplied once every 2 years.

3.1.1.4. Data/Commanding Capabilities

See Sound Level Meter and Acoustic Dosimeter sections for available data.

3.1.1.5. Hazard Concerns

N/A

3.1.2 Active Noise Reduction (ANR) Headset Kit

3.1.2.1 ANR Headset Kit Description

This kit consists of half of a cargo transfer bag (CTB) containing all of the hardware for hearing protection.

3.1.2.2 ANR Headset Kit Contents

- ANR Bose Headset (4)

3.1.2.2.1 ANR Bose Headset

ANR Bose Headsets are Commercial Off-The-Shelf equipment. The commercial name for the headset is the Bose® Quiet Comfort® 2 Headphone. The primary purpose for these headsets is to be used during an On-Orbit Hearing Assessment (O-OHA). The Bose ANR headsets 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 Headset

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 2). On the audio cable are “Hi” and “Lo” settings that are used to adjust the output volume of different audio sources (Figure 3). “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.

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).

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

3.1.2.3 Hardware Interfaces with Vehicle

The ANR Headset Kit itself has no interfaces with the ISS.

3.1.2.4 Resupply Schedule

The ANR Headset Kit will no longer be resupplied to ISS. Only the headsets will be resupplied on an "as needed" basis.

3.1.2.5 Data/Commanding Capabilities

N/A

3.1.2.6 Hazard Concerns

N/A

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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.

Figure 1. 0.5 CTB containing EHS Water Kits

Figure 2. Contents of the 0.5 CTB

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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 in 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 Potable Water Samplers SRV-K and SVO-ZV, may be discarded as common trash. The Potable Water Samplers 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 Potable Water Sampler SRV-K 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 Potable Water Sampler SVO-ZV 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 samplers are not interchangeable among the different ports.

Figure 3. Water Sample Collection Packet

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

Op Nom	P/N	Volume of H_2O collected
Water Sample Collection Packet	SEG46121614-602	N/A
Potable Water Collection Packet SRV-K	SEG46119988-315	
Small Waste Water Bag	SEG46119988-612	50 mL
Potable Water Sampler SRV-K	SEM46110793-308	
Disinfectant Wipe	D35100	
Potable Water Collection Packet SVO-ZV		
Small Waste Water Bag	SEG46119988-612	50 mL
Potable Water Sampler SVO-ZV		
Disinfectant Wipe		
Potable Water Collection Packet PWD	SEG46119988-316	
Small Waste Water Bag	SEG46119988-612	50 mL
PWD Adapter	SEG46121618-301	

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Disinfectant Wipe	D35100	
Micro Sample In-Flight Analysis Packet Micro Sample In-Flight Analysis Bag	SEG46119988-312 SEG46119988-610	 125 mL
TOCA Analysis Packet TOCA Sample Analysis Bag TOCA Bag Clip	SEG46121617-301 SEG461121617-601 SEG46121616-602	 175 mL
Post-Flight Analysis Packet Post-Flight Analysis Bag	SEG46119988-313 SEG46119988-611	 1000 mL (shared) 500 mL (micro) 750 mL (chemical)

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

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

Figure 6. PWD Collection Packet

Figure 7. Micro Sample In-Flight Analysis Packet

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Figure 8. Post-Flight Analysis Packet

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, but since the contents of each packet are exactly the same, only paying attention to the expiration date is necessary. 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 heptaphydrate, 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 ºC to 37 ºC for 44 hours (± 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.

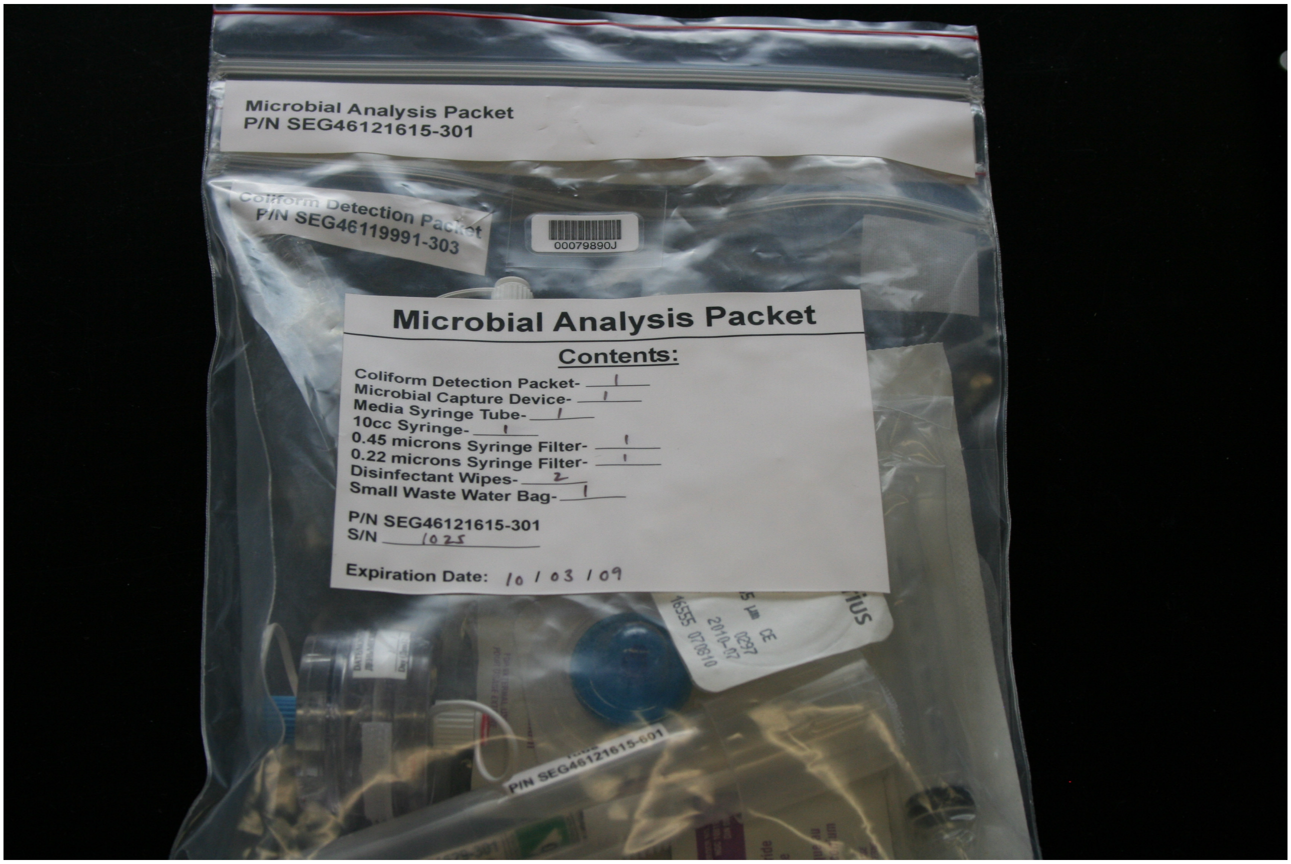

Figure 9. Microbial Analysis Packet

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

Op Nom	P/N
Microbial Analysis Packet	SEG46121615-301
Coliform Detection Packet Coliform Detection Bag	SEG46119991-303
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 Media Syringe	SEG46121615-601 SEG46121629-301

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Figure 10. Contents of Microbial Analysis Packet

Figure 11. 0.45 µm Water Filter (Yellow)

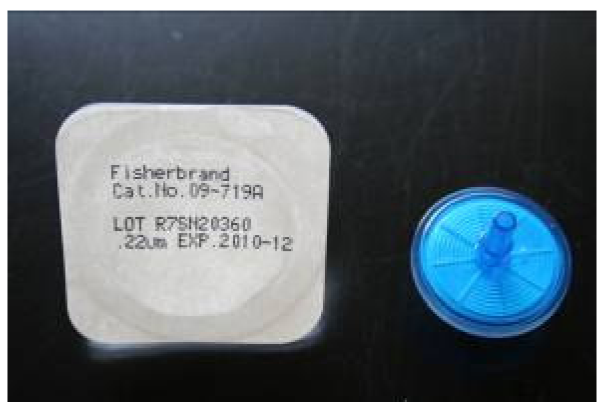

Figure 12. 0.22 µm Air Filter (Blue)

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Figure 13. Microbial Capture Device (MCD)

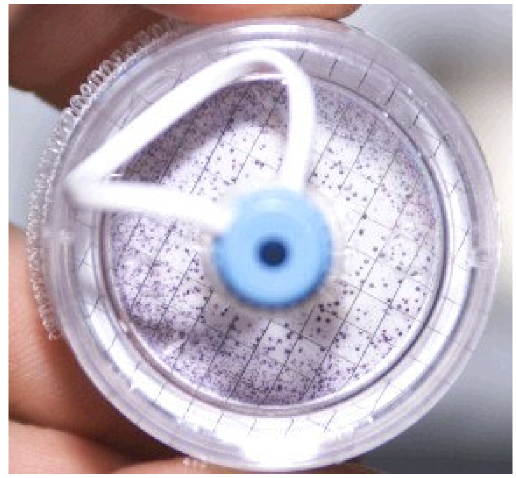

Figure 14. Growth on MCD

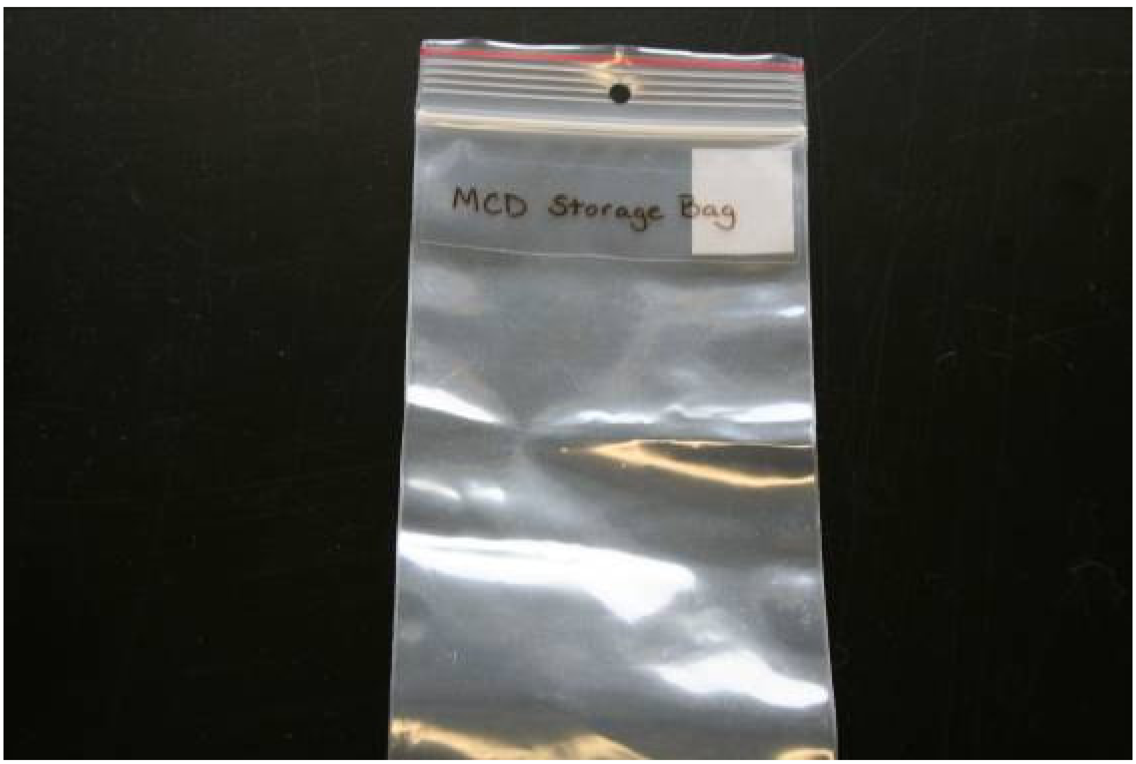

Figure 15. MCD Storage Bag

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.

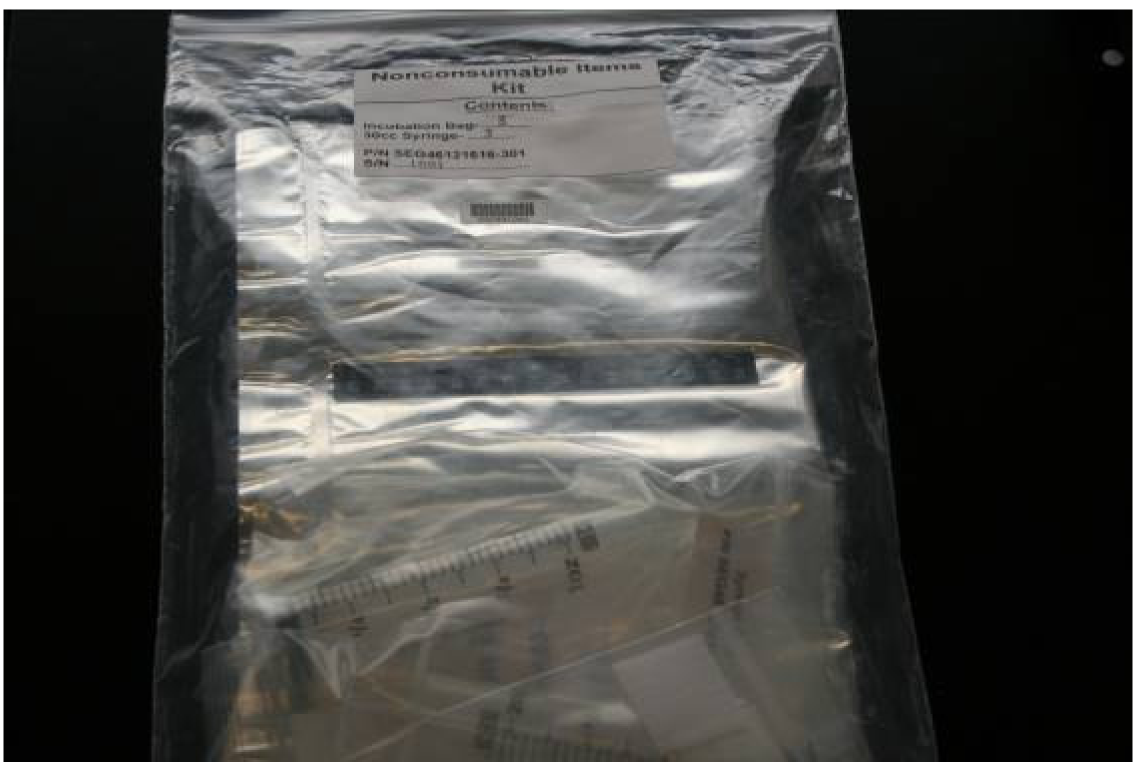

Figure 22. Nonconsumables Items Kit

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

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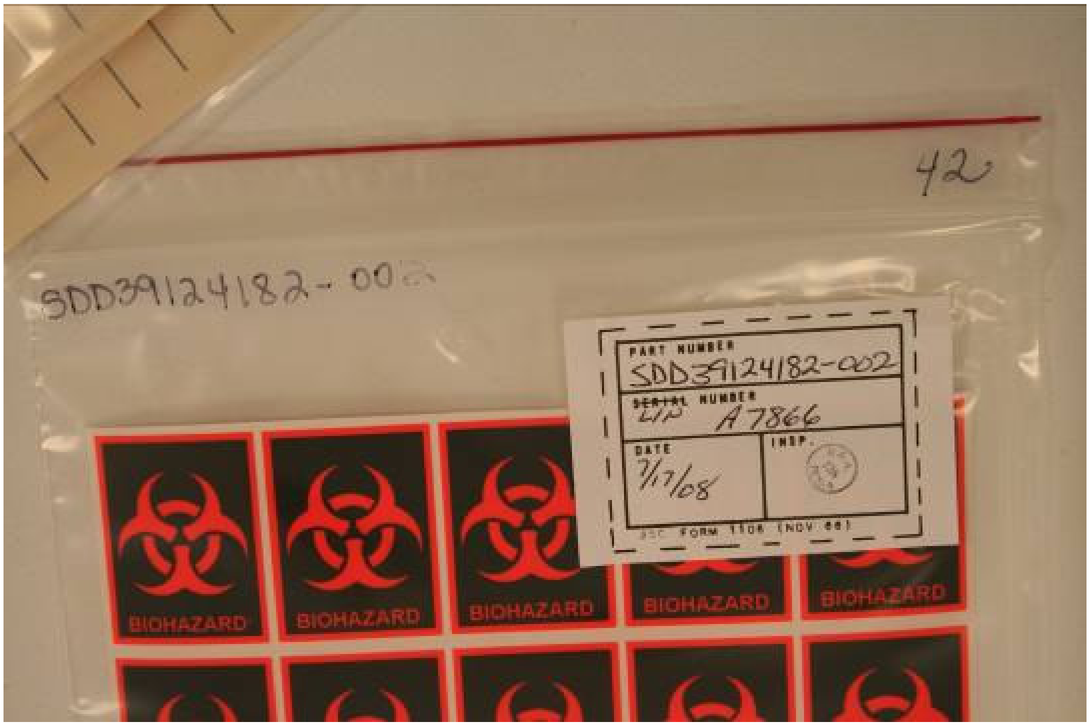

Figure 25. Biohazard Labels

Figure 26. Mylar Incubation Bag

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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

None

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. Petri Dish Stowage Bag Assembly (red and white dots) (**C**)
i. Incubation Bag Assembly (**C**)
j. Disinfectant Wipes
k. Plastic Bag (6x6”) (**C**)
l. Plastic Bag (4x3”)
m. Scissors
n. Colony Growth Key Chart and Data Sheet
o. Gauze

*****‘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

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Figure 2. Petri Dish Packet Assembly

Inoculated Media Plates after incubation:

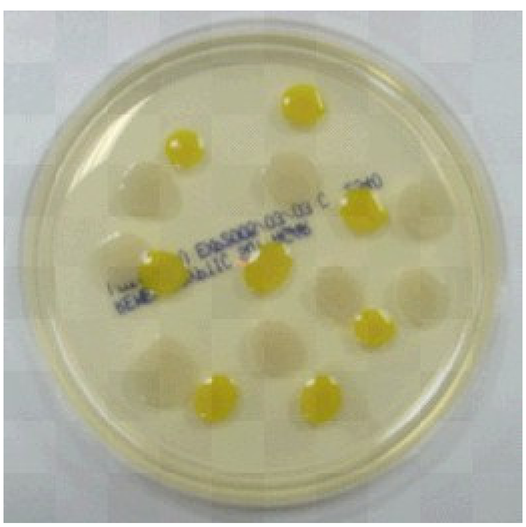


Figure 3. Bacterial Colonies (smooth)

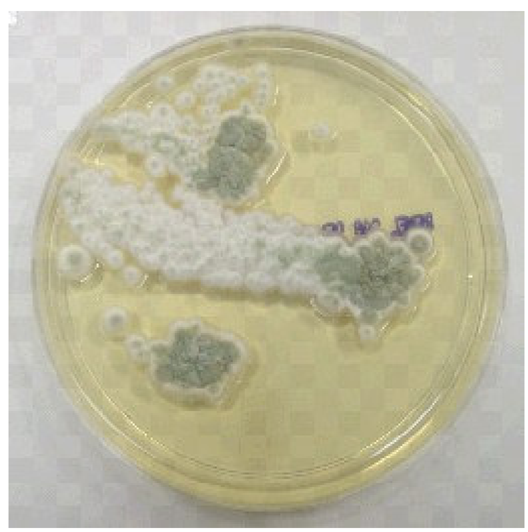


Figure 4. Fungal Colonies (fuzzy)

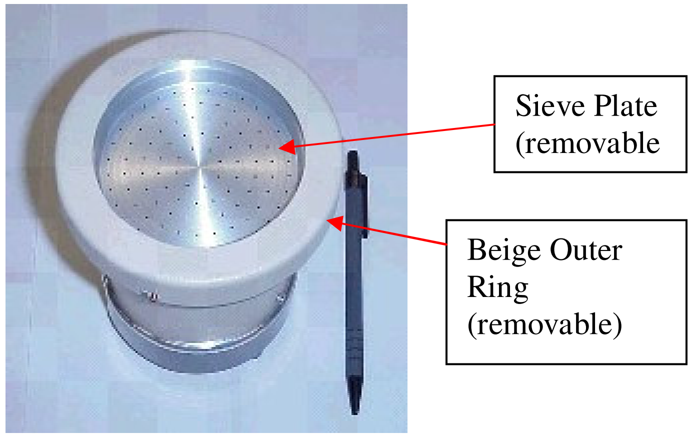


Figure 5. Microbial Air Sampler Top

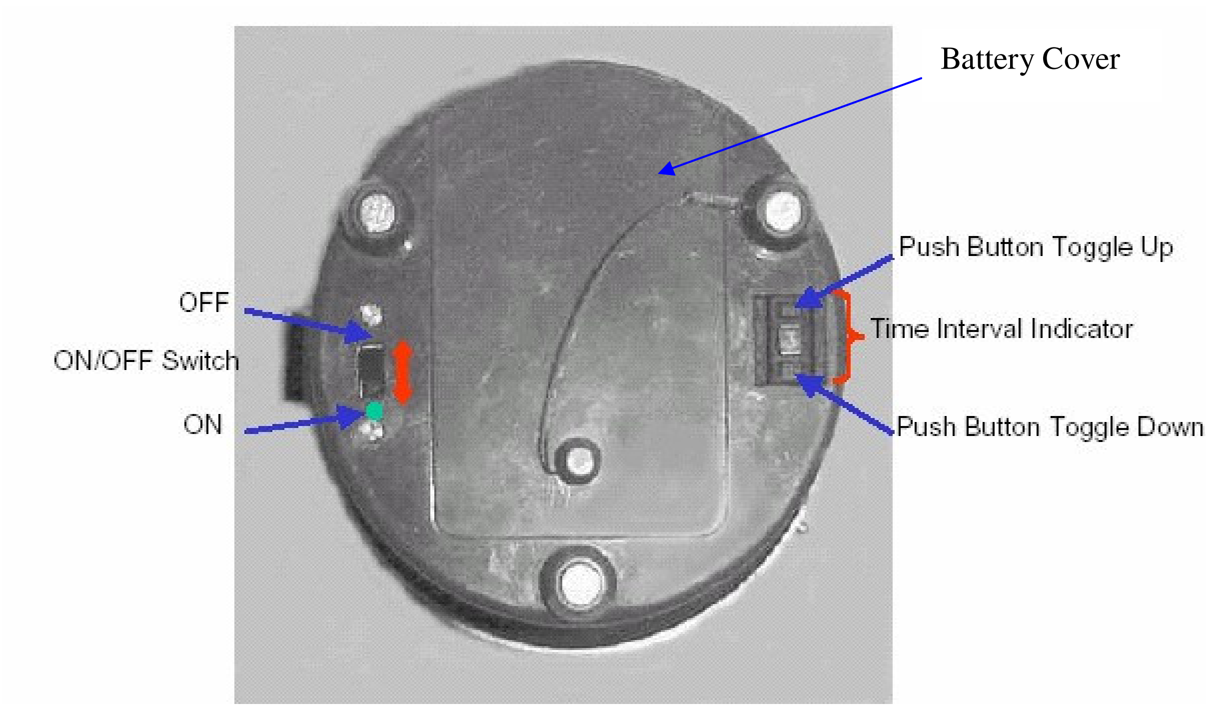
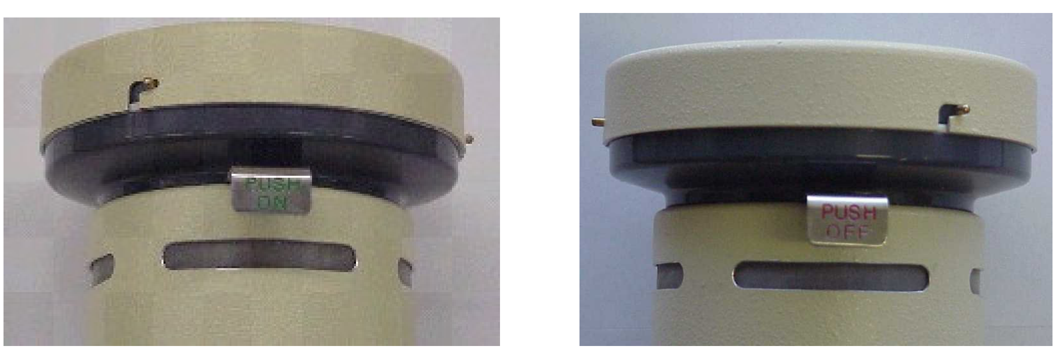


Figure 6. Microbial Air Sampler Bottom



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

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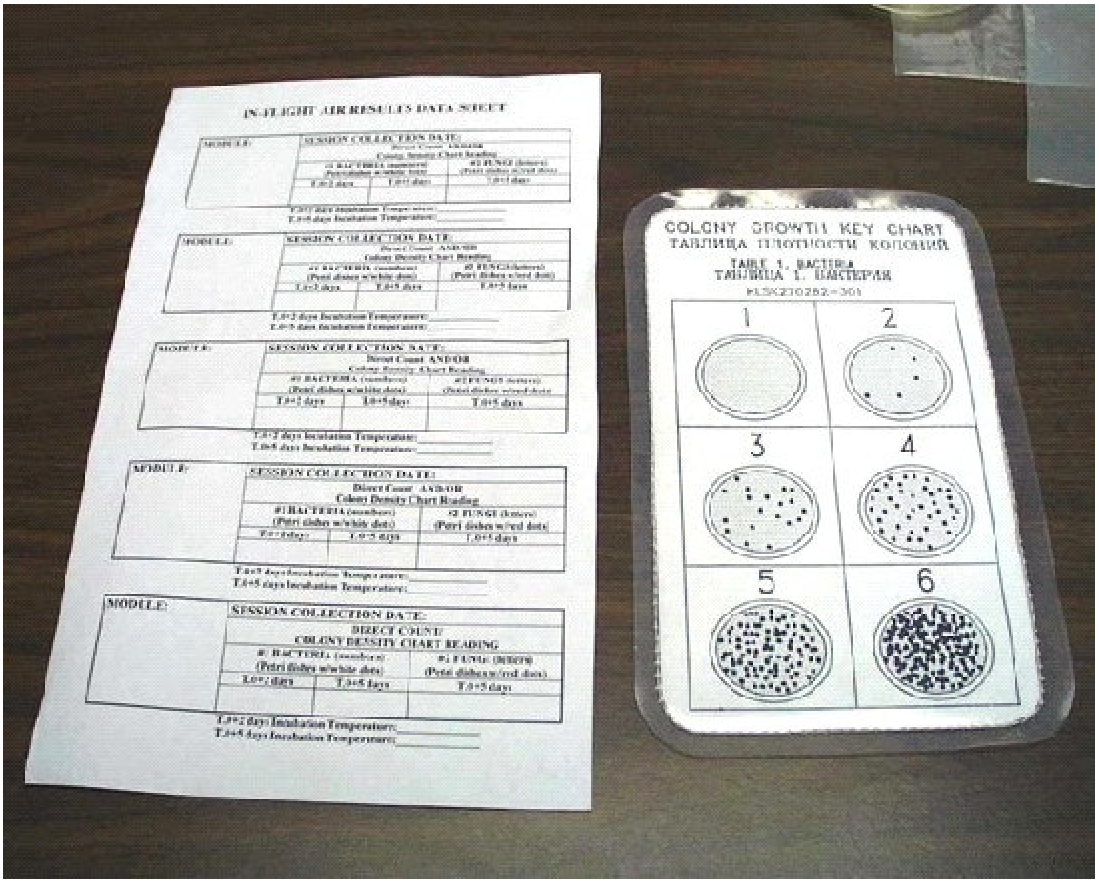

Figure 9. In-Flight Air Results Data Sheet and Colony Growth Key Chart (Also in the procedure)

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^3 (811.6 in^3)	29.2 x 25.4 x 19.1 cm (11.5” x 10” x 7.5”)	CHeCS Rack - refer to IMS Database	4 – 35ºC (39 – 95ºF)	20 – 35ºC (68 – 95ºF)	
MAS unit				MAS Kit in CHeCS Rack			

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

Once a year, a new Microbial Air Sampler Kit will be sent up. The old kit will be returned for ground analysis and refurbishment.

3.2.2.5. Data/Commanding Capabilities

The Microbial Air Sampler contains data sheets, which will be used to record results after analysis. After all results for each sample have been collected, the data will be called down to MCC-H.

3.2.2.6. Hazard Concerns

N/A

3.2.3. Surface Sampler Kit

3.2.3.1. Surface Sampler Kit Description

The Surface Sampler Kit provides hardware for taking surface samples for in-flight assessment of bacterial and fungal bioload on International Space Station (ISS) surfaces.

Figure 1. Contents of one Surface Sampler Kit

Figure 2. Contents of one Surface Sampler Packet

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Inoculated Media Slides after incubation:

Figure 3. Bacterial Colonies (smooth)

Figure 4. Fungal Colonies (fuzzy)

3.2.3.2. Surface Sampler Kit 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 Items
  a) Sharpie Marker
  b) Colony Density Chart
  c) In-Flight Surface Results Data Sheet
  d) Scissors
  e) 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	Mass M(E)	Volume M(E)	Dimensions M(E)	Nominal Stowage Location	Storage Temp °C (°F)	Operating Temp °C (°F)	Operating Pressure mmHg (psia)
Surface Sampler Kit	1.0 kg (2.2 lbs)	3567.2 cm^3 (217.7 in^3)	**14.5cm x 17cm x 14.5cm** (5.7 in x 6.7 in x 5.7 in)	CHeCS Rack – refer to IMS Database	4–35ºC (39–95ºF)	4–35ºC (39–95ºF)	
Media slide					4–35ºC (39–95ºF)	20-35ºC (68-95) ºF ideal for incubation period	
Containment Bag Assembly							

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^2 fungi is detected up to 400 CFU per 100cm^2

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 Kit and Surface Sampler Packet Assemblies 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 Kits are currently resupplied on an as-needed basis, but usually one kit is delivered on every shuttle flight. Each kit contains consumables for 10 sampling locations. No maintenance is required.

3.2.3.5. Data/Commanding Capabilities

The Surface Sampler Kit contains data sheets, which can be used to record results after analysis. After all results for each sample have been collected, the data will be called down to MCC-H.

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 redundant control to detect the existence of a hazardous condition. 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.

Measuring Total Organic Carbon (TOC) provides 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 is working properly.

3.2.4.2. High Level Concept

Total carbon enters the TOCA via a water sample. "Total carbon" is total inorganic carbon (TIC) plus total organic carbon (TOC). The TOCA converts TOC and TIC into CO_2 gas and measures concentration using Non Dispersive Infrared (NDIR) detection. Then TOCA converts and removes TIC by pH shift, which forces inorganic carbon species to CO_2. TOCA oxidizes organic carbon to CO_2 to allow NDIR detection and quantification.

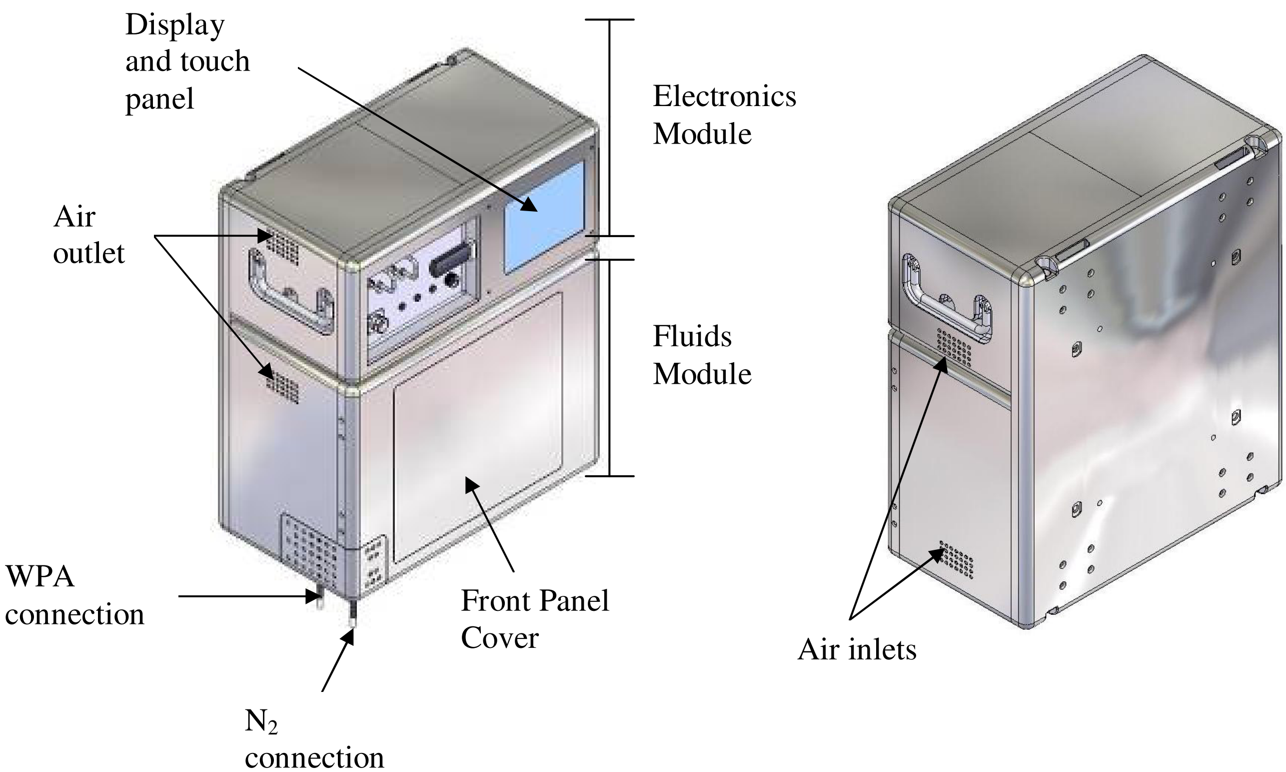

Figure 1. Total Organic Carbon Analyzer

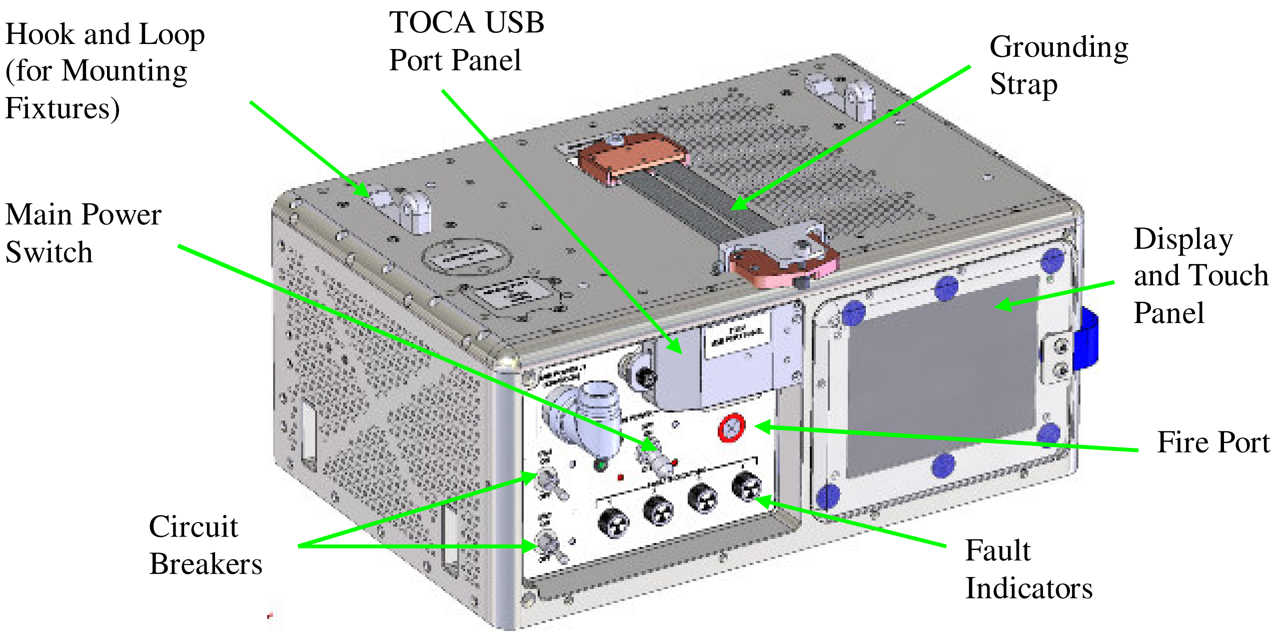

Figure 2. Electronics Module

Figure 3. TOCA Class I Flight Unit

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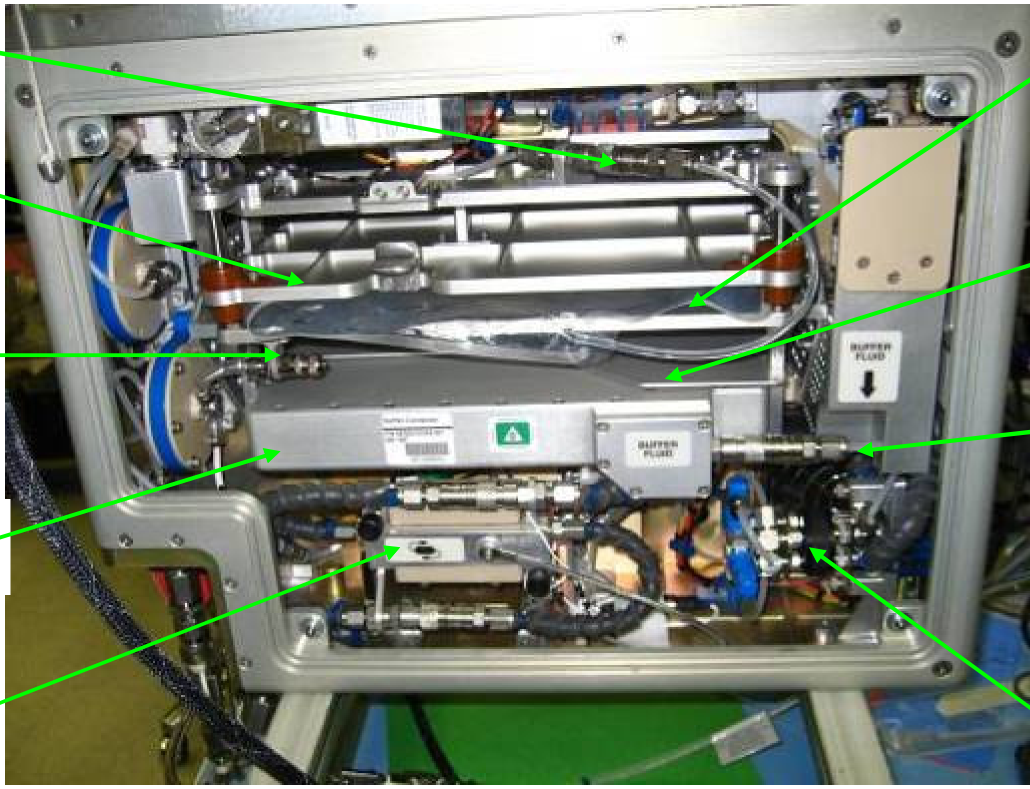


Figure 4. TOCA Fluids Module Interior

3.2.4.3 Front Panel Crew Interfaces

- SW1 – Manual switch, applies or removes power from the TOCA
- 24V Cb – Manual breaker with remote trip; enables or disables 24VDC and TEC power supply
- 15V & 12V Cb – Manual breaker with remote trip; enables or disables 15VDC and 12VDC power supply
- J1 – 120 VDC power in from UOP
- LED – when illuminated indicates that the 5VDC power supply is on

3.2.4.4 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 Water Bag
     vi. QD Guard
     vii. TOCA Power Cable
     viii. TOCA Grounding Strap

ix. TOCA Mounting Fixture
x. TOCA Water Sample Hose
xi. Lab 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 contents – generic CTB not owned by CHeCS
  a) Low TOC/TIC Calibration Packet
  b) High TOC Calibration Packet
  c) Calibration Check Packet

- 0.5 CTB S/N 1375 contents – generic CTB not owned by CHeCS
  a) QD Guard
  b) TOCA Power Cable
  c) TOCA Grounding Strap
  d) Cable Straps
  e) Oxidizer
  f) TOCA Waste Water Bag
  g) TOCA Mounting Fixture
  h) Timer/Stopwatch
  i) Gas Liquid Separator
  j) Buffer Container
  k) TOCA USB Drive & Compact Disk foam (contains 2 spare USB Drives and 1 Compact Disk)

Table 3.2.4.4-1 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 3.2.4.4-2 Hardware-Specific Parameters for TOCA

Power Requirements	120 VDC
Power Source	UOP 6
Analytical Range	TOC: 250-250,000 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

Reproducability	Relative Standard Deviation +/- 25% for TOC range of 1000 – 25,000 micrograms/L
Operating Ranges	
Indications for Out-of-Range Parameters	Unit will shut down or fault indicators on the front panel of the electronic box will change to black and white.

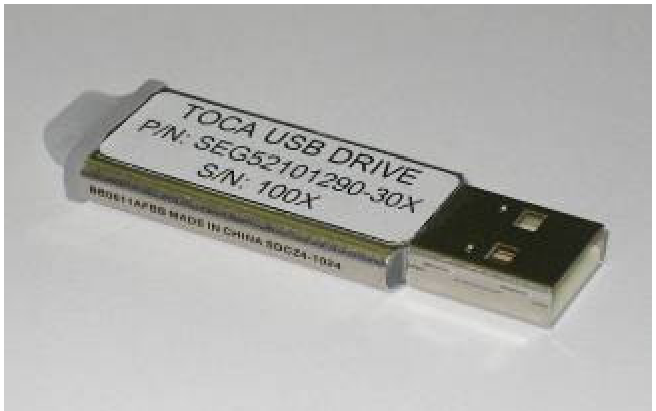
TOCA Waste Water Bag Description

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. 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. The waste water cannot be reclaimed due to the sodium phosphate crystals that would be left on the towel after the water evaporates. Therefore, the full Waste Water Bag will be discarded into wet trash.

Figure 5. TOCA Waste Water Bag

TOCA Data Storage

Data will be stored on an internal Compact Flash and a removable SanDisk Cruzer® Micro USB Drive. The USB Drive can store 1 GB of data. There are two spare Drives on-orbit. 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.



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

TOCA Grounding Strap

Figure 8. TOCA Grounding Strap

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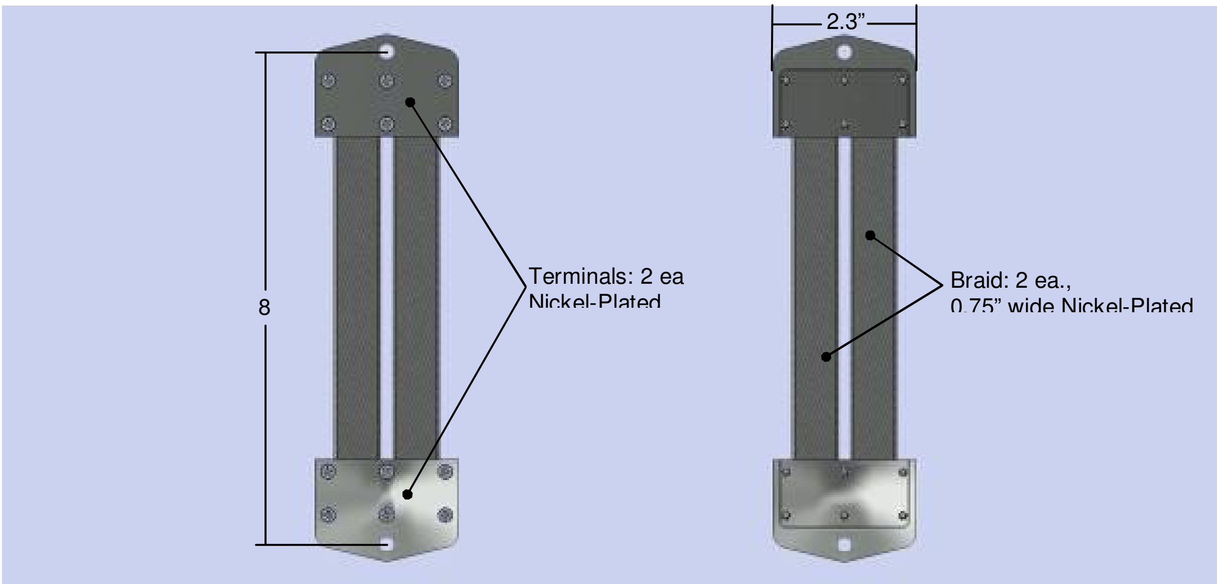


Figure 9. Schematic of TOCA Grounding Strap

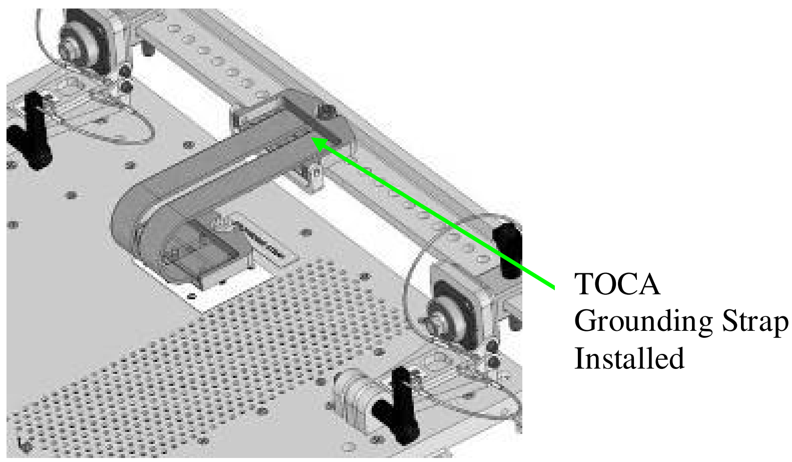
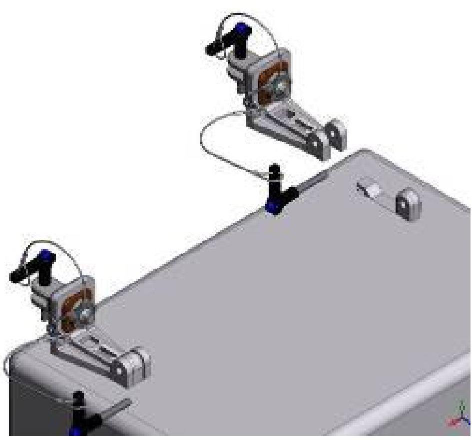


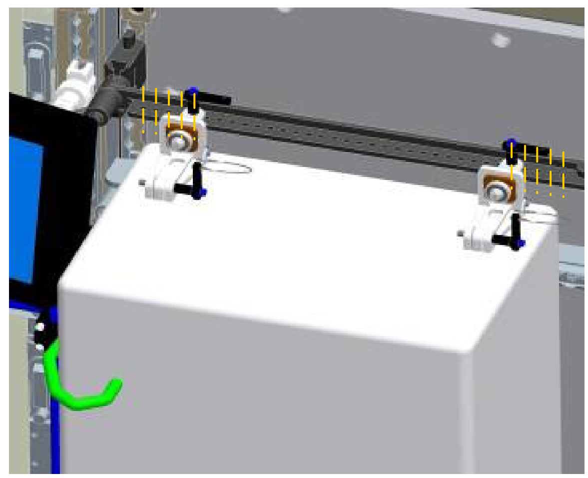
Figure 10. TOCA Grounding Strap Installed

<u>TOCA Mounting Fixture Decription</u>

The mounting fixtures (4) are attached to the TOCA via hook and loop interface and secured by pip pins. They allow the TOCA to attach to the EDV Attachment Brackets.

Figures 11-12.TOCA Mounting Fixtures





Figures 13-14. Mounting Fixtures Installed on TOCA

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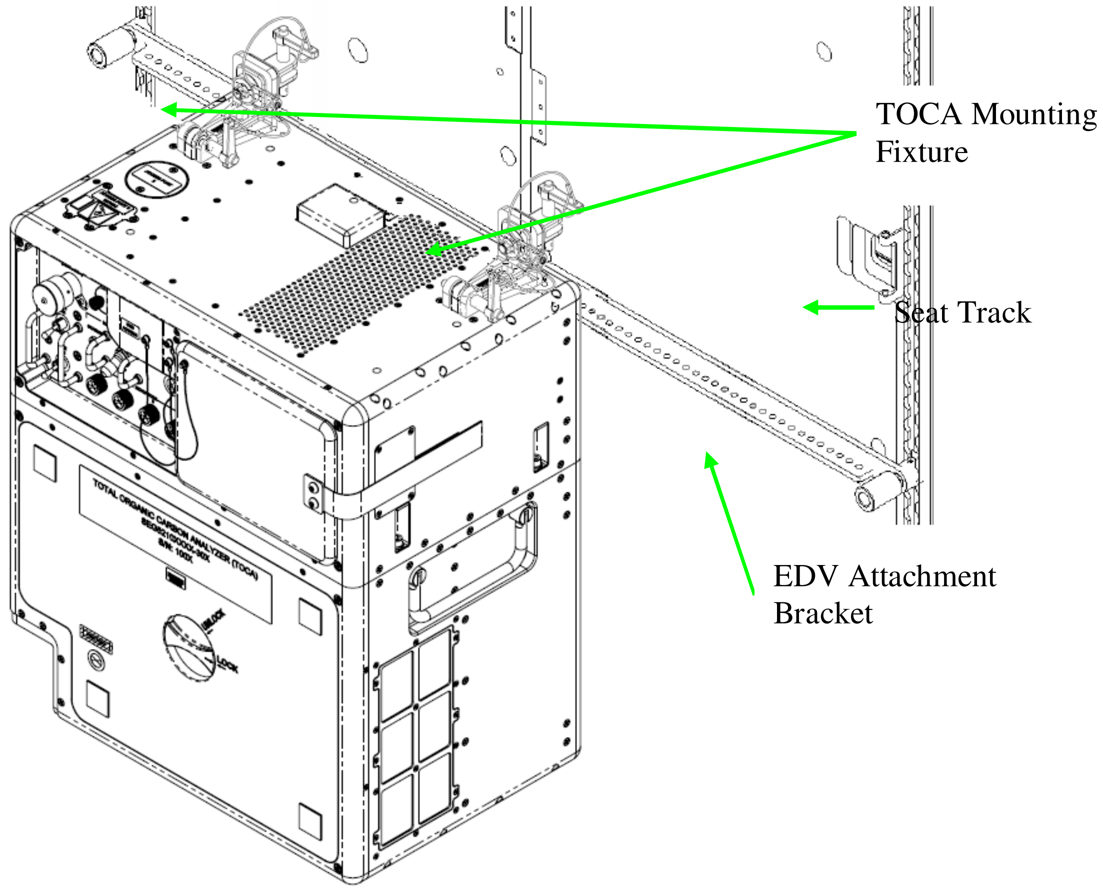


Figure 15. TOCA Installed on Rack

QD Guard

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

Figure 16. QD Guard

TOCA Nitrogen and Water Connection

The Lab TOCA N_2 Hose and TOCA Water Sample Hose should never be disconnected once they are installed.

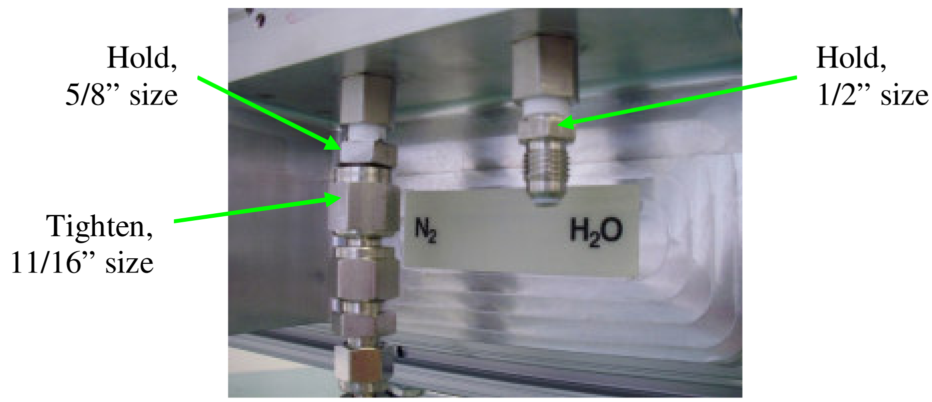


Figure 17. N_2 and Water Sample Hose Connections

GN$_2$ QD connection at the Z panel

The GN_2 QD is where the Lab TOCA N_2 Hose connects to TOCA. This Hose may sometimes be disconnected; therefore, crew is instructed in the procedure to verify its connection prior to starting an analysis.

Figure 18. GN2 QD Connection at Z Panel

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 to the difference in CO_2 partial pressure across the membrane leaving an almost fully aqueous sample stream. The diffused gas then flows to the gas loop where its CO_2 content is measured and then expelled. The GLS is installed during TOCA installation, and there are three spares on-orbit.

Figures 19-20. Gas Liquid Separator, Location to be Installed

Oxidizer Description

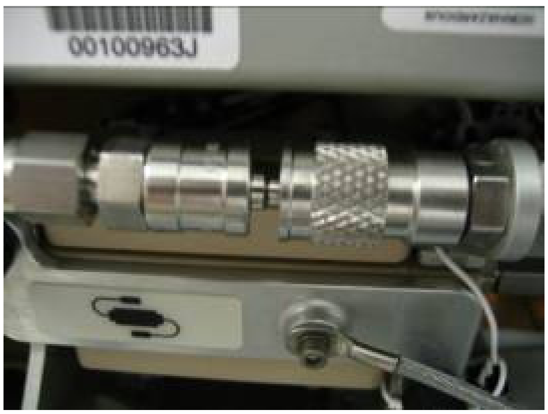
The oxidizer reactor converts organic carbons to CO_2 by using electrolysis to split water molecules into O_2 and H_2. The O_2 is then available to oxidize the organic carbon into CO_2, and H_2 is a by-product of the process. The electrolysis process occurs when sample fluid flows between 2 (anode and 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 100 mL/min. The Oxidizer reactor typically adds 4-5 watts of heat to the water sample.

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_2 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_2PO_4 and ~1% 0.5M Na_2HPO_4 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 6 (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 21-22. Buffer Container

QD Connections



Figures 23-24. Incorrect and Correct QD Connections, Respectively

TOCA Water Sample Hose

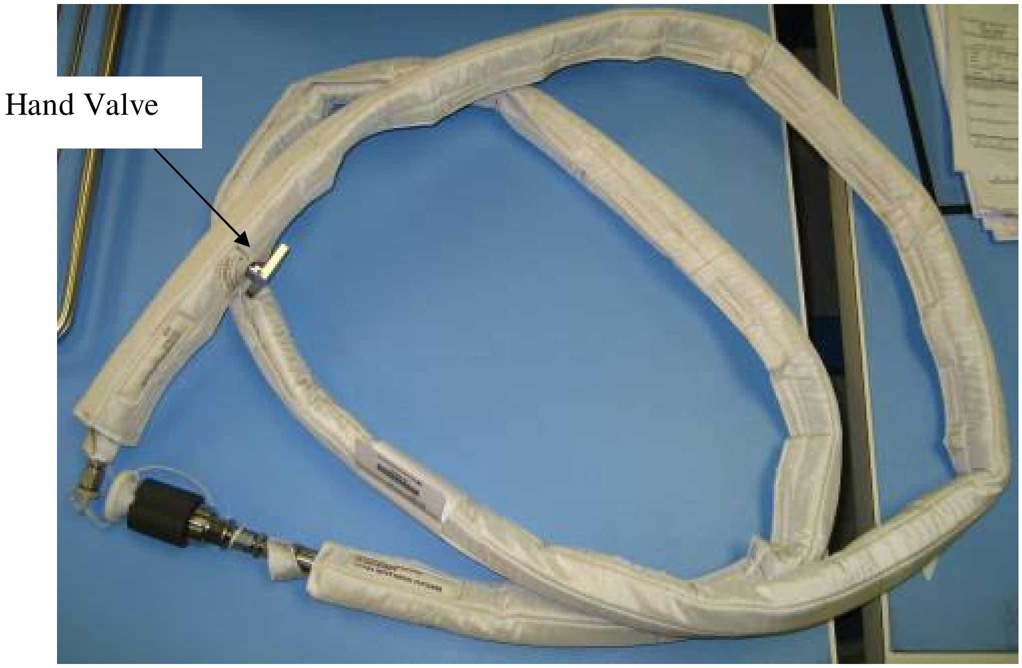


Figure 25. TOCA Water Sample Hose

OLD TOCA Water Sample Bag and Clip

Each sample collected will be 175 mL of water. The TOCA only requires 150 mL of water for analysis. A Qosina clip is installed to allow for gas liquid separation. The extra 25 mL of water is collected to allow some water to be separated from the volume to be analyzed when installing the clip. These bags will be removed from the EHS Water Kits and discarded after the new bags are proven to work well.

Figure 26. Old TOCA Water Bag

NEW TOCA Water Sample Bag

Each sample collected will be 175 mL of water. The TOCA only requires 150 mL of water for analysis. A Qosina clip is installed to allow for gas liquid separation. The extra 25 mL of water is collected to allow some water to be separated from the volume to be analyzed when installing the clip. The red circle is the difference in design between the old and new bags. This lip was added in the new design to eliminate leakage.

Figure 27. New TOCA Water Bags

Screen Shots of Displays

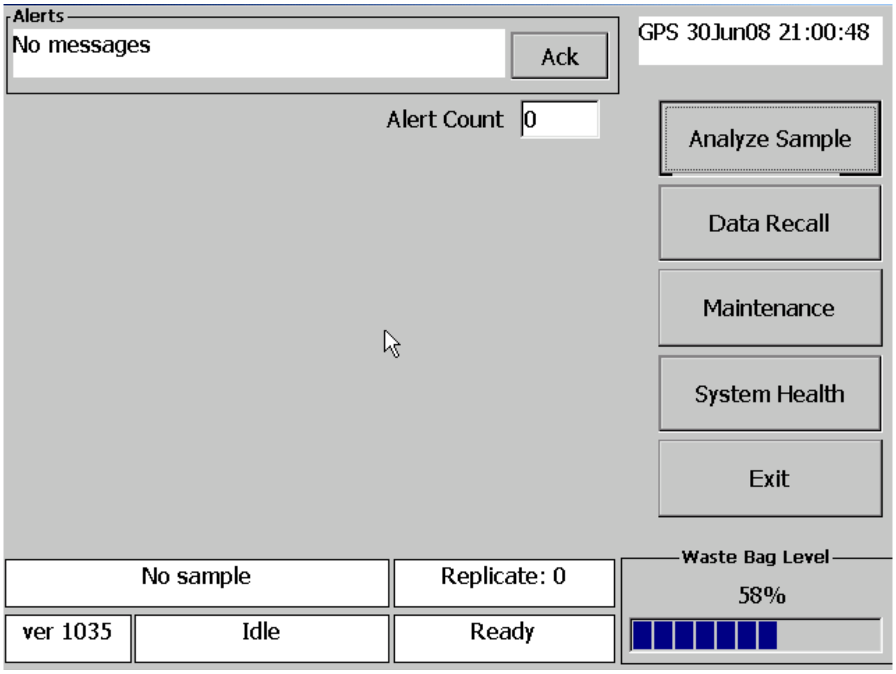


Figure 28. Screen Shot of Main Screen

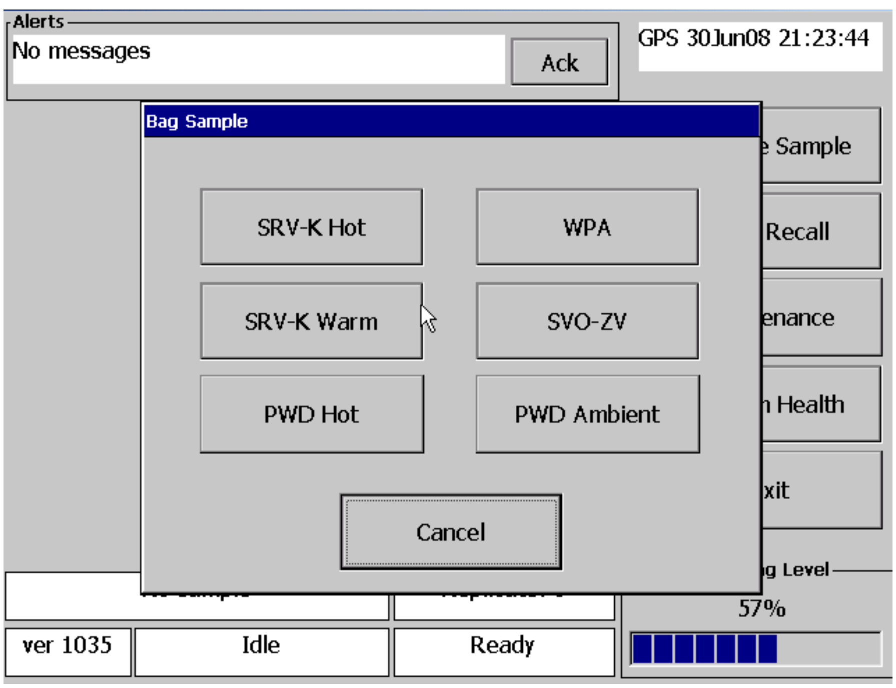


Figure 29. Bag Sample Type Screen

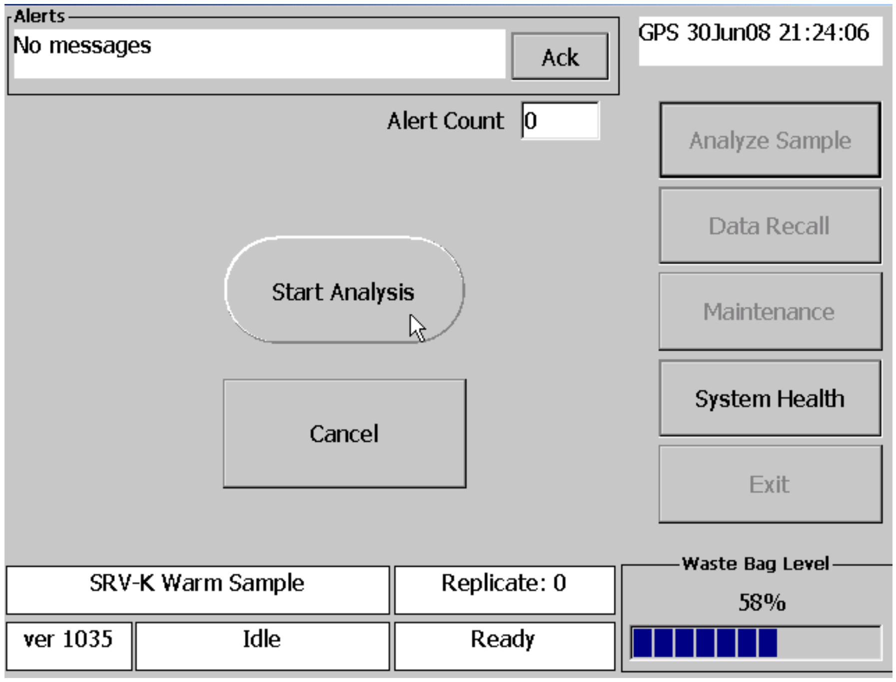


Figure 30. Start Analysis Screen

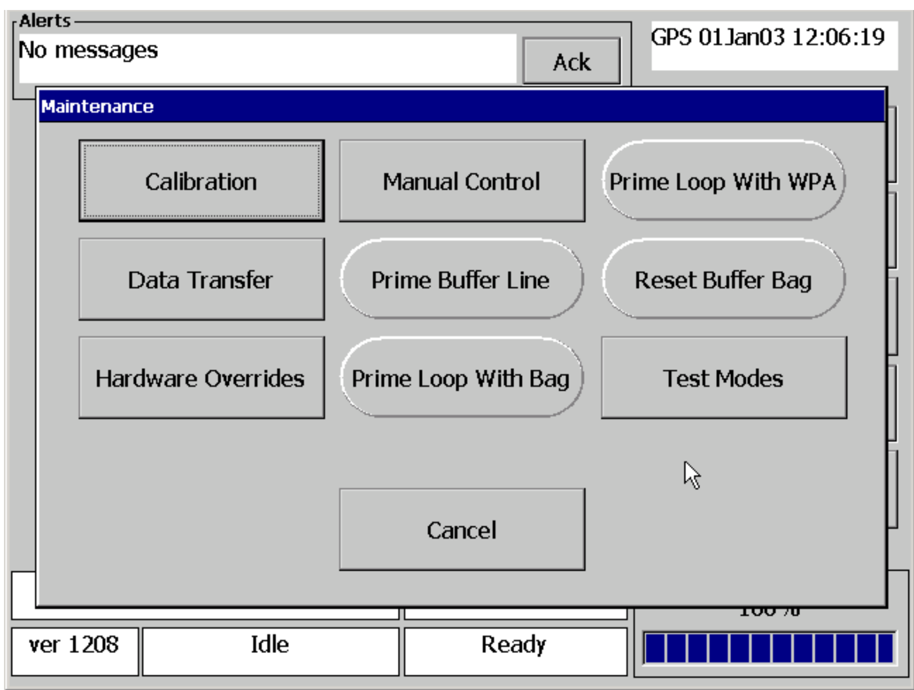


Figure 31. Maintenance Screen

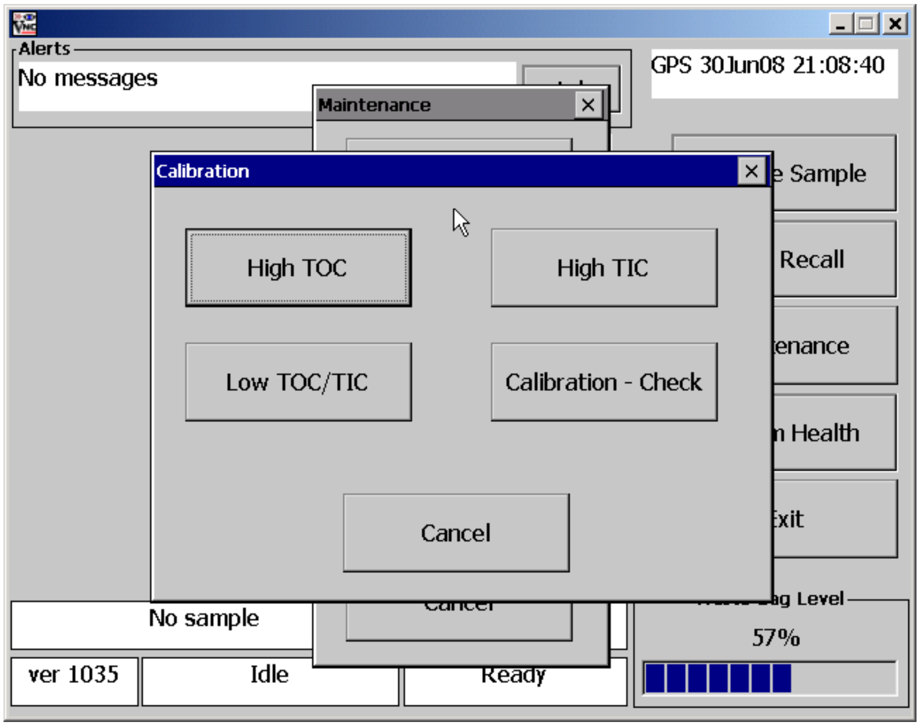


Figure 32. Calibration Type Screen

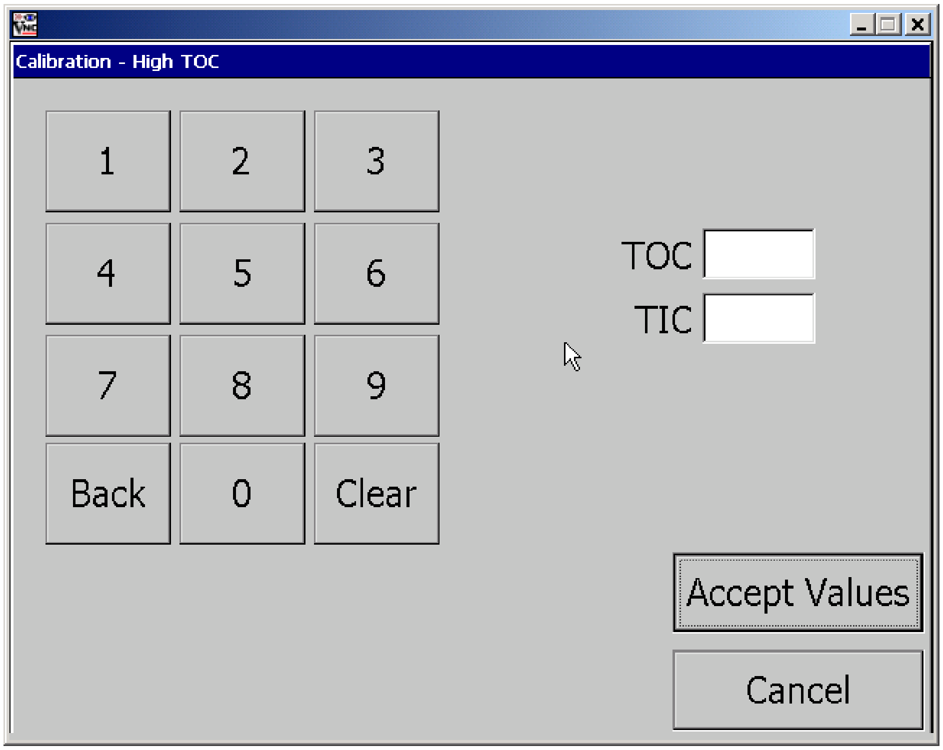


Figure 33. Known TOC and TIC Screen

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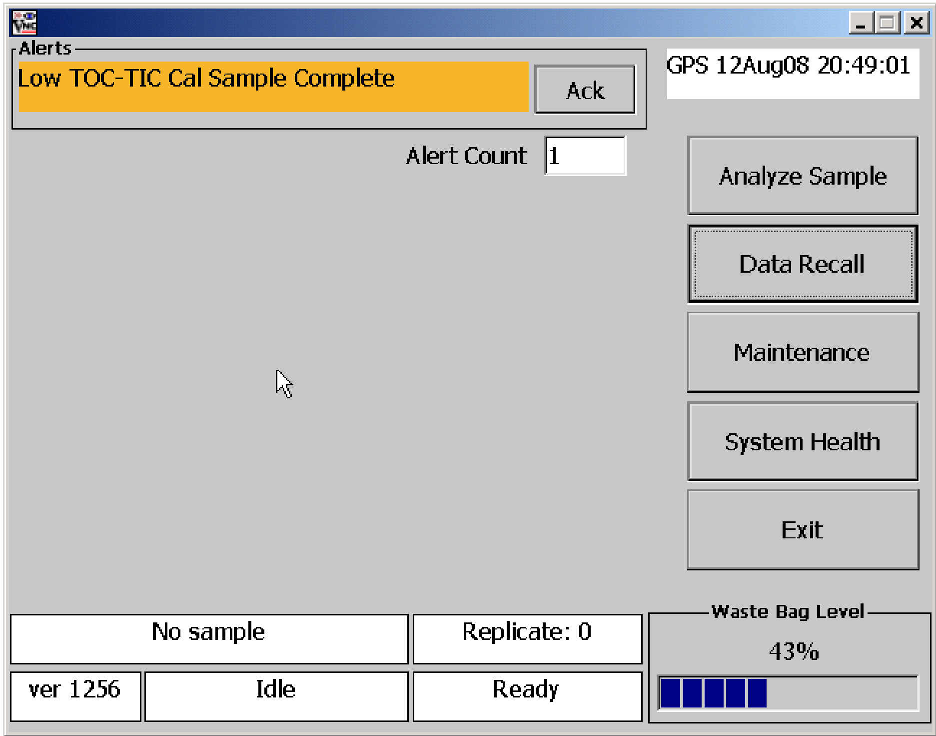

Figure 34. Low TOC-TIC Calibration Complete Screen

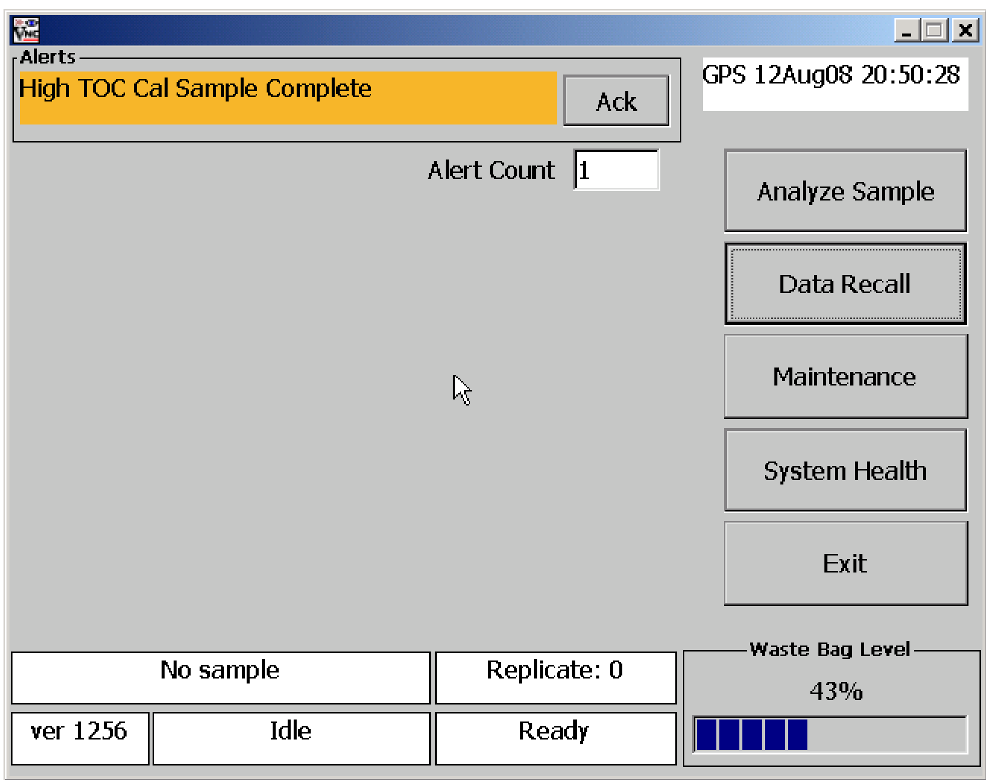

Figure 35. High TOC Calibration Complete Screen

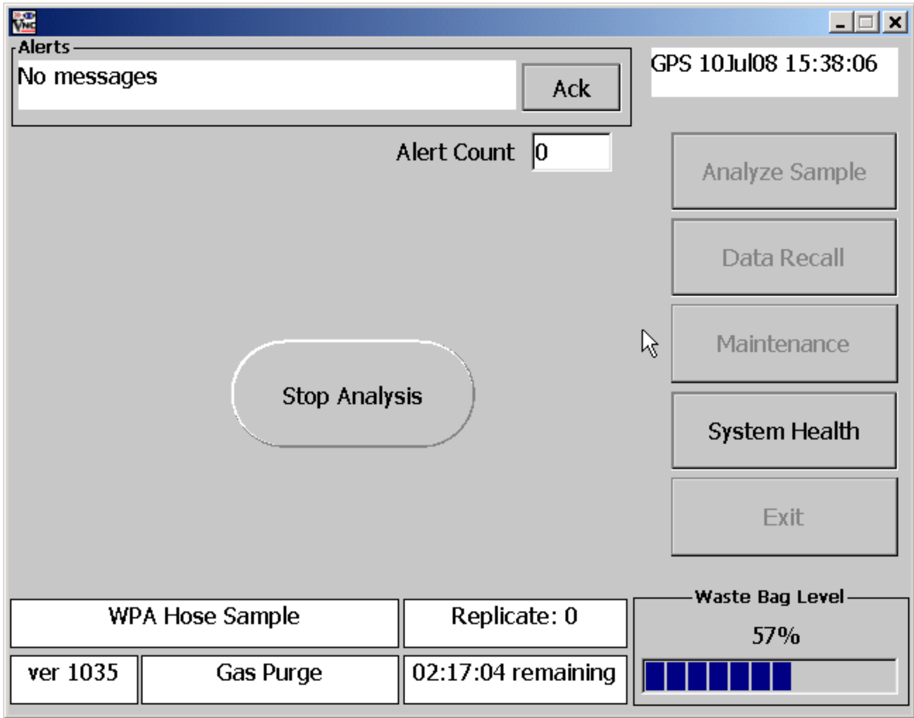

Figure 36. Stop Analysis Screen

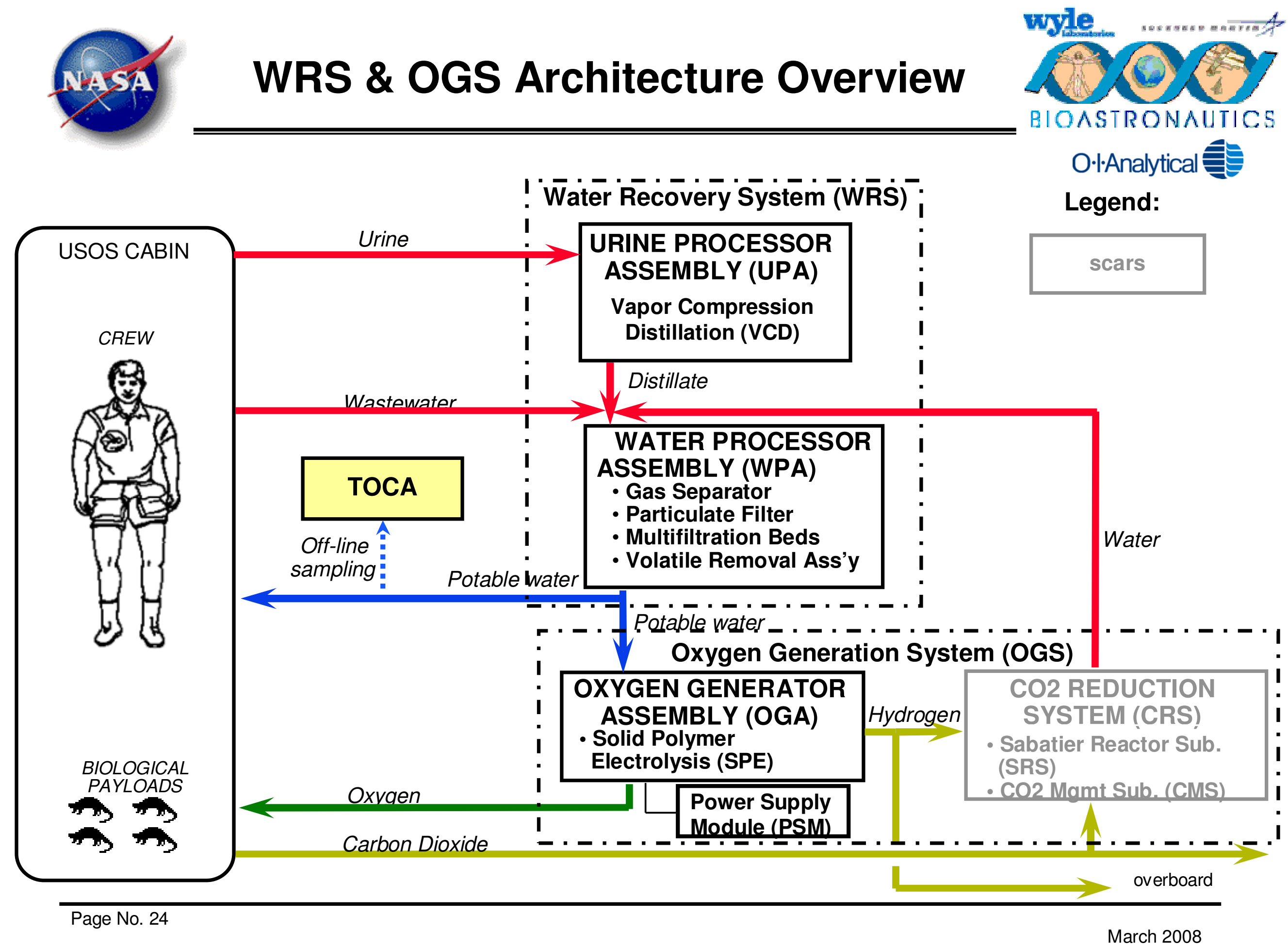

Figure 37. WRS & OGS Architecture

3.2.4.5 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 shutown, 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 38. Example Fault Indication After an Automatic Shutdown

Fault 1 is considered the most significant bit (MSB). The message in Figure 38 can be interpreted from the Error Table in Figure 39 to be an Error 13, low ambient pressure.

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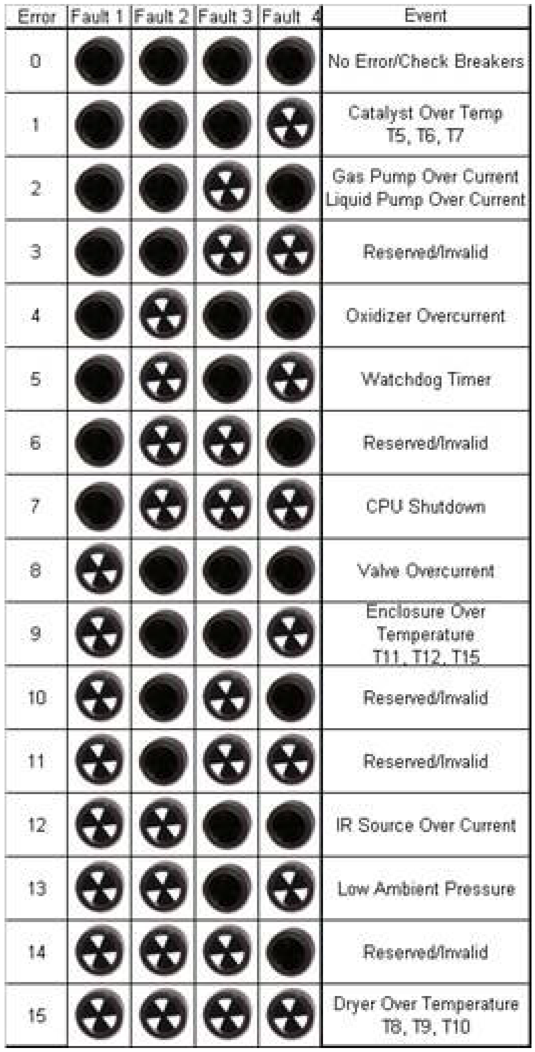

Error	Fault 1	Fault 2	Fault 3	Fault 4	Event
0	●	●	●	●	No Error/Check Breakers
1	●	●	●	⊛	Catalyst Over Temp T5, T6, T7
2	●	●	⊛	●	Gas Pump Over Current Liquid Pump Over Current
3	●	●	⊛	⊛	Reserved/Invalid
4	●	⊛	●	●	Oxidizer Overcurrent
5	●	⊛	●	⊛	Watchdog Timer
6	●	⊛	⊛	●	Reserved/Invalid
7	●	⊛	⊛	⊛	CPU Shutdown
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 39. Error Table

3.2.4.6 Hardware Interfaces with Vehicle

The TOCA unit will be temporarily mounted on the OGS rack via EDV Attachment Brackets to seat tracks, then mounted on its permanent location on the WRS2 rack face. Once in its permanent location, the TOCA power cable will interface with UOP6. The Lab TOCA N_2 Hose will be connected to the LAB1P4 Z Panel (WRS 2 RIP). The TOCA Water Sample Hose will be connected to the Potable Water Container at the WRS1 RIP.

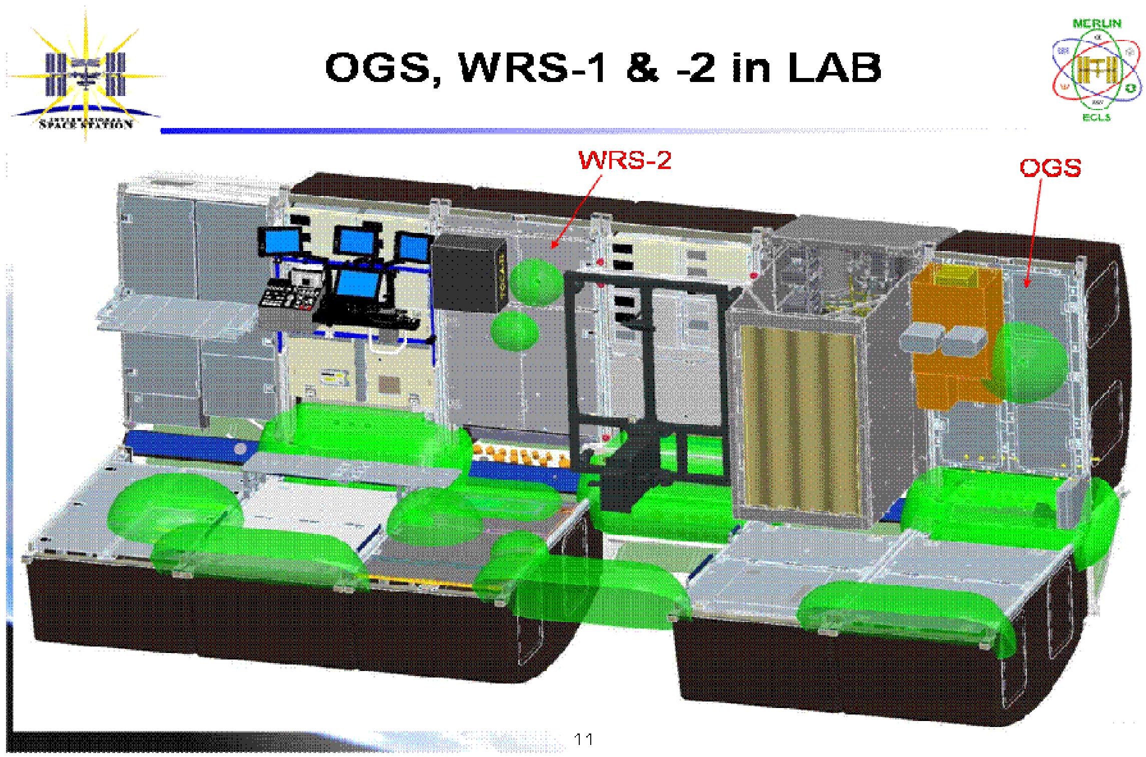

Figure 40. TOCA in its Final Location, WRS-2 Rack Face

3.2.4.7 Resupply/Maintenance Schedule

The first TOCA unit will be replaced after one year, and then the second unit will be replaced after five years of on-orbit time. The ORUs will be manifested on an as-needed basis.

3.2.4.8 Data/Commanding Capabilities

All sample data is auto-recorded on the USB Drive and transferred to a designated SSC with KFX, then downlinked.

3.2.4.9 Hazard Concerns

		Item name: Total Organic Carbon Analyzer (TOCA)			
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

		Item name: Total Organic Carbon Analyzer (TOCA)			
		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 (EVCPDS)

3.3.1.1. EVCPDS Description

The EVCPDS 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. EVCPDS

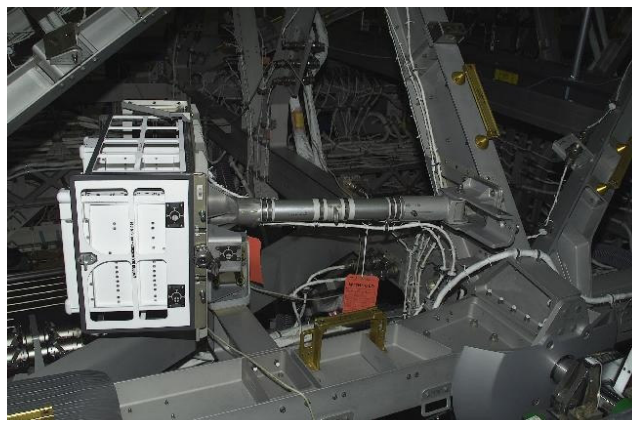

Figure 2. EVCPDS attached to the S0 Truss

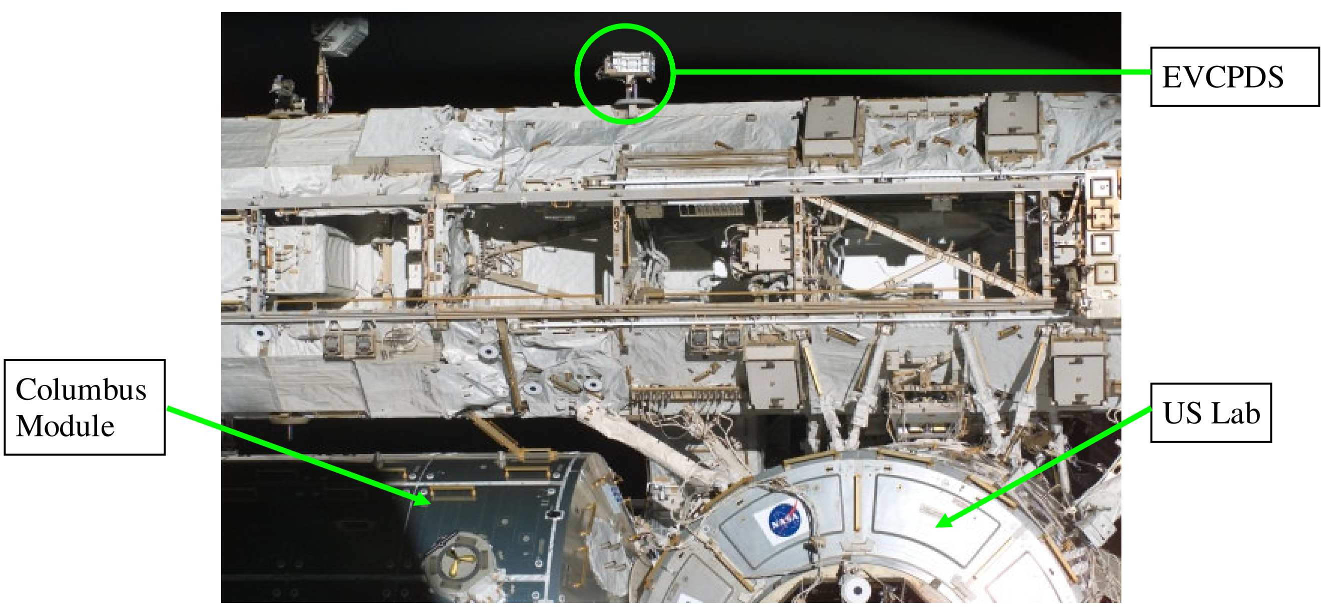

Figure 3. EVCPDS on S0Truss

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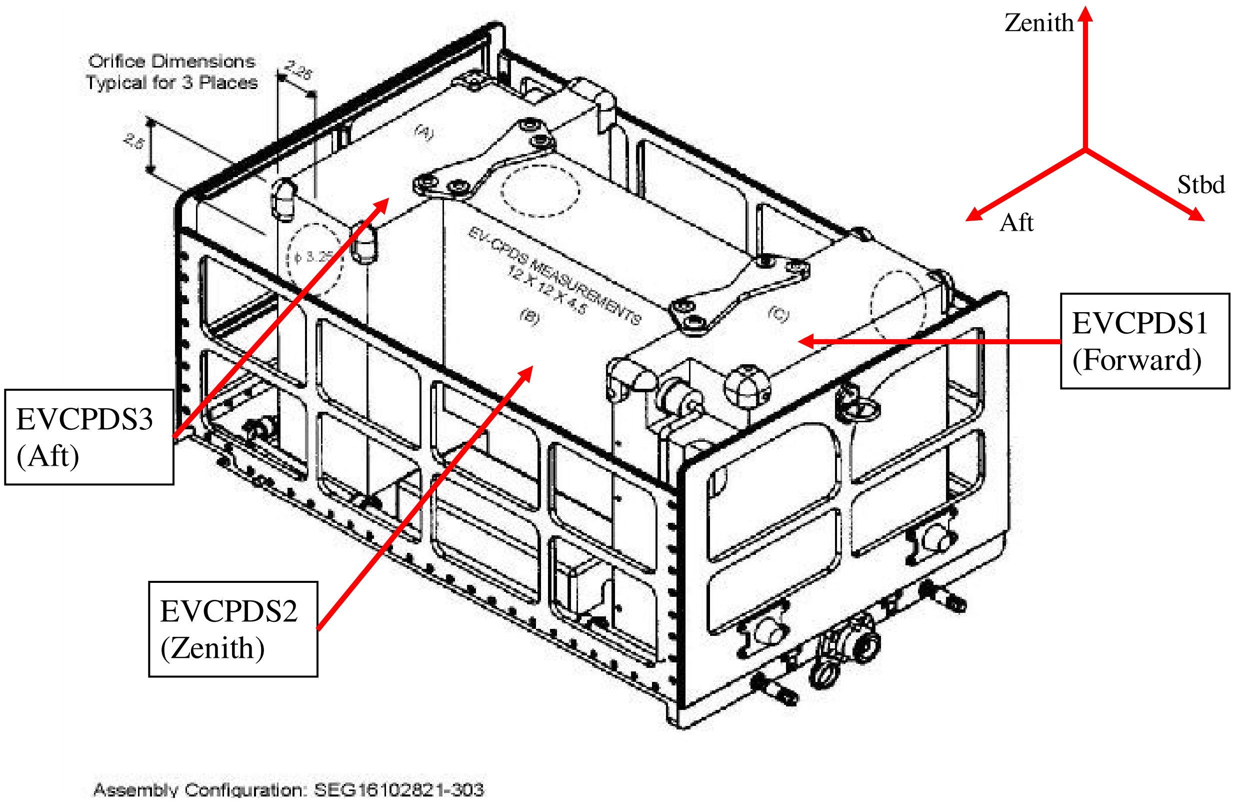

Figure 3. EVCPDS Assembly Configuration

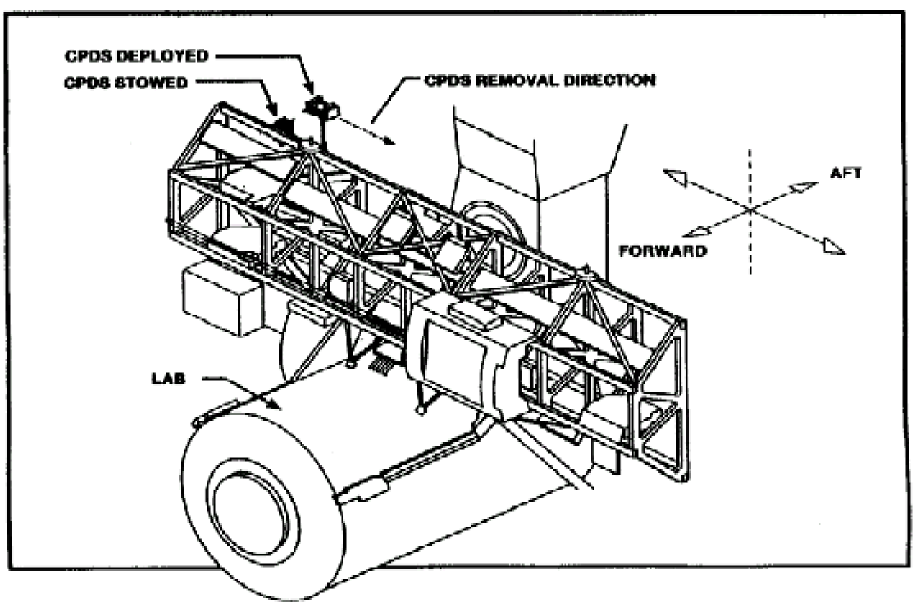

Figure 4. EVCPDS Location on S0 Truss

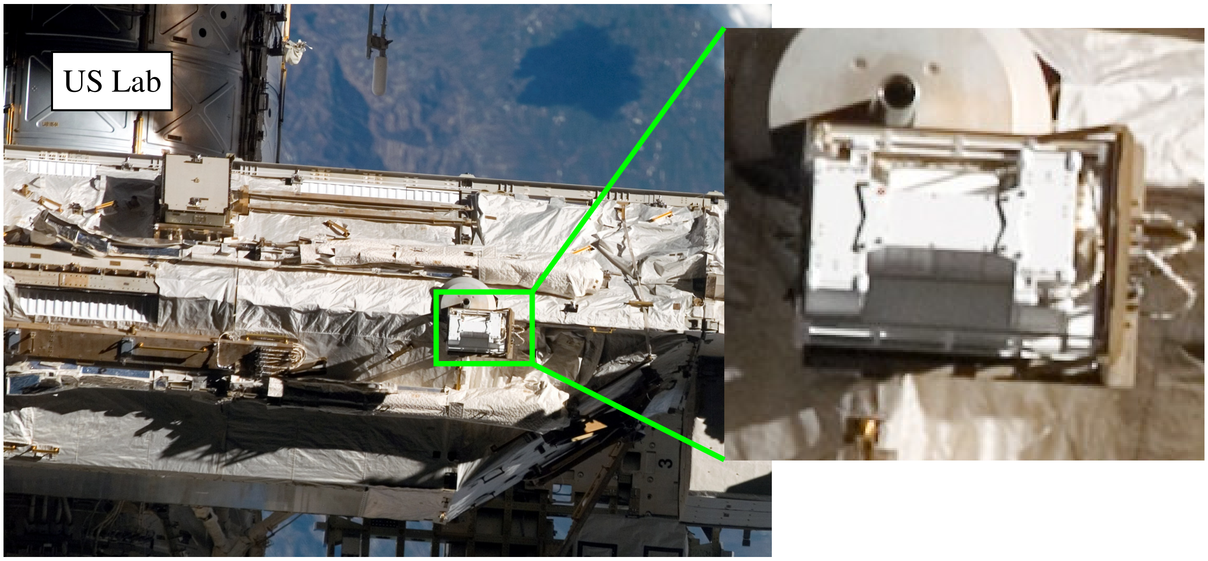

Figure 5. EVCPDS on S0 Truss During STS-122/1E

3.3.1.2. EVCPDS 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.

EVCPDS Heater Configuration

The EVCDPS 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 EVCPDS instrument RCPM (S01A_C). The automatic heaters are controlled by thermostats (activated at -20°C) in each instrument and are powered via the EVCPDS 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 EVCPDS 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 EVCPDS 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 EVCPDS 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)
EVCPDS Assy. (3 units in 6B Av. Box)	33.11 kg (73lbs)	0.10 m^3 (3.65 ft^3)	35.41cm x 63.02cm x 41.15cm (13.94" x 24.81" x 16.2")	S0 Truss	-53 - 50ºC (-63- 122 ºF)	-53 - 50ºC (-63-122 ºF)	15 PSI - Vacuum* [<1mmHg]

*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

EVCPDS 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		
Total[1]	17	**51**		
External Heater	15	45	S0-2B_C	3
Max Power Draw[2]	~32	**~96**		

[1]Nominal operating configuration with instrument and internal heaters on.
[2]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; however, the lifetime has a minimum of 5 years, which was exceeded in 2007.

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
- 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 30 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.

3.3.1.6. Hazard Concerns

Hazard Title	Severity	Likelihood
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)

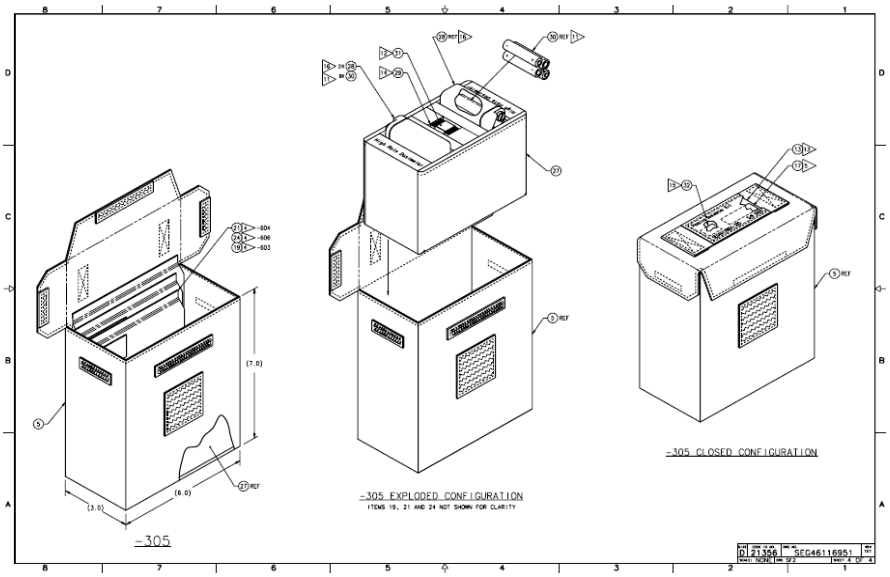

Figure 3. Schematic of PDK with High Rate Dosimeter Foam Insert

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^3 (126.0 in^3)	15.2 cm x 8.9 cm x 17.8 cm (6" x 3.5" x 7")	CHeCS Rack	-10 - 80°C (14 -176°F)		13.5-15.2 psia
RAM	0.0136 kg, (0.03 lb)	$1.8x10^{-5}m^3$ ($6.51x10^{-4}$ ft^3)	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.)	1.8x10-5 m^3 (6.51x10-4 ft^3)	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)	$1.7x10^{-4}$ m^3 ($6.1x10^{-3}$ ft^3)	10 cm x 6.6 cm x 2.8 cm (3.9" x 2.6" x 1.1")	CHeCS Rack			

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. 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

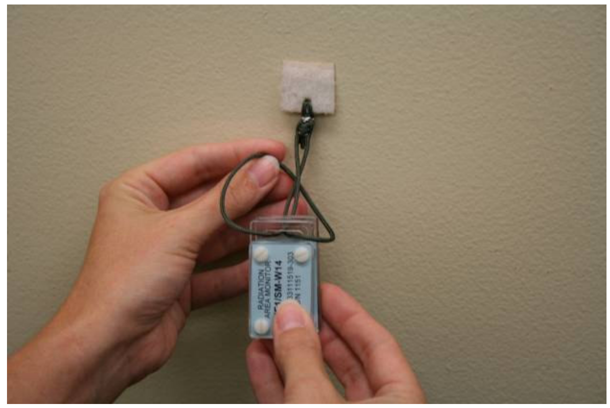

Figure 5. RAM with Tether

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

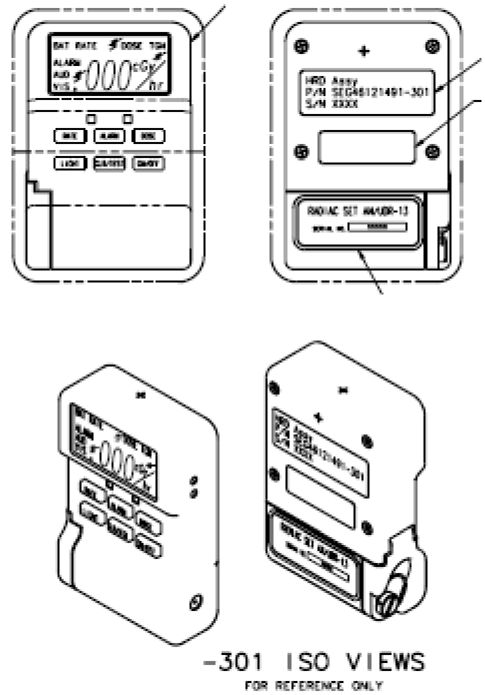

Figure 7. High Rate Dosimeter Schematic

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.

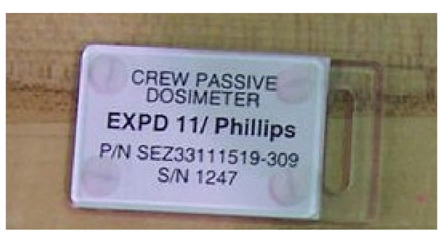

Figure 8. Crew Passive Dosimeter

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

3.3.2.3. <u>Hardware Interfaces with Vehicle</u>

- 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. TEPC measured dose is compared with the Russian radiation monitor, R-16, located in the Russian Service Module. 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, ends of modules, 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 mrads/min). There is a manual On/Off switch capability. Once the rate drops below the set point, the alarm will silence itself.

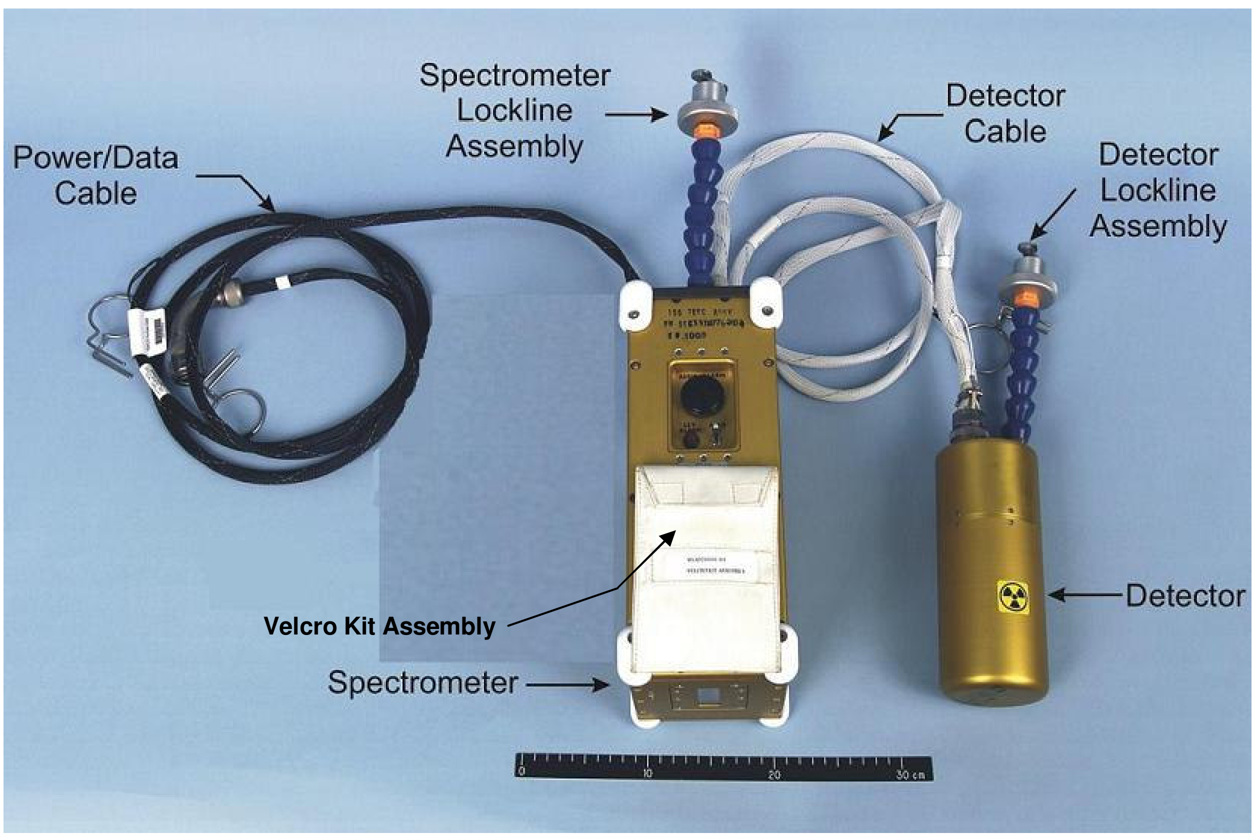

Figure 1. TEPC with Power/Data Cable Assembly

Figures 2-3. TEPC Spectrometer

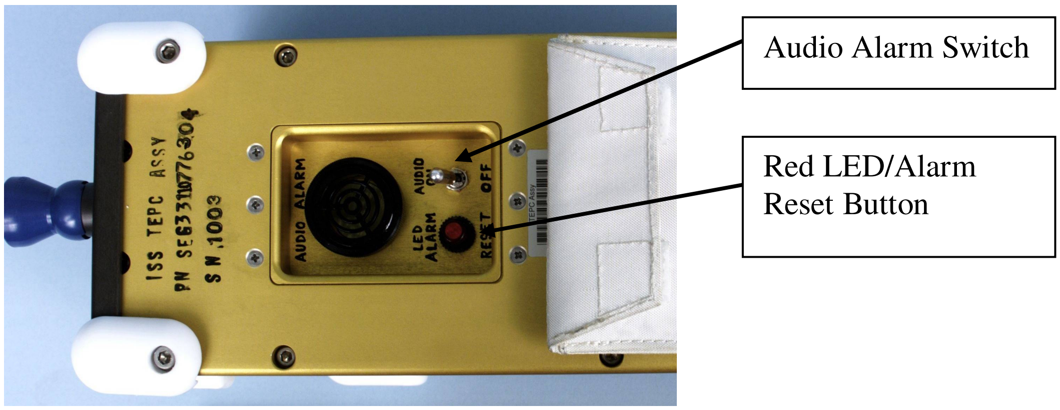

Figure 4. TEPC Audio Alarm

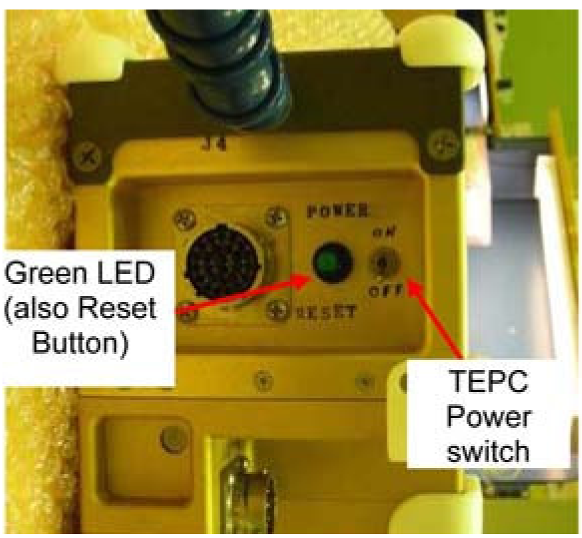

Figure 5. TEPC Power Controls

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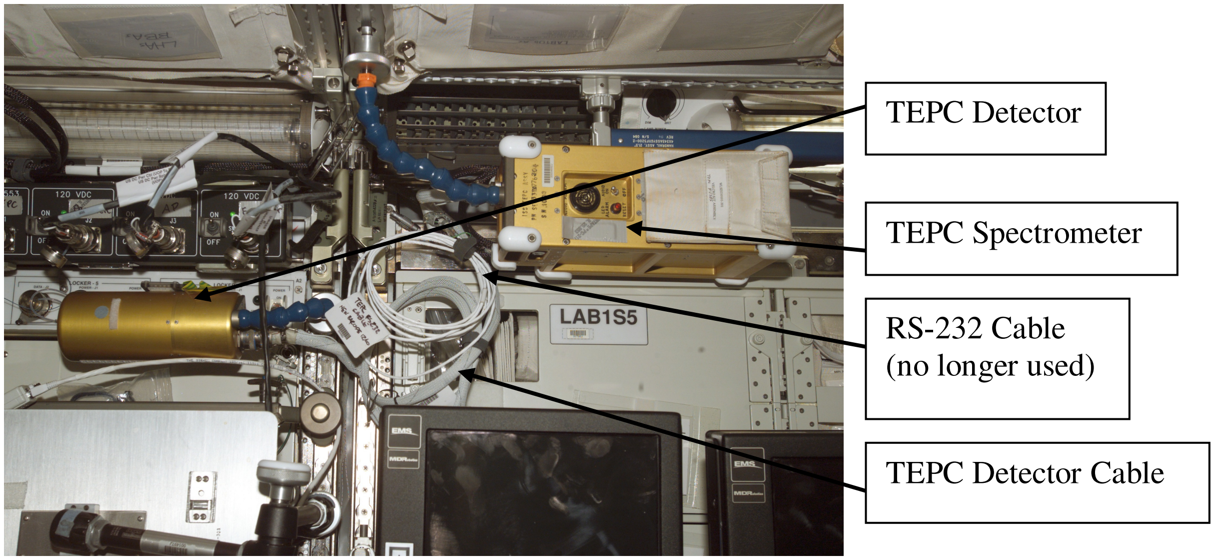

Figure 6. TEPC Spectrometer and Detector deployed in US LAB

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^3 (431.31 in^3)	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	CHeCS PCR or PS-120 Junction Box (type of power strip)
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 (LAB1OS4). This provides 4 power outlets, only one of which has 1553 capability to allow CHeCS data to flow through to the 1553 data bus.

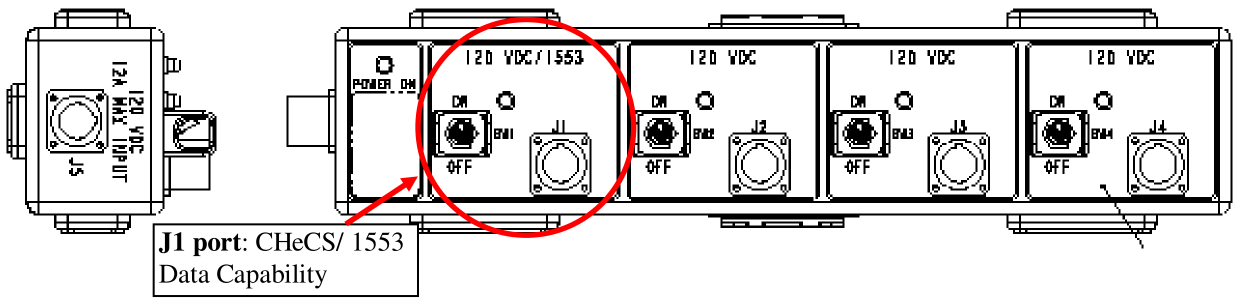

Figure 7. PS-120 Schematic

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. 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.

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. Once in 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.

3.3.3.6. Hazard Concerns

N/A

3.3.4. Failed/Obsolete Hardware

*** Due to lack of funding to support the refurbishing of the final available flight unit, the IVCPDS will not be available for use starting mid-Expedition 16. Available funding will instead go towards next generation charged particle dosimetry 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

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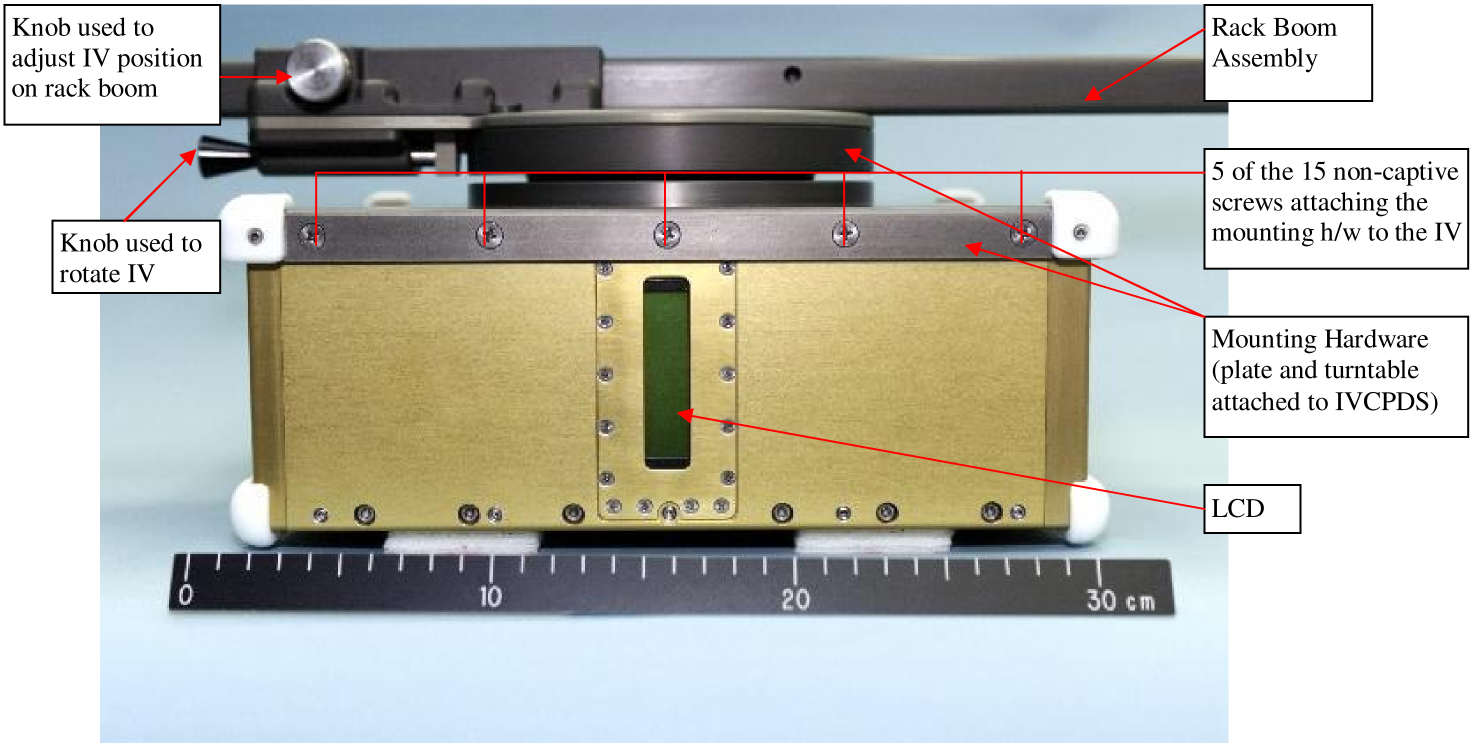

Figure 2. Side View of Intravehicular Charged Particle Directional Spectrometer

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^3 (853.5 in^3)	32.4cm x 32.4cm x 13.3cm (12.75"x 12.75"x 5.25")	US LAB (varies)	-31 - 52 ºC (-25 - 125 ºF)	-40 - 50 ºC (-40- 122ºF)	9 - 15 psi

Table 3.3.4.1.2-2 Hardware-Specific Parameters

Power Requirements	120VDC, 28VDC
Power Draw	12 W
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 IVCPDS power switch can be turned OFF, before the ISS Crewmember resets the UOP, he/she must first turn the IVCPDS instrument off, then reset the UOP, and finally turn the IVCPDS power switch to ON.

3.3.4.1.3. Hardware Interfaces with Vehicle

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

The IVCPDS is periodically relocated to acquire measurements in different areas of the ISS. A relocation may simply require the crewmember to rotate the IVCPDS 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 IVCPDS 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 IVCPDS 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

IVCPDS 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. IVCPDS 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 IVCPDS 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 IVCPDS is powered on, the LCD on the front panel displays “Instrument in Standby” mode and the IVCDPS 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 IVCPDS 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_2) 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_2 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_2 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^3 (295.5 in^3)	29 cm x 15.2 cm x 10.9 cm (11.4" x 6" x 4.3")	CHeCS: LAB1S4_A2	-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 - 38ºC (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.

Trainer: Bethany Fenner (281) 461-2792 bethany.c.fenner@nasa.gov & Elisca Hicks (281) 212-1356 elisca.hicks-1@nasa.gov
Ops Rep: William Misek (281) 483-6163 william.t.misek@nasa.gov
HW Engr: Mary Walsh (281) 483-3331 Mary.Walsh-1@nasa.gov
Book Mgrs: Jamie Moore (281) 483-5145 jamie.l.moore@nasa.gov & Faith Knudsen (281) 483-5963 faith.s.knudsen@nasa.gov
Tech Writer: Kimberlee Jadwick (281) 461-2611 kimberlee.j.jadwick@nasa.gov

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.

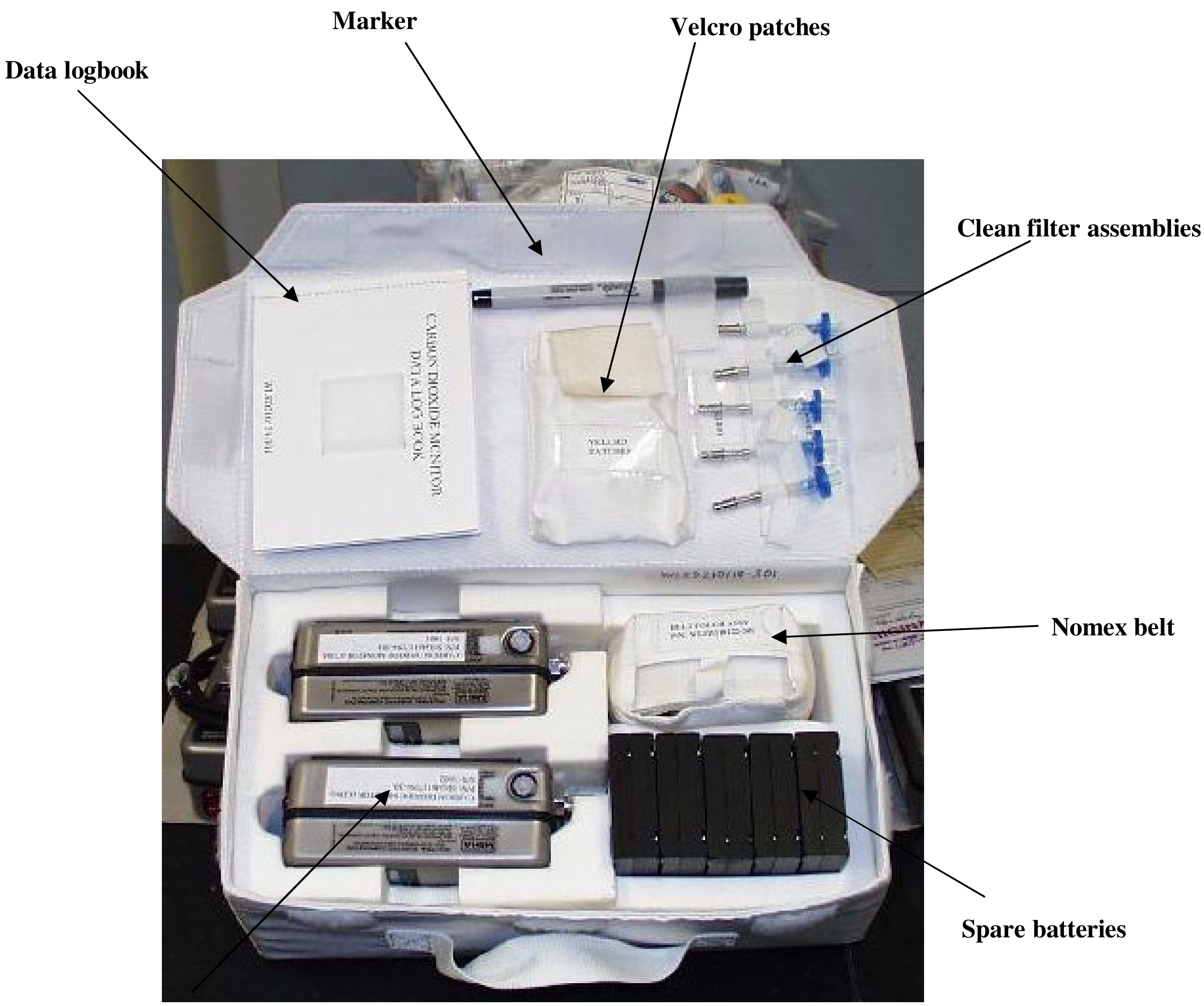

Figure 1. CDM Stowage Kit

3.4.1.2.1 Carbon Dioxide Monitor

The Carbon Dioxide Monitor (CDM) contains an infrared-based carbon dioxide sensor that does not require oxygen to measure the CO_2 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 3.4.1.2.1-1. Hardware-Specific Parameters

Power Requirements	(2) 9 volt lithium-manganese batteries contained inside 1 battery pack (Not rechargeable on orbit)			
Measurement Capabilities of CO_2 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_2 Concentra-tion (%)	Precision (%) 8 - hr	Accuracy (%) 1 day*	Accuracy (%) 14 days*
	≤0.10	± 0.03	± 0.03	± 0.03
	0.10<x<2.0	Linear interpolation between 0.03 and 0.3		
	≥2.00	undefined	undefined	undefined
	@ 80% Relative Humidity	± 0.20	± 0.20	± 0.30
	*Time following sensor calibration			

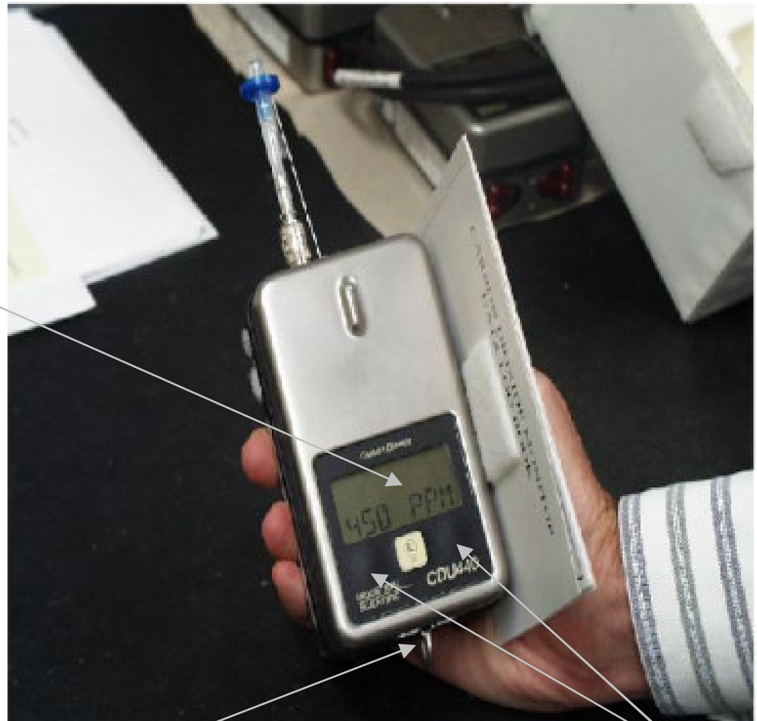

Figure 2. Carbon Dioxide Monitor Display

<u>CDM Display</u>

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_2 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_2 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. 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

Hazard Title	Sev	Like-lihood	Hazard Condition Description	Applicability/ Hazard Report
Fire/Explosion (Detonation)	CAT	IMP	Fire/Explosion within hardware causes injury to crew or damage to station	Applicable/ GEN-CDMK-1
Explosion/ Implosion (No Detonation)	N/A	N/A	Explosion inside hardware due to a ruptured pressure vessel	N/A
Environmental	N/A	N/A	Exposure to extreme temperature/pressure variations of space	N/A
EMI	CRT	IMP	Hardware emits excessive EMI (radiative or conductive)	Applicable/ GEN-CDMK-2
Contamination	CAT	IMP	Shatterable materials released into crew cabin due to impact to LCD.	Applicable / GEN-CDMK-3
Radiation	N/A	N/A	Exposure of crew to ionizing radiation	N/A
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
Impact	N/A	N/A	Shatterable materials release due to rotating equipment fracture	N/A
Toxicity	CAT	IMP	Crew exposed to the effects of toxic contamination from materials offgassing	Applicable/ GEN-CDMK-5
Electrical Discharge/ Shock	N/A	N/A	Crew exposure to electrical shock leading to burns/injury to the crew	N/A
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
Structural Failure	N/A	N/A	Failure of structural element leading to crew injury	N/A
Rapid Safing	N/A	N/A	Emergency egress from a module impeded by hardware component due to biomedical wiring/restraint	N/A
Battery Hazards	CAT	IMP	Release of chemicals into cabin due to improper design	Applicable/ GEN-CDMK-6
Created by Failure to Function	N/A	N/A	Instrument fails to function leading to injury to crew or damage to Station	N/A
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
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_2) 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_2) 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^3 (1592.3 in^3)	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^3 (627 in^3)	41.9 cm x 24.1 cm x 10.2 cm (16.5” x 9.5” x 4.0”)	LAB1S4_C2	-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^3 (627 in^3)	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^3 (26.1 in^3)	12.1 cm x 7.0 cm x 5.1 cm (4.75” x 2.75” x 2.0”)	PRIME: SM Central Post BACKUP: SM 208 NOD1S4-03 NOD2S6-51	-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.

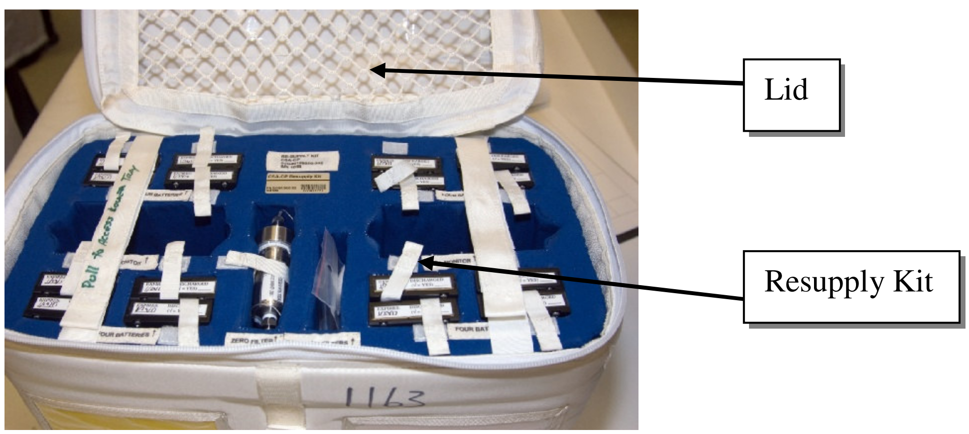

Figure 1. CSA-CP Transport Kit (open, oblique view)

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.

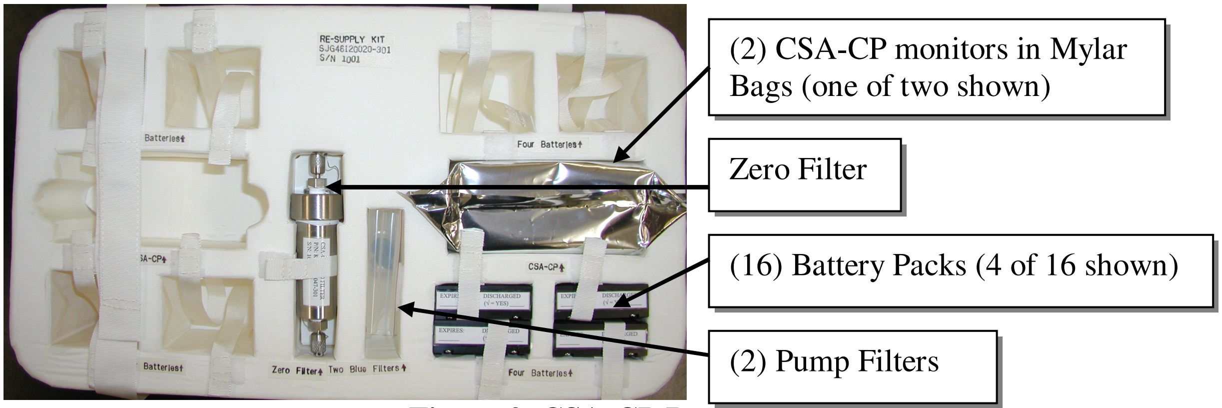

Figure 2. CSA-CP Resupply Kit

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.

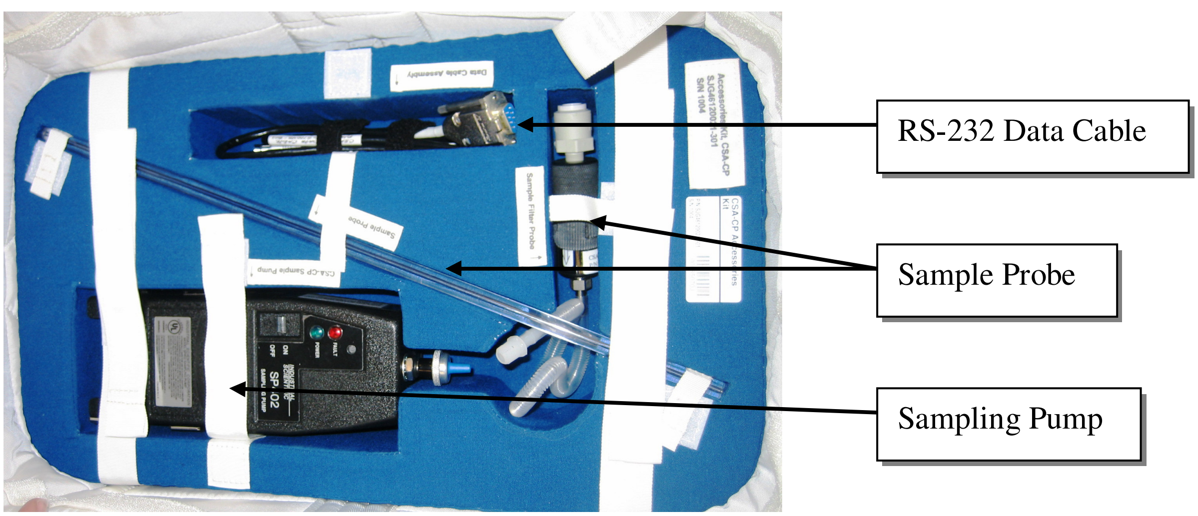

Figure 3. CSA-CP Accessories Kit

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_2 and is powered by a replaceable battery pack. The CSA-CP draws a steady state current of 1.22 ± 0.19 mA with the unit powered off and 4.80 ± 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.

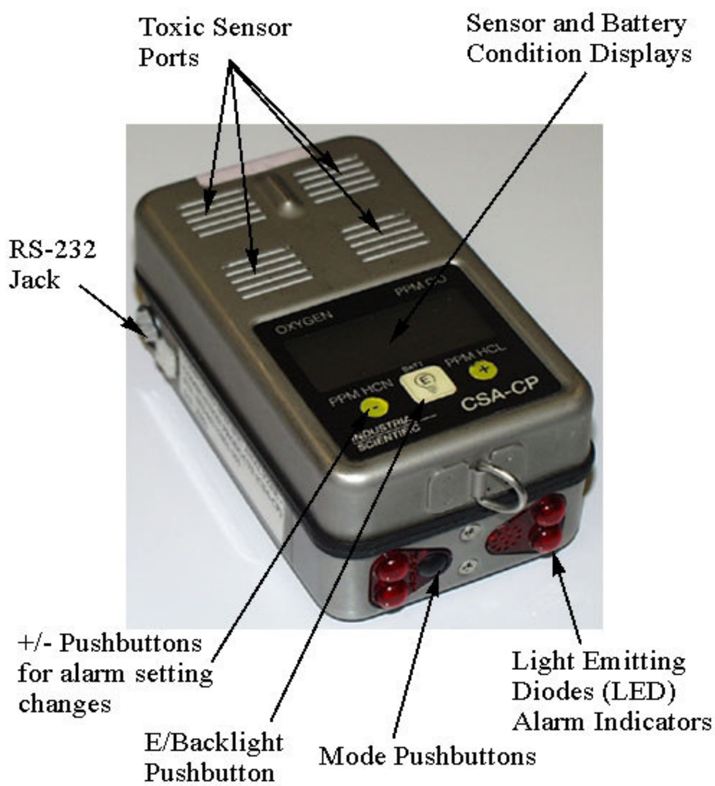

Figure 4. CSA-CP with parts labeled

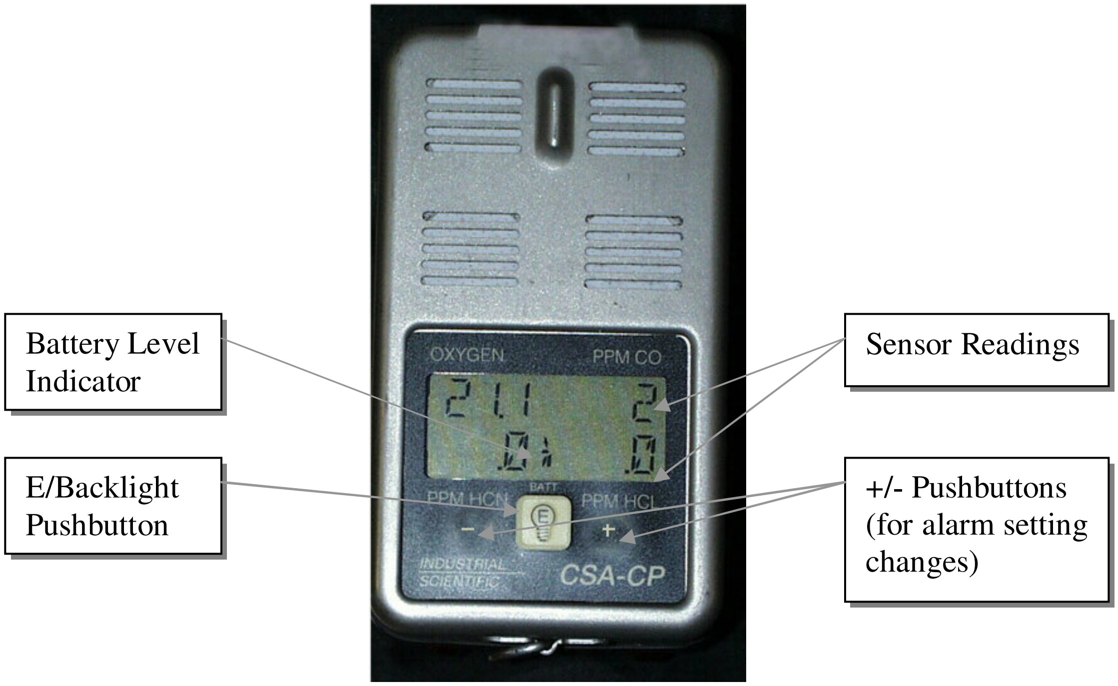

Figure 5. CSA-CP Monitor View

Table 3.4.2.2.4-1   Hardware-Specific Parameters

<table>
<tr><td>Power Requirements</td><td colspan="6">(2) 9 volt batteries (Lithium Manganese Dioxide) contained within 1 battery pack
(Not rechargeable on-orbit)</td></tr>
<tr><td>Storage</td><td colspan="6">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</td></tr>
<tr><td></td><td colspan="6">* Operating range: 20-80% RH
† Operating range: 13.9-14.9 psi</td></tr>
<tr><td rowspan="5">Measurement Parameters/Analysis Capabilities</td><td>Sensor</td><td>Linear Response Range</td><td>Full Scale Range†</td><td>Display Resolution</td><td>Response – Baseline to 80% Maximum Response</td><td>Recovery – Maximum Response to 20% Above Baseline</td></tr>
<tr><td>CO*</td><td>3-400 ppm</td><td>-999-999 ppm</td><td>1 ppm</td><td>≤30 seconds</td><td>≤30 seconds</td></tr>
<tr><td>HCN</td><td>0.4-30 ppm</td><td>-99.9-99.9 ppm</td><td>0.1 ppm</td><td>≤1.5 minutes</td><td>≤1.5 minutes</td></tr>
<tr><td>HCl</td><td>0.4-30 ppm</td><td>-99.9-99.9 ppm</td><td>0.1 ppm</td><td>≤3 minutes</td><td>≤3 minutes</td></tr>
<tr><td>Oxygen</td><td>14-32%</td><td>0-40%</td><td>0.1% (by volume)</td><td>≤1 minute</td><td>≤1 minute</td></tr>
<tr><td></td><td colspan="6">* 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</td></tr>
<tr><td rowspan="5">Accuracy</td><td>Sensor</td><td>Concentration*</td><td>Accuracy†</td><td colspan="3">Affects of Low Pressure on Accuracy</td></tr>
<tr><td>CO</td><td>40 ppm
500 ppm</td><td>± 10 ppm
± 50 ppm</td><td colspan="3">Less than 10% effect in accuracy to a pressure of 9 psi
Max. pressure range: 13.2-15.2 psi</td></tr>
<tr><td>HCN</td><td>10 ppm
20 ppm</td><td>± 4 ppm
± 6 ppm</td><td colspan="3">Accuracy at lower pressures is significantly worse (up to 50%)
Max. pressure range: 13.2-15.2 psi</td></tr>
<tr><td>HCl</td><td>10 ppm
20 ppm</td><td>± 5 ppm
± 6 ppm</td><td colspan="3">Unknown (no testing performed)
Max. pressure range: 13.2-15.2 psi</td></tr>
<tr><td>Oxygen</td><td></td><td>± 6 mmHg</td><td colspan="3">No significant effect
Max. pressure range: 9.5-15.2 psi</td></tr>
<tr><td></td><td colspan="6">* 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.</td></tr>
</table>

Display

The CSA-CP measures HCN, HCL, and CO in ppm. O_2 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.

O2	**CO**
HCN	**HCL**

- 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 10PPM
HCN 1PPM
HCL 1PPM
O_2 1%
} Low alarm
Data logger Auto start

CO 10PPM
HCN 1PPM
HCL 1PPM
O_2 40%
} High Alarm

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_2 sensor will be set to extreme values in order to prevent the O_2 alarm from being triggered. The O_2 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 can not 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 24 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".

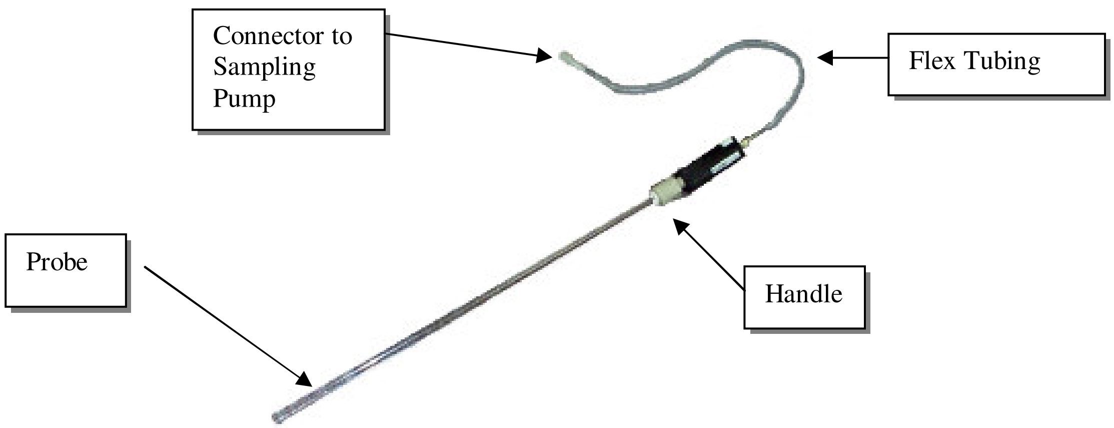

Figure 6. Sample Probe for CSA-CP Active Mode Remote Sampling

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

<u>CSA-CP Sampling Pump</u>

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.

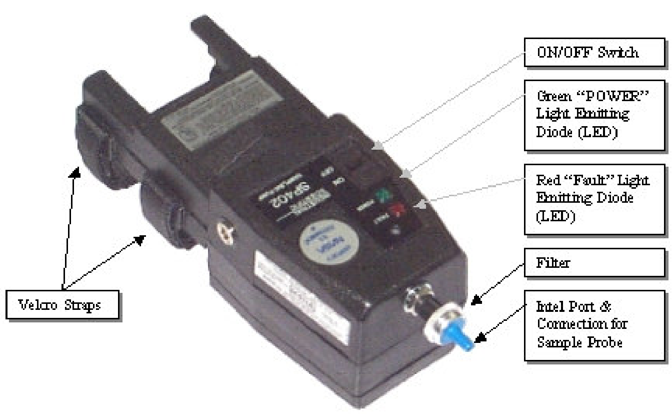

Figure 8. Sampling Pump

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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. 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/O2 and Sampling Pump exceeds 113°F due to instrument overheating causing injury to the IVA crewmembers.
Contamination	Critical-Catastrophic	Improbable	Release of hazardous contaminates 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

Hazard Title	Severity	Likelihood	Hazard Condition Description
			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_2)

3.4.3.1. CSA-O2 Description

The CSA-O2 is outwardly very similar to the CSA-CP. However, unlike the CSA-CP, the CSA-O2 contains only an O2-sensitive electrochemical sensor rather than the CSA-CP's full compliment of O2, HCN, CO, and HCl sensors.

Without the HCl, HCN, and CO sensors, the crew is able to take the CSA-O2 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_2 concentration to over 23.5%. During these protocols, at least two CSA-O2 units are required to provide readings that supplement those of the MCA.

3.4.3.2. CSA-O2 Kit Component List and Description

- CSA-O2 Resupply Kit
    a. CSA-O2 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-O2 Resupply Kit	5.7 kg (12.5 lbs)	10299.9 cm^3 (627 in^3)	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-O2 units	0.6 kg (1.32 lbs)	431.97 cm^3 (26.1 in^3)	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-O2 Resupply Kit

The Resupply Kit used for the CSA-O2 hardware is identical to the kit used with the CSA-CP hardware except that the CSA-O2 kit contains only spare battery packs in addition to its compliment of monitors.

Because the battery changeouts for the CSA-O2s occur less frequently than those for the CSA-CPs, new CSA-O2 Resupply Kits only need to be provided approximately every 12 months.

3.4.3.2.2 CSA-O2 Monitor

The CSA-O2 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-O2 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.

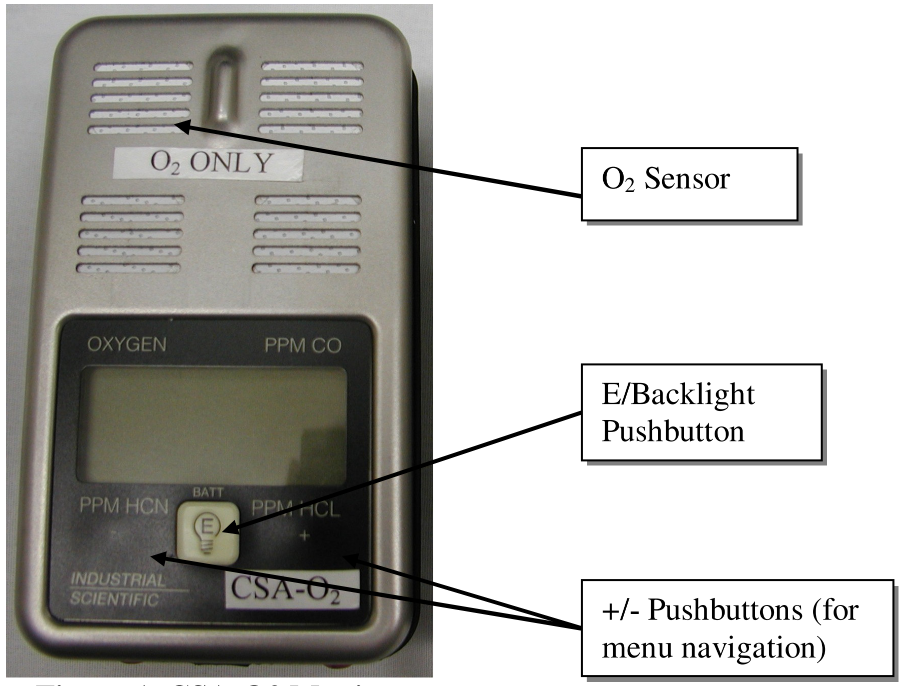

Figure 1. CSA-O2 Monitor

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 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-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 O2 readings of the CSA-O2 are measured in percentage (%, by volume).

The CSA-O2 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.

O2

- 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-O2 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 is 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-CP (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 can not 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. 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 contaminates 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	Catastrophic	Improbable	Erroneous high/low readings displayed by the CSA-CP/O2 monitor due to failure of Portable Gas Delivery System to flow

Hazard Title	Severity	Likelihood	Hazard Condition Description
Accurately Calibrate CSA-CP/O2			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

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)
Portable Gas Delivery System	8.9 lbs* 4.04 kg	14184.5 cm^3 (865.6 in^3)	41.7 cm x 23.1 cm x 14.7 cm (16.4" x 9.1" x 5.8")	JPM1F6_F1	-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			JPM1F6_F1	-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.

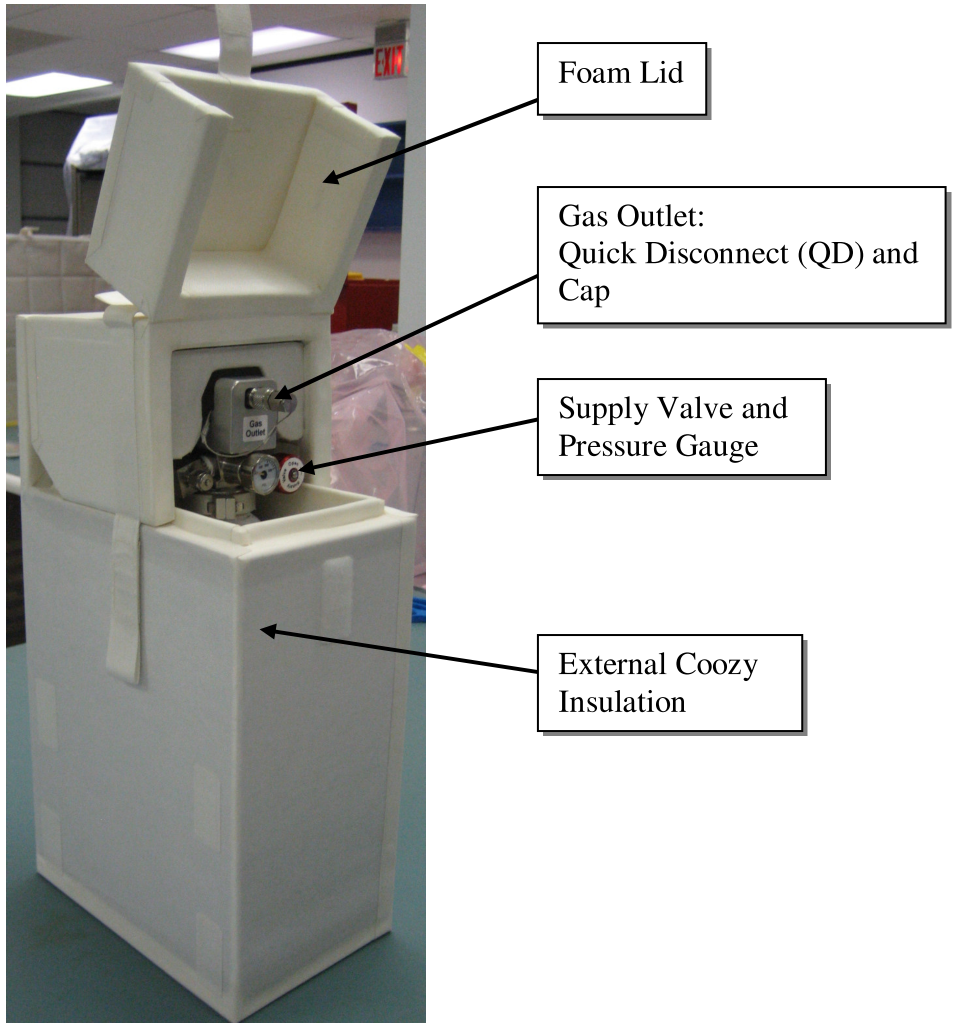

Figure 1. Portable Gas Delivery System

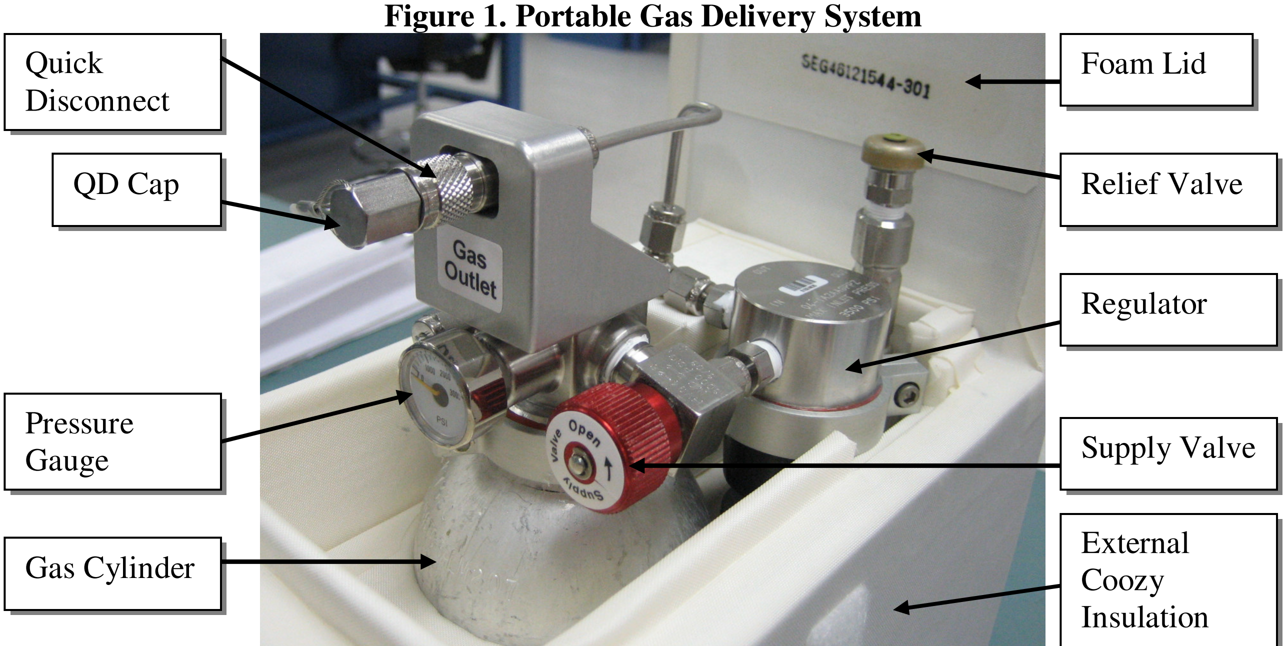

Figure 2. Portable Gas Delivery System (Gas Cylinder Assembly)

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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_2

* 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 O2 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.

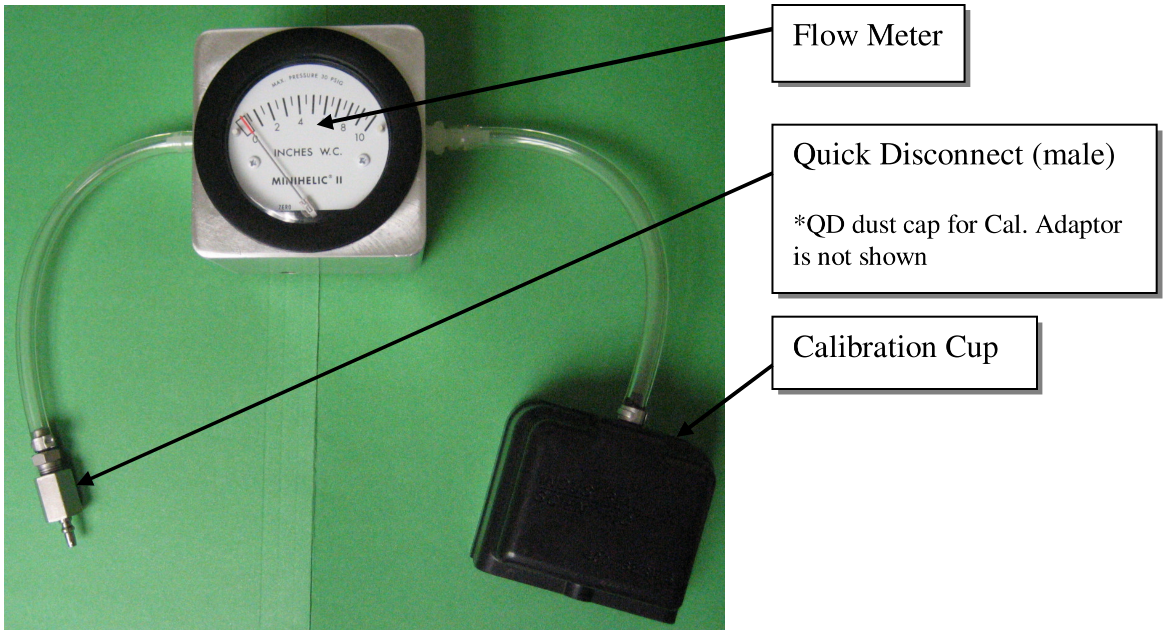

Figure 3. CSA Calibration Adaptor

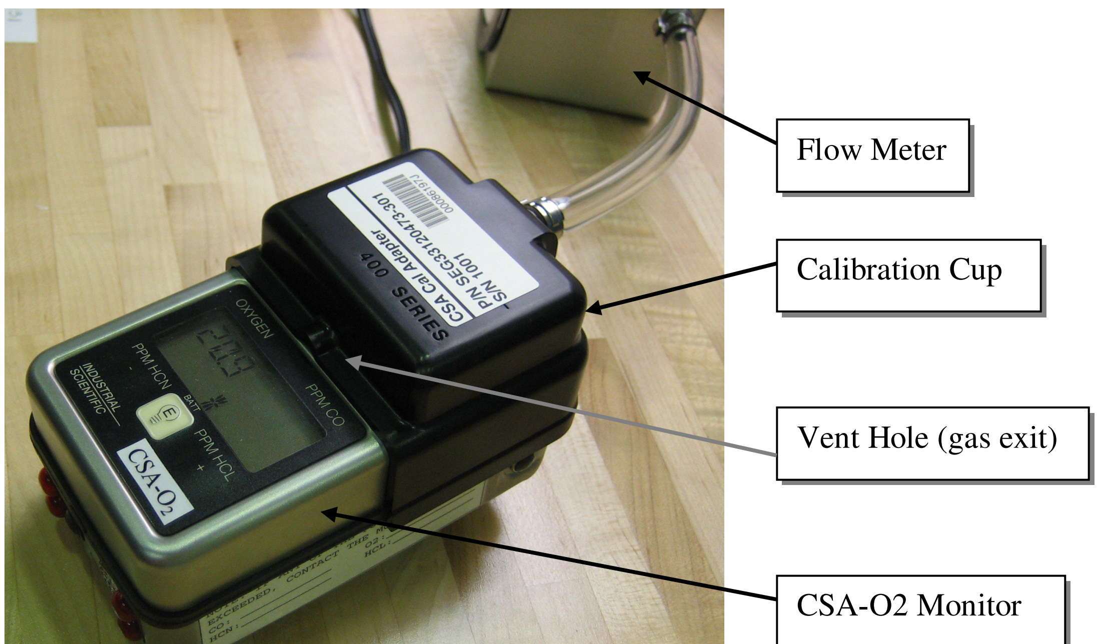

Figure 4. CSA Calibration Adaptor (Calibration Cup)

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. No in-flight results will be available.

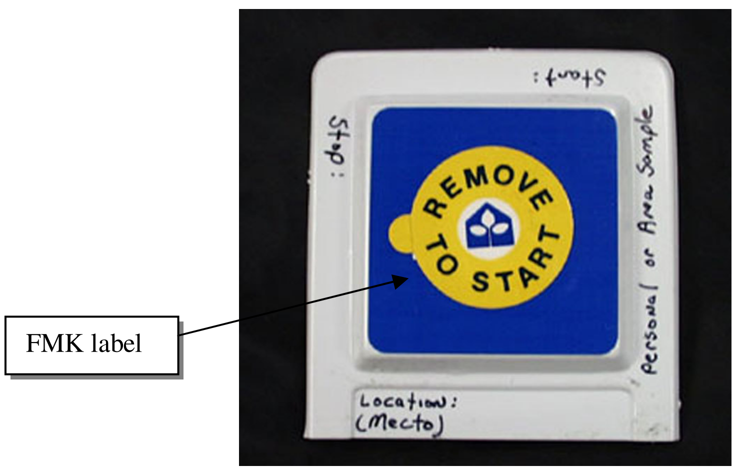

Figure 1. Formaldehyde Monitor

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

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)
Formaldehyde Monitoring Kit	0.1 kg (0.22 lbs)	793.0 cm^3 (48.4 in^3)	22 cm x 12.0 cm x 3.0 cm (8.67" x 4.73" x 1.18")	CHeCS: LAB1S4_C1	4 - 43 ºC (39 - 110 ºF)		
Formaldehyde Monitor	3.9 g (0.009 lbs)	31 cm^3 (2 in^3)	6.5 cm x 6.5 cm x 0.75 cm (2.6" x 2.6" x 0.3")	Inside FMK	4 - 43 ºC (39 - 110 ºF)	-7 - 38 ºC (20- 100 ºF)	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

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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.

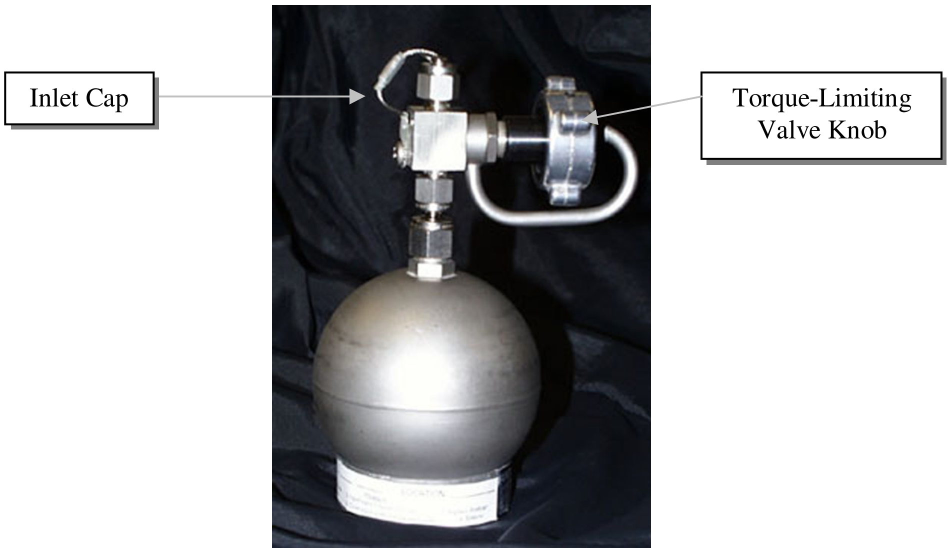

Figure 1. Grab Sample Container

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^3 (124.3 in^3)	17.5cm x 12.1cm x 8.9 cm (6.9" x 4.8" x 3.5")	CHeCS: LAB1S4_C1	4 – 35 ºC (39 – 95 ºF)	-7 – 38 ºC (20- 100 ºF)	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. Volatile Organic Analyzer (VOA)

3.4.7.1. 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 3.4.7.1-1 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)
VOA	42.2 kg (93lbs)	109518.8 cm^3 (6683.3 in^3)	85.1cm x 48.3cm x 26.7 cm (33.5" x 19.0" x 10.5")	CHeCS: LAB1S4_H2	5°C - 40°C (41ºF – 104 ºF)	17ºC – 29ºC (63ºF – 85ºF)	13.5 to 15.2 psia
VOA OMI Kit	10.67 kg (23.518 lbs)	27890 cm^3 (1702 in^3)	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 ºF)	18.3 – 26.7ºC (65 – 80ºF)	
VOA Sample Bag Kit	1.23 kg (2.708 lbs)	4425 cm^3 (270 in^3)	25.4 cm x 22.9 cm x 7.62 cm (10" x 9" x 3")	Refer to IMS			

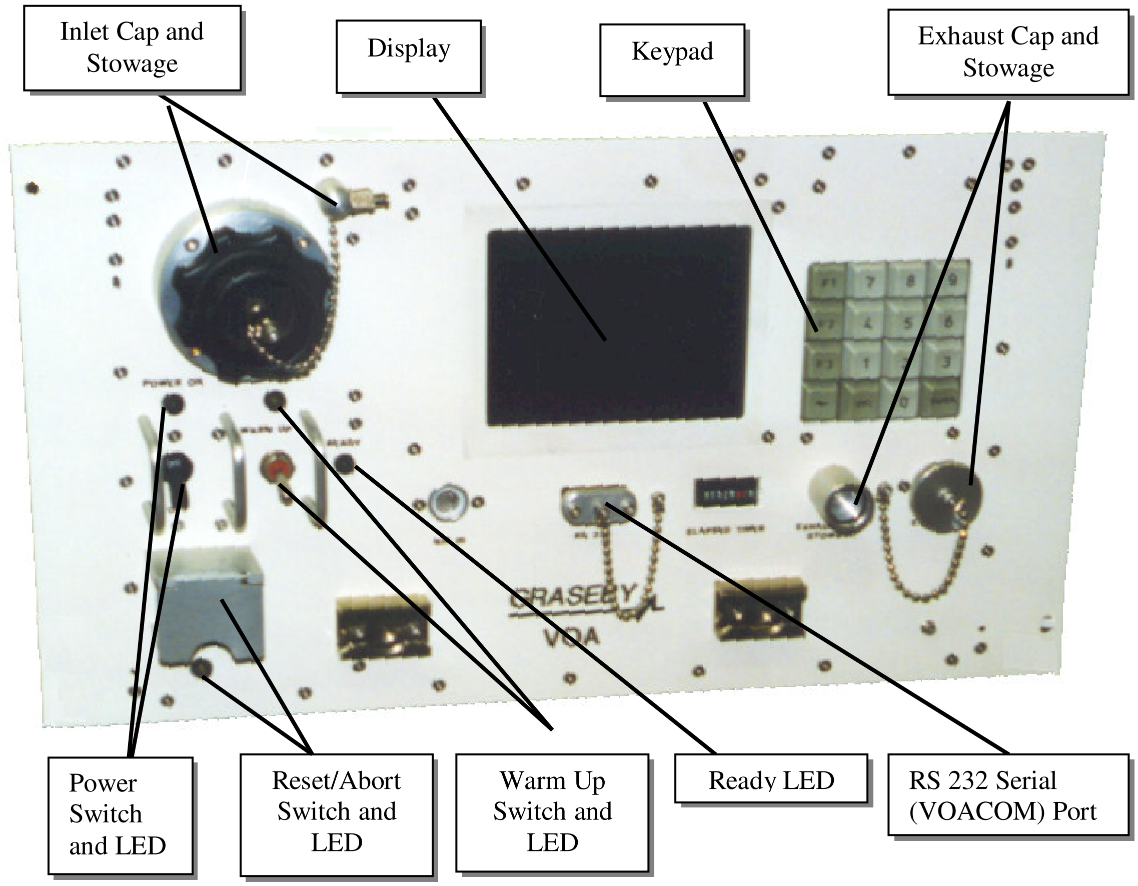

Figure 1. VOA Front Panel

Table 3.4.7.1-2 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	• Voltage: 113-126 VDC; 120 VCD is nominal • Humidity: 27-70% relative humidity, non-condensing • Nitrogen Pressure: 55 psi – 140 $\pm$ 10 psi • Nitrogen Usage: 2ml/min in STANDBY, 4-6 ml/min in ACQUIRE • Nitrogen Pressure After Nitrogen Transfer from the Shuttle: Less than 112 psi

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3.4.7.1.1 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 3.4.6.1.1-1 lists the compounds that are detected by the VOA.

Table 3.4.7.1.1-1 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 over heating. 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 can not 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).

3.4.7.1.2. 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 OMIs. 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 OMIs 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.

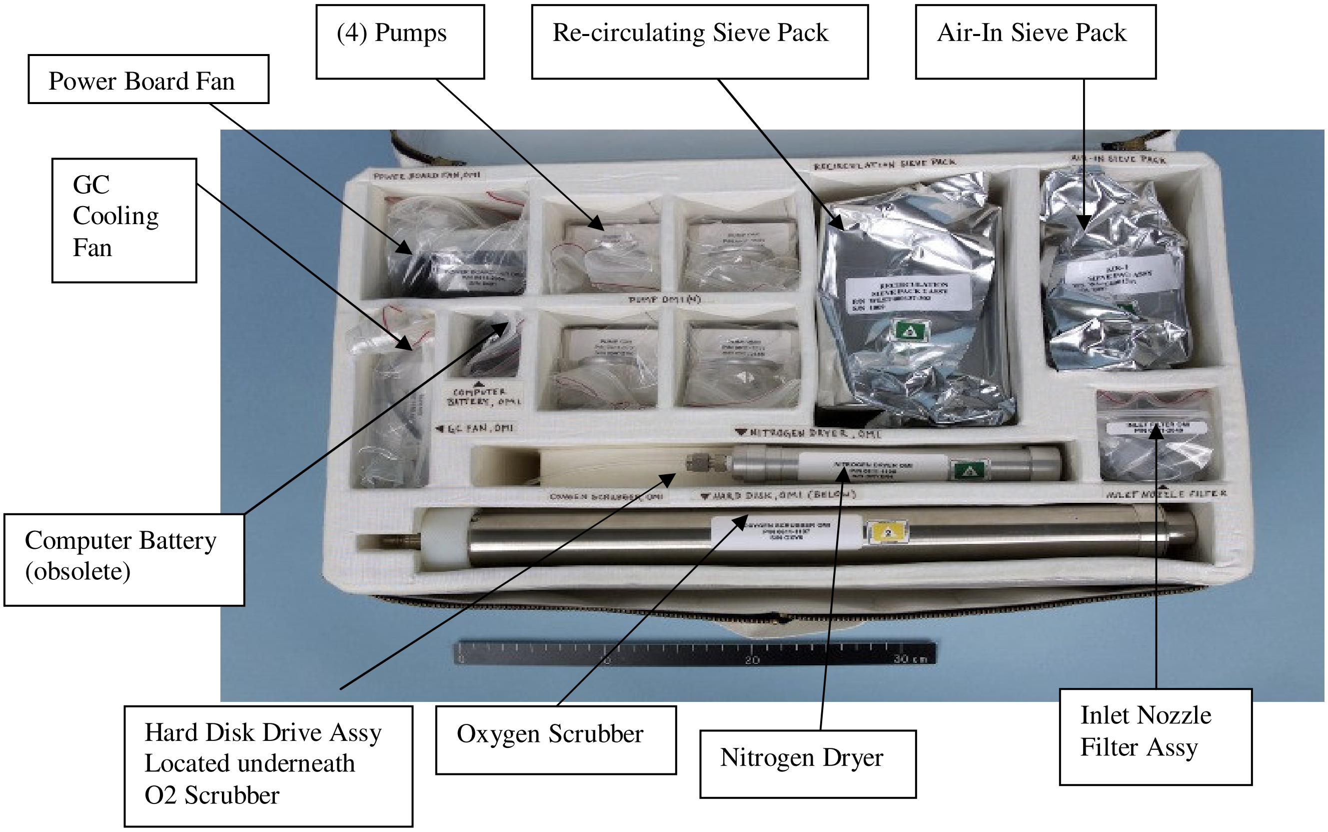


Figure 2. VOA OMI Kit

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 and 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)

3.4.7.1.3. 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 sampled 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

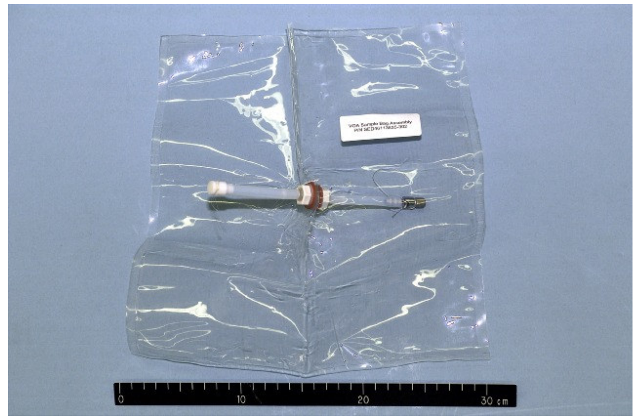


Figure 4. VOA Sample Bag

3.4.7.2. 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.

3.4.7.3. 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.

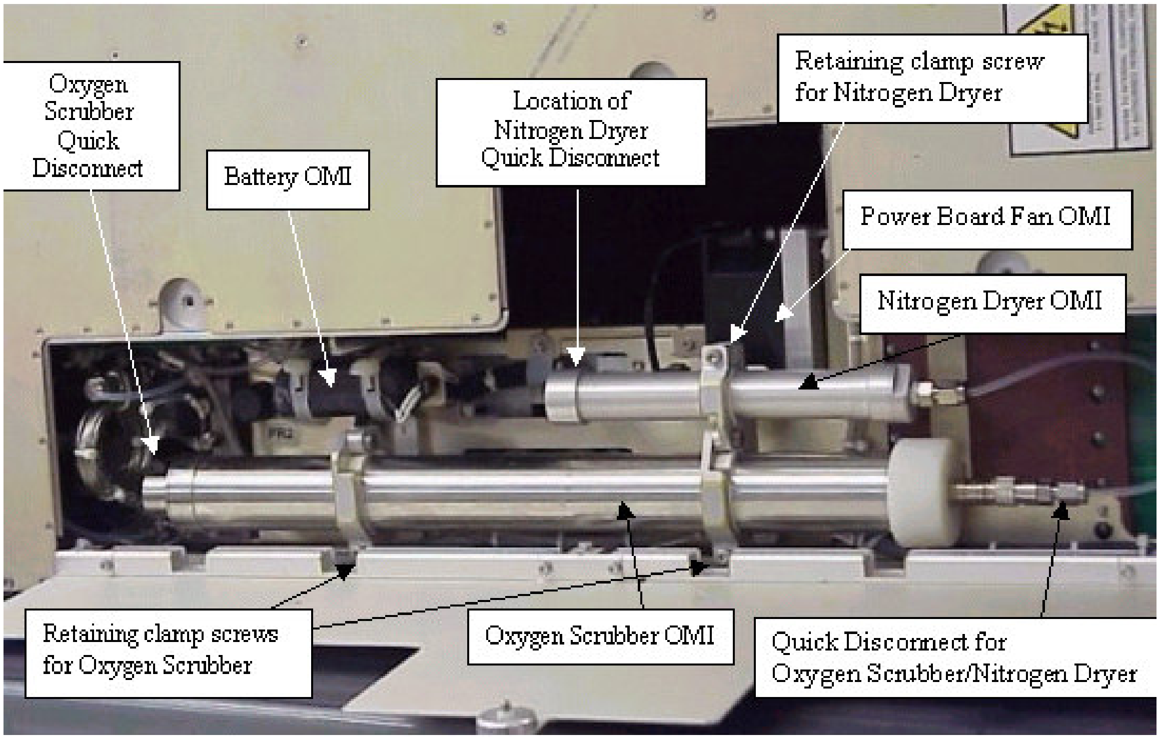


Figure 5. VOA, Bottom Right, Access Panel #4

Besides the OMIs, there are a number of other limited-life items within the VOA as summarized in Table 3.4.6.3-1 below. All items designated OMI can be replaced on orbit, all other items are ground-based maintainable only.

Table 3.4.7.3-1 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	4,320 operating hrs (~ 6 months)
Trap Material CarboTrap, (150mg), (2 off)	No	>5 Years
Trap Material Carboxin, (50mg), (2 off)	No	>5 Years

3.4.7.4 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.

3.4.7.5. 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 and 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 45º C.
- Failure of an internal VOA component (valve or regulator) could cause a nitrogen leak through the bleed valve or relief valves.

3.4.7.6 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.

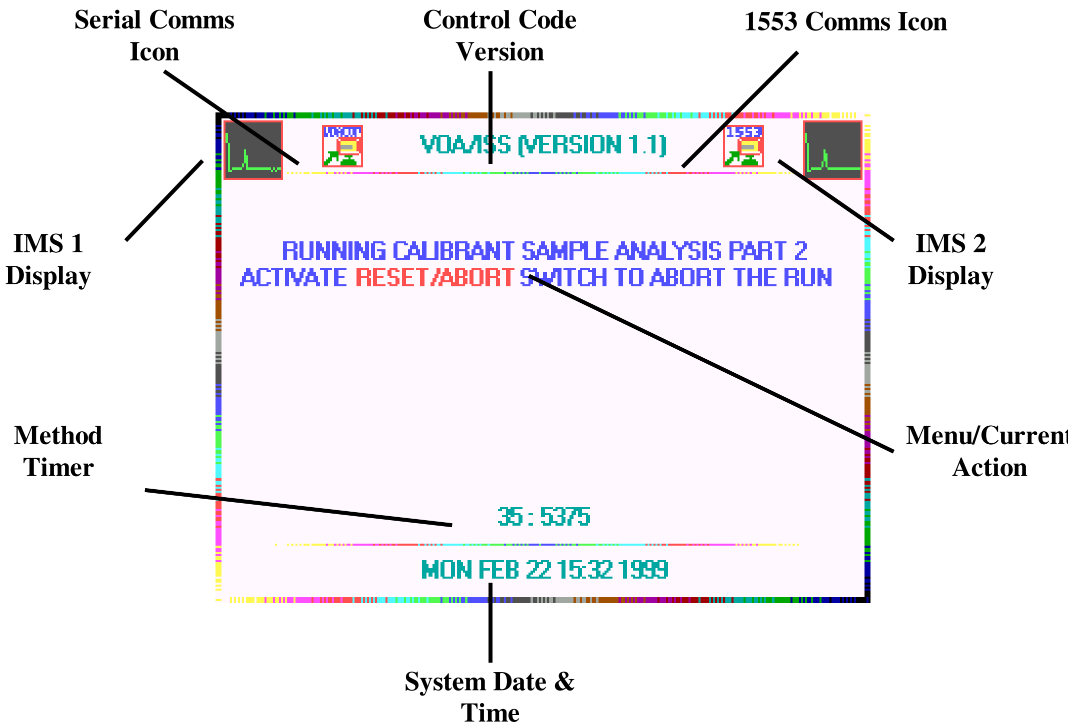


Figure 6. VOA Display with Explanations Listed Below

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'.

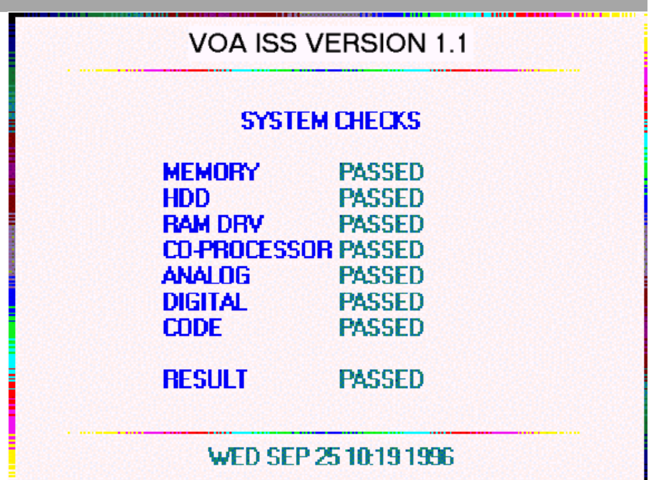
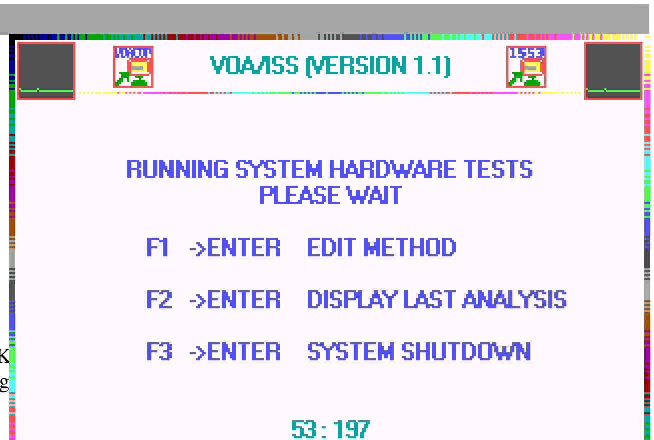
IMS2 Display: If the IMS channel 2 is operating, a thumbnail display of the IMS spectrum will be displayed. If the IMS channel is disabled, its thumbnail display will be an 'X'.

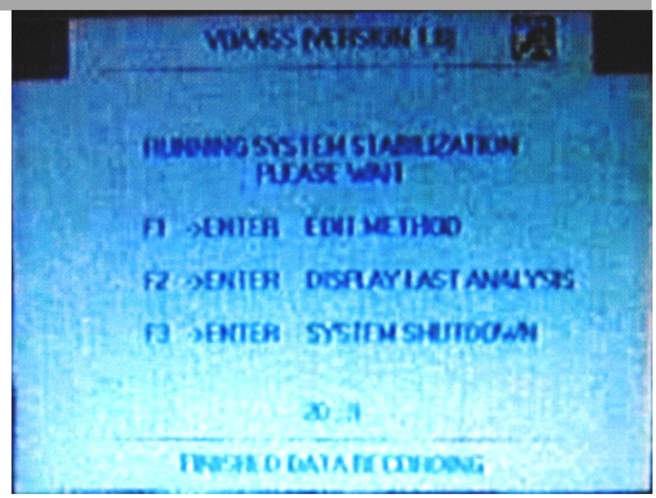
Method Timer: The sequences of events to describe an analysis run, system startup, warm-up or shutdown are stored in user-definable method files. The method timer shows how long in seconds that each method has been running and how long it has to complete.

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.

3.4.7.6.1. 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.

<table>
<tr><th></th><th></th><th>VOA LCD</th></tr>
<tr><td>Description</td><td>USER INPUT: 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.</td><td>Blank (VOA off)</td></tr>
<tr><td>VOA Linux Console Display</td><td>Mode: Unknown
Method File: Unknown</td><td></td></tr>
<tr><td>Duration</td><td>N/A</td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>Description</td><td>The ON 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.</td><td>Blank</td></tr>
<tr><td>VOA Linux Console Display</td><td>Mode: Unknown
Method File: No Method File Currently Running</td><td></td></tr>
<tr><td>Duration</td><td>3 minutes</td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>Description</td><td>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</td><td rowspan="3">
</td></tr>
<tr><td>VOA Linux Console Display</td><td>Mode: Unknown
Method File: No Method File Currently Running</td></tr>
<tr><td>Duration</td><td>3 minutes</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>Description</td><td>Once computer testing has completed, operational sequencing will pass to method file control. The first method file to be loaded is the SYSTEM HARDWARE</td><td>
</td></tr>
</table>

	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.	
VOA Linux Console Display	**Mode**: Warming Up **Method File**: Hardware Test	
Duration	4 minutes	
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 Linux Console Display	**Mode**: Warming Up **Method File**: Stabilization	
Duration	30 seconds	

Description

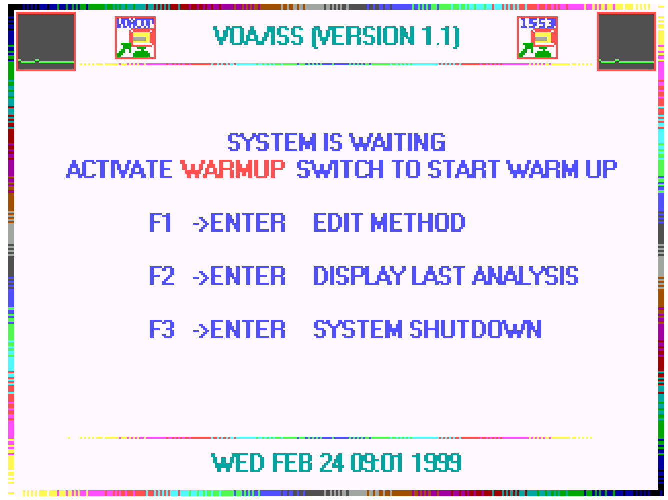
On completion of the Stabilization method file, the VOA has reached the end of its initial power on sequence and is in a state ready for the next operational stage, warm up.

VOA Linux Console Display

Mode: Standby
Method File: No Method File Currently Running

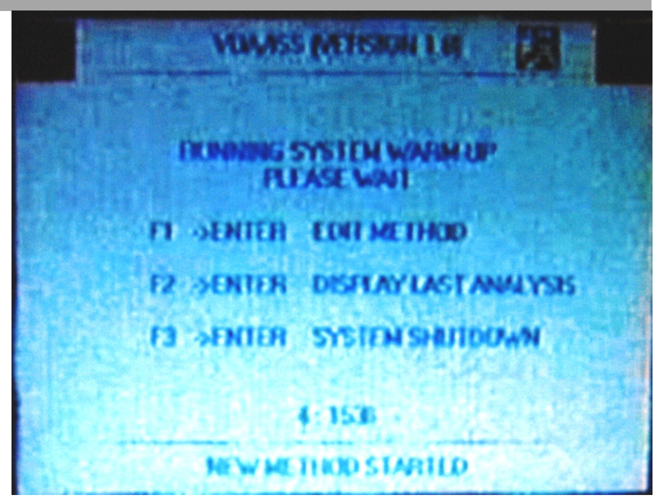
Duration

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 Linux Console Display

Mode: Warming Up
Method File: Warm Up

Duration

20 to 70 minutes

Description

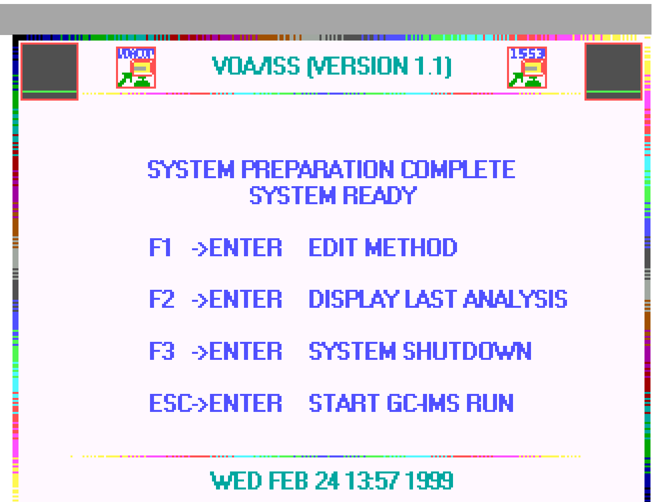
Once the Warmup Method File has completed, the equipment is in the STANDBY mode and ready for an analysis run as indicated on the display panel and by illumination of the READY LED located to the right of the Warm Up Switch.

VOA Linux Console Display

Mode: Standby
Method File: No Method File Currently Running

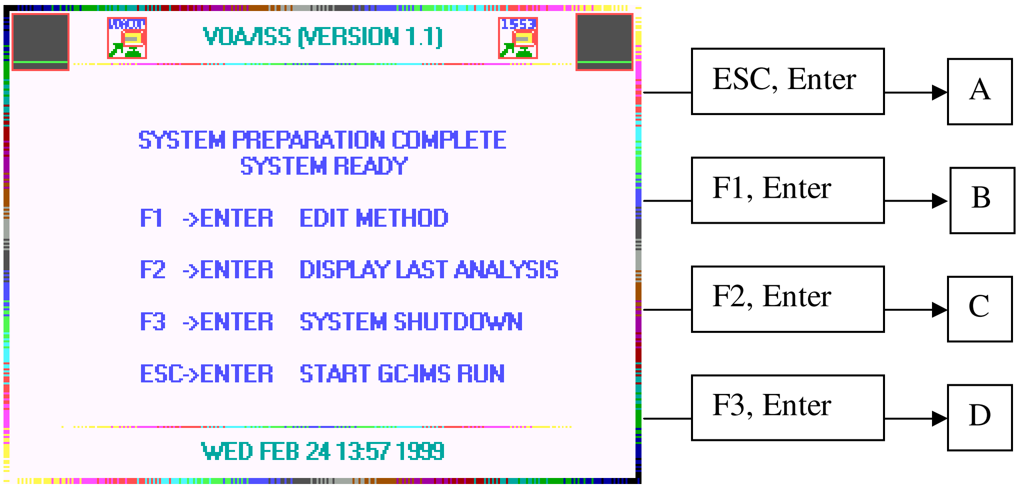
Duration

N/A (stays in this mode until user input is applied)



3.4.7.6.2. 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.



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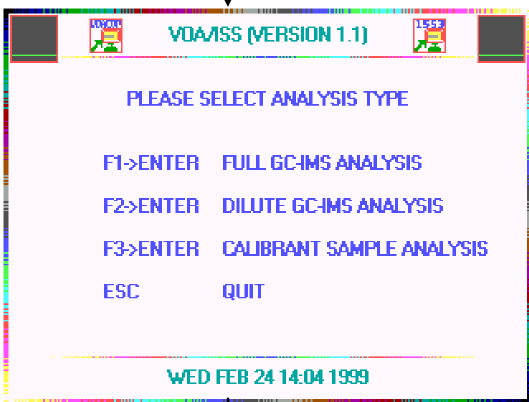
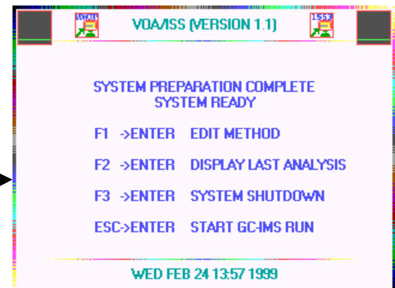
A From the Main Menu ("System Preparation Complete System Ready"):

Esc, Enter

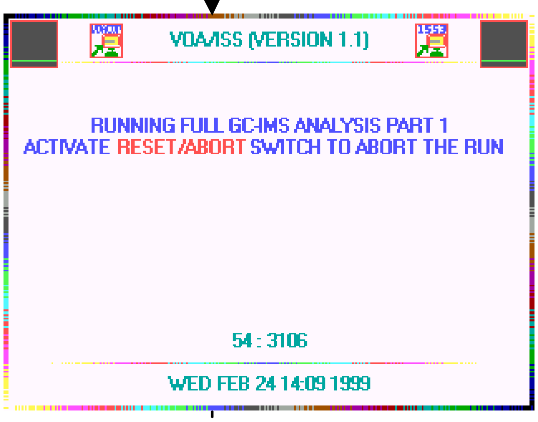
→ Proceeds by user
⇢ Proceeds automatically



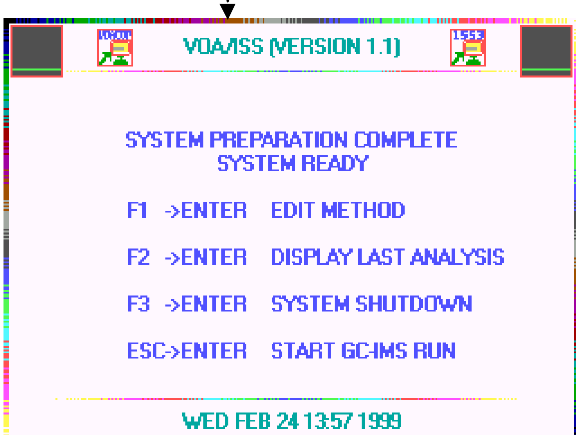
ESC



F1, Enter

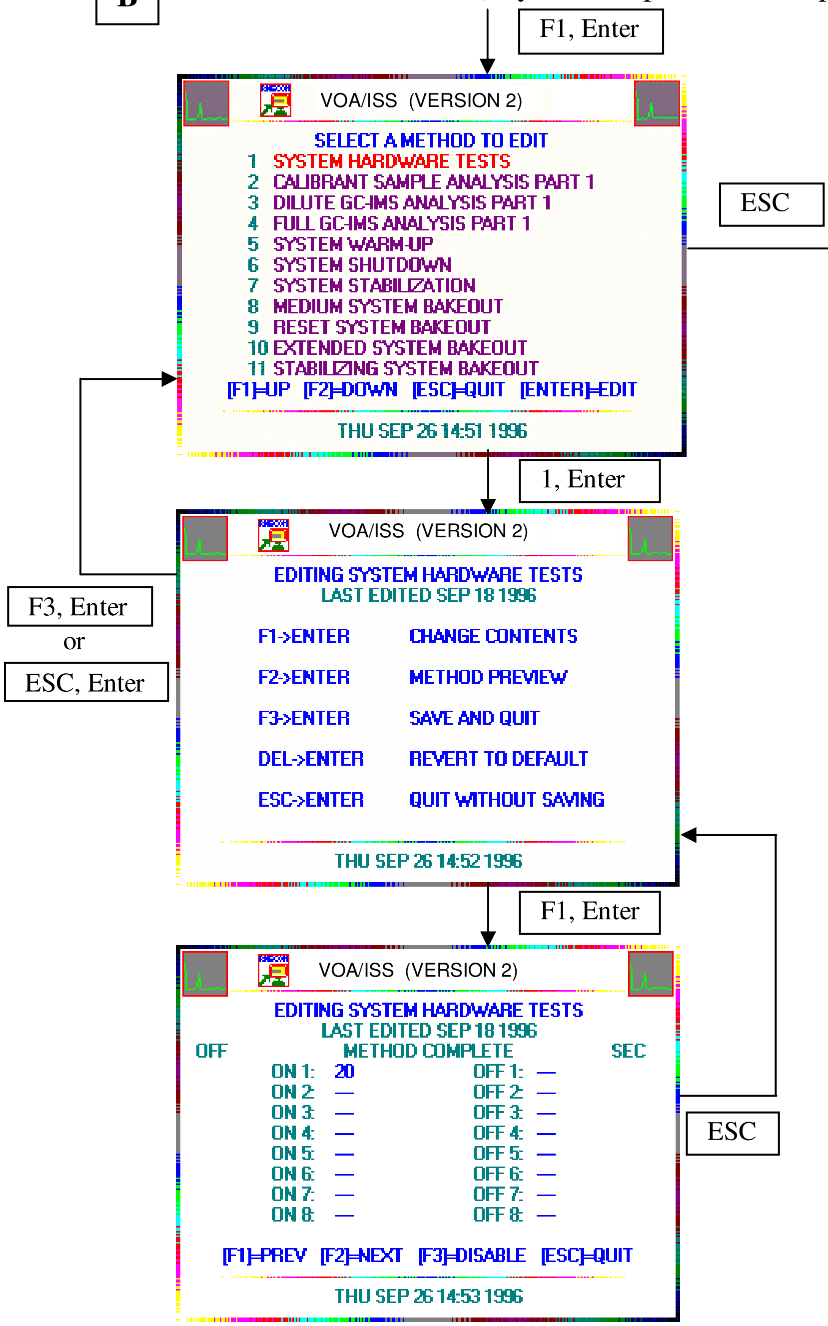


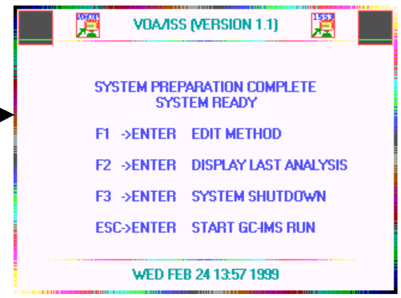
The following will occur when an analysis run is initiated:
1. READY LED will turn off.
2. Part 1 of 2 Method Files will start.
3. Method file identifier and time elapsed/remaining will be displayed.
4. On completion of part 1, an acquired data file will be saved.
5. Analysis of the acquired file will 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.

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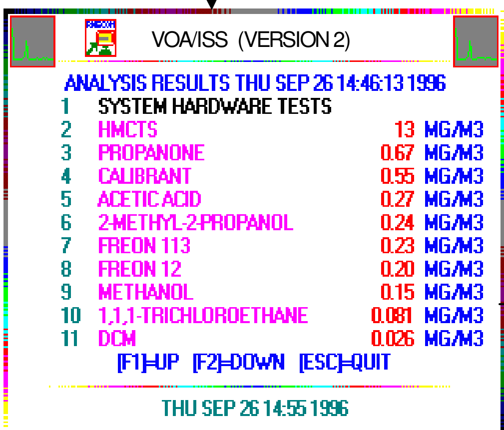
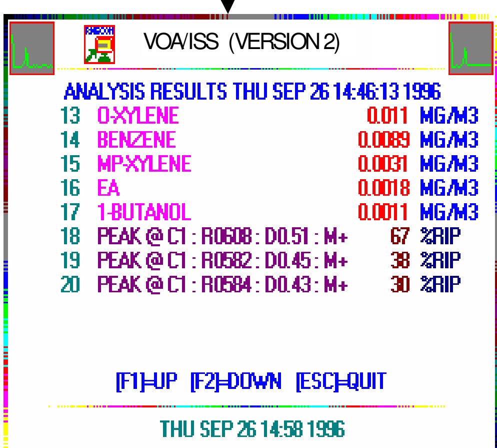
C From the Main Menu (“System Preparation Complete System Ready”):

F2, Enter

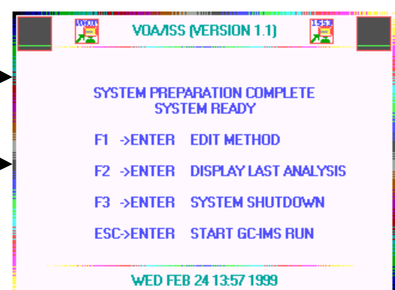


The results of the last analysis performed by the equipment may be viewed when the menu item '**F2>Enter Display Last Analysis**‘ option is available from the Main Menu.

F2



ESC



D From the main Menu ("System Preparation Complete System Ready"):

F3, Enter

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)

4.1.1. 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 subpacks 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.

Figure 1-2. ALSP and Contents

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4.1.2. ALSP Contents List and Description

Subpacks	7. Urinary Leg Bag
1. Airway Subpack	8. Gloves
2. Assessment Subpack	9. Sponges
3. Bandages Subpack	10. Intubation Bulb
4. Drug Subpack	11. Automatic Blood Pressure Cuff (ABPC)
5. Emergency Surgery Subpack	12. Syringe, 10cc
6. Iv Administration Subpack	**Additional Components**
ALSP Lid	1. Intravenous Fluid (0.9% Sodium Chloride Solution) - 4.5L
1. Stethoscope	2. Sharps Container
2. Blood Pressure Cuff	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^3 (2912.0 in^3)	66 x 35.6 x 20.3 cm (26.0" x 14.0" x 8.0")	CHeCS: LAB1S4_ D1	15 – 30 ºC (59 – 86 ºF)		Standard Habitable Module Pressure
Drug Pack	3.6 kg (7.9 lbs)	5436.83 cm^3 (331.78 in^3)	8.3 x 36.8 x 17.8 cm (8.3" x 14.5" x 7.0")	In ALSP			

4.1.2.1. Airway Subpack

Figure 3. Airway Subpack

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 Nov 2006.**

4.1.2.2. Assessment Subpack

Figure 4. Assessment Subpack

Contents:

Pulse Oximeter	Pulse Oximeter Transducers
Tongue Depressors	Oral Disposable Thermometer
Penlight	

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Tech Writer: Kimberlee Jadwick (281) 461-2611 kimberlee.j.jadwick@nasa.gov

4.1.2.3. Bandages Subpack

Figure 5. Bandages Subpack

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).

*** Reference SODF Medical Checklist for all information regarding medications.**

4.1.2.5. Emergency Surgery Subpack

Figure 7. Emergency Surgery Subpack

Contents:

Steri-Strips	Alcohol Wipes	Bandage Scissors
Benzoin Swabs	Povidone-Iodine Swabs	Carpuject Injector
Scalpels	Medical Tape (1”)	Gloves (sterile)
Sutures	Sterile Drape	
Surgical Instruments Assembly: Needle Driver, Hemostats, Scissors		

4.1.2.6. IV Administration Subpack

Figure 8. IV Administration Subpack

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

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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)

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

The IV Infusion Pump provides powered continuous infusion of Intravenous Fluid (0.9% Sodium Chloride or Dextrose) in a microgravity environment.

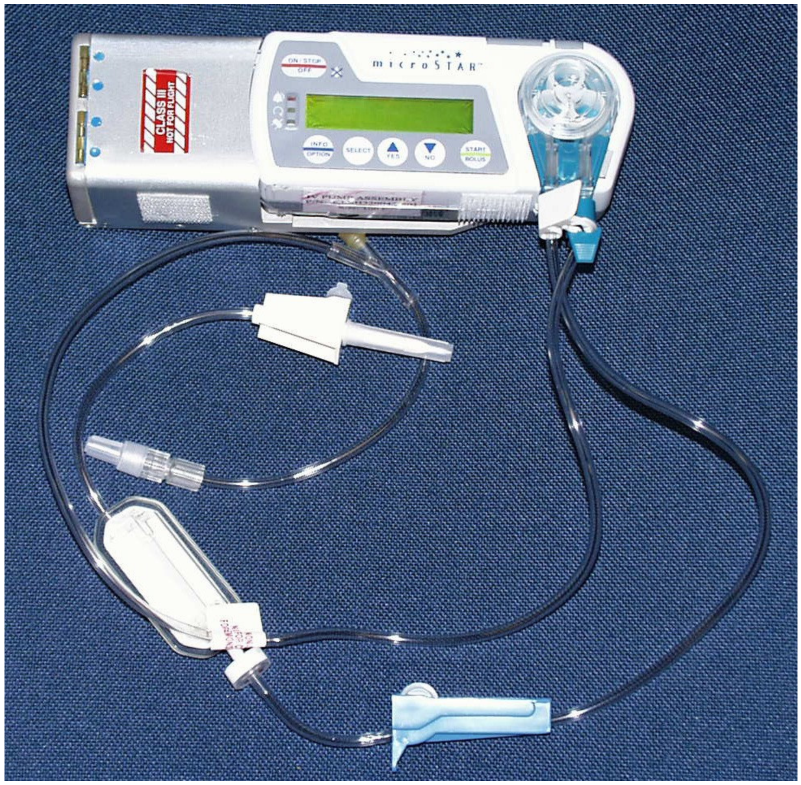

Figure 10. IV Infusion Pump

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	• Operating Ranges: The IV infusion pump power supply shall provide no less than 10 hours of continuous flow at a rate of 125ml/min • Nominal Values of Parameters: Keep Vein Open (KVO) rate: 0.9ml/hr • Accuracy: +/-5%

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.
- 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 PCBA Cartridge Kit are included. Other items include dental hardware and surgical supplies.

Refer to SODF, ISS Medical Checklist for all information on medications.

Figures 1-2. AMP

4.2.2. AMP Contents List and Description

• **Subpacks**	• **AMP Lid**
1. Surgical Supply Subpack	1. Stethoscope (AMP-1)
2. Injectable Subpack	2. Blood Pressure Cuff (AMP-1)
3. Dental Subpack	3. Ziploc Bags (AMP-2) (AMP-3)
4. Physical Exam Subpack	
5. Portable Clinical Blood Analyzer	• **AMP-3**
(PCBA) Subpack	1. Medical data logs (AMP-3)
• **Pallets**	2. Pen (AMP-3)
1. Pallet 1 (Oral Medications)	3. PCBA Control Solution Kit (AMP-3)
2. Pallet 2 (Topical Medications)	4. BK Wipes (AMP-3)
3. Pallet 3 (Bandages and Dressings)	
4. Pallet 4 (Splints, assorted supplies)	
• **Additional Components**	
1. PCBA Cartridge Kit	
2. PCBA (Contained in the PCBA Subpack)	
3. Tonometer (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^3 (2600.0 in^3)	63.5 x 33 x 20.3 cm (25” x 13” x 8”)	CHeCS: LAB1S4_ D2	15 – 30 ºC (59 – 86 ºF)		Standard Habitable Module Pressure

Figure 3. Injectable Subpack

4.2.2.1. Injectable Subpack

Contents:

Injectable Subpack contains injectable medications. Refer to SODF, ISS Medical Checklist for all information on medications.

Bandaids (Sheer Spots)	Needles
BK Wipes	Tubex Injector

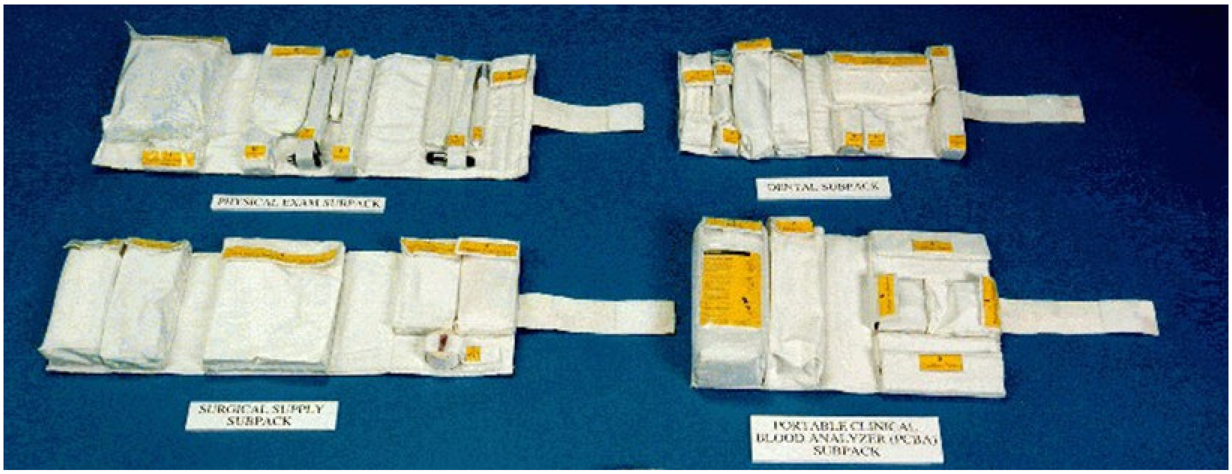

Figure 4. Physical, Dental, Surgical Supply and PCBA Subpacks

4.2.2.2. Dental Subpack

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 Subpack

Contents:

Tape Measure	Reflex Hammer
Visual Acuity Card	Tonopen
Tonopen Tip Covers	Otoscope Handle and Head
Ophthalmoscope spare bulb	Otoscope spare bulb
Otoscope Specula	Ophthalmoscope Head

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Tongue depressors	Stethoscope earpieces
Penlight	Magnifying glass
Mouth/Throat Mirror	

4.2.2.4. PCBA Subpack

Contents:

Portable Clinical Blood Analyzer (PCBA)	Electronic Simulator
Fingerstix	Capillary Bulbs
Capillary Tubes	Capillary Tube Droppers

4.2.2.5. Surgical Supply Subpack

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

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4.2.2.6. AMP Pallet 1

Pallet 1 contains oral medications. Refer to SODF, ISS Medical Checklist for all information on medications.

4.2.2.7. AMP Pallet 2

Pallet 2 contains topical medications: Refer to SODF, ISS Medical Checklist for all information on medications.

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.

Fingersplint	SAM Splint
Urine Chemstrips and color chart	Bandaids
Peak Flow Meter	Air Temp. Monitors
Eye Pads	Posterior Nasal Packing
Eye Shield	Ziploc

4.2.2.10. Portable Clinical Blood Analyzer (PCBA)

The PCBA provides clinical chemistry analysis of crewmembers' 65µL blood samples. Analysis requires 120 seconds upon activation. It uses either an EC8+ or CREA (Creatinine) cartridge to perform the analysis.

Table 4.2.2.10-1 Hardware-Specific Parameters

Power Requirements	9V alkaline batteries; 2 required for nominal operation

Figure 5. PCBA

4.2.2.11. PCBA Cartridge Kit

The PCBA Cartridge Kit may contain EC 8+ and CREA (Creatinine) required for clinical chemistry analysis of crewmembers blood samples. The required 65µL blood sample is placed in a cartridge via 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 pH and Glucose levels lose reliability after approximately 2 weeks at ambient temperature.

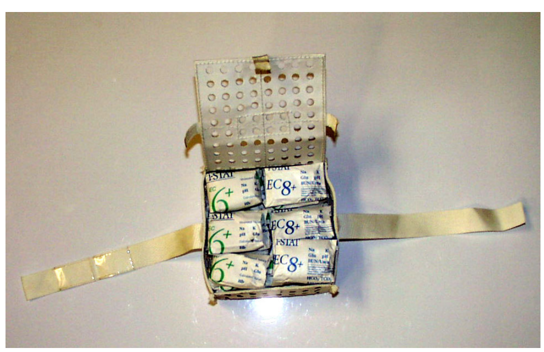

Figure 6. PCBA Cartridge Kit

Table 4.2.2.11-1 Hardware-Specific Parameters

Measurement Parameters:		
Cartridge Type:	**Constituent:**	**PCBA Ranges:**
• 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_2)	10-100mmHg
	Urea Nitrogen (BUN)	3-140mg/dl
	Total Carbon Dioxide ($TC0_2$)	1-85 mmol/L
	Bicarbonate (HC_3)	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

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.

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 with each crew rotation.
- A freshly calibrated tonometer is flown in the AMP.
- The PCBA is flown in the AMP.
- The PCBA Cartridge Kit is resupplied every 3 months, every crew rotation and AMP resupply.
- Although no in-flight repair of the AMP will be performed, the Tonopen tonometer can be calibrated in-flight. 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)

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 which is 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

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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) Non-hazardous level “4” red decal (qty 8)
  b) Silver Shield Bags (qty 8)
  c) Silver Shield Gloves (qty 7 pr)
  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^3 (643.51 in^3)	30.08 x 25.6 x 18.56 cm (11.8” x 10.1” x 7.3”)	CHeCS: LAB1S4_ A1	4 – 32 ºC (40 – 90 ºF)		Standard Habitable Module Pressure
Eyewash Kit	TBD	TBD	TBD	SM 229A	4 – 32 ºC (40 – 90 ºF)		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.

Table 4.3.2.1-1 Hardware-Specific Parameters

Fluid/Gas Description	Eyewash connects with SV0-ZV water port. Fluid flow is approximately 0.5L/min of water

Components:

- SVO-ZV Adapter
- Eye Goggles and Tubing
- 3-way valve
- Eyewash Wastewater Bag connectors
- Eyewash Wastewater Bags (1.85L)

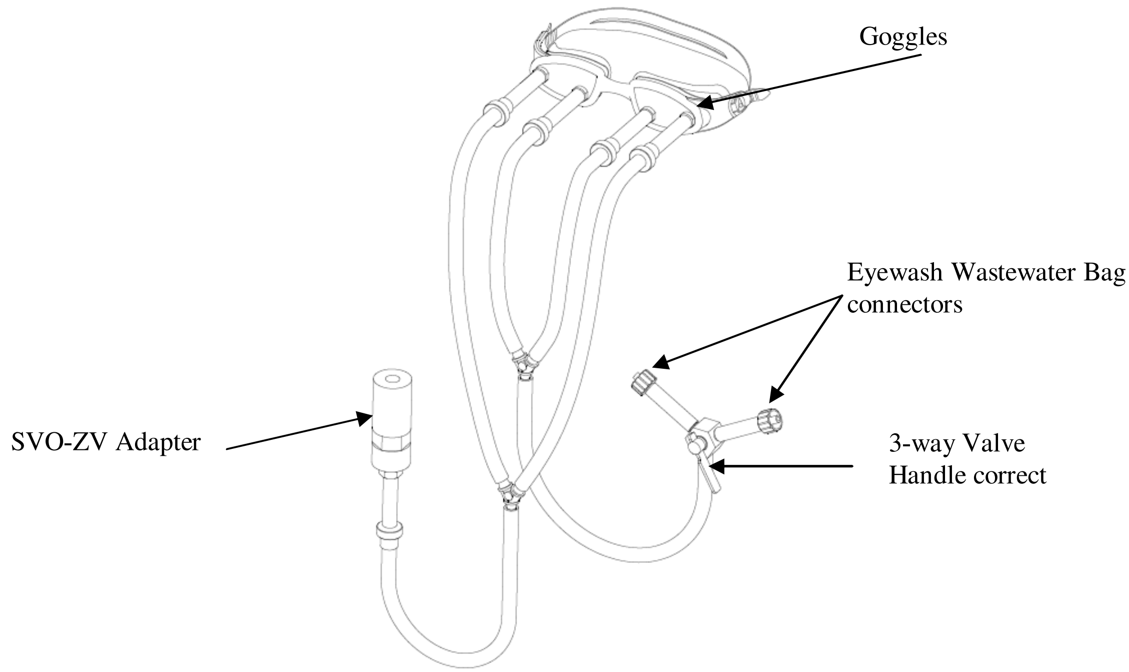

Figure 4. Eyewash

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.

% full	*length (seam to seam)*	*width*	*height (bottom to top)*	*Liters of water*
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.

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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.

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)

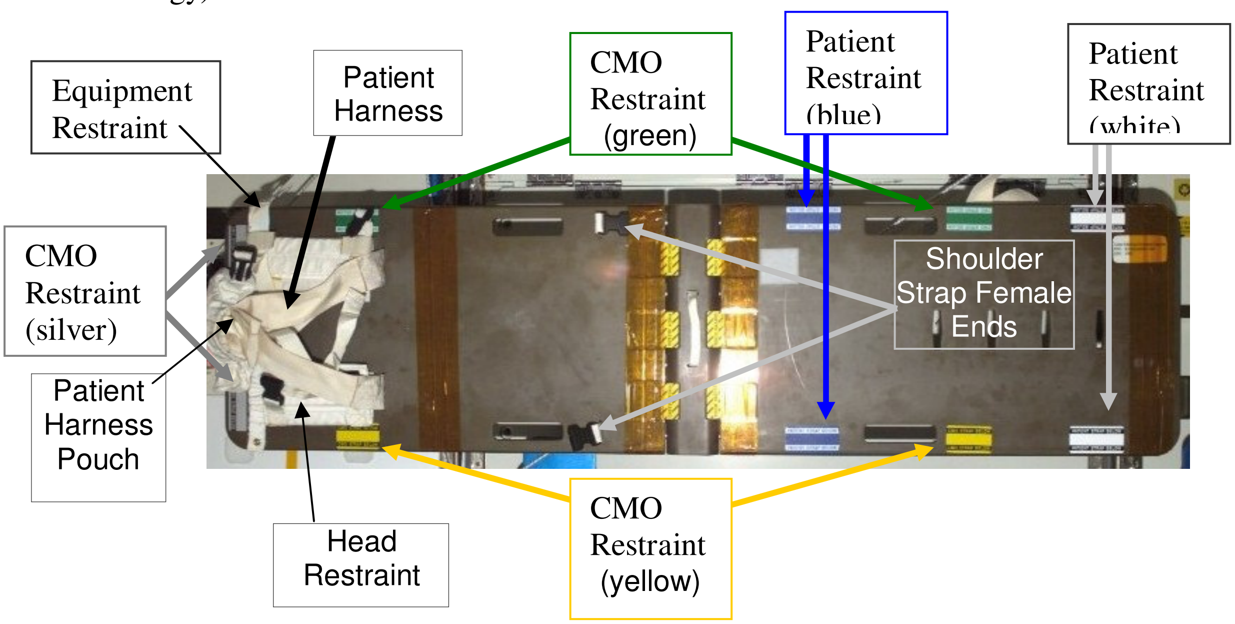

Figure 1. CMRS

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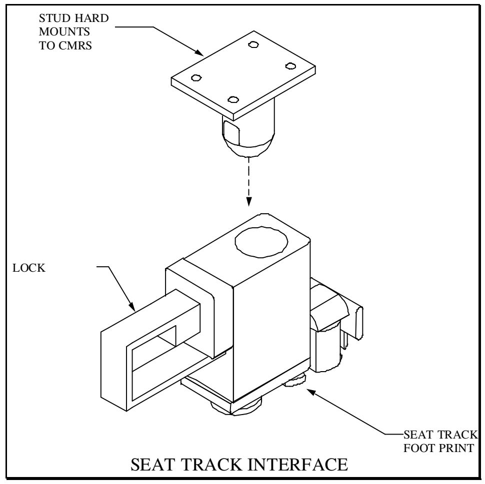

Figure 2. Seat Track Interface

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)

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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^3 (1794 in^3)	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 ºC (40 – 115 ºF)	4 – 46 ºC (40 -115 ºF)	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

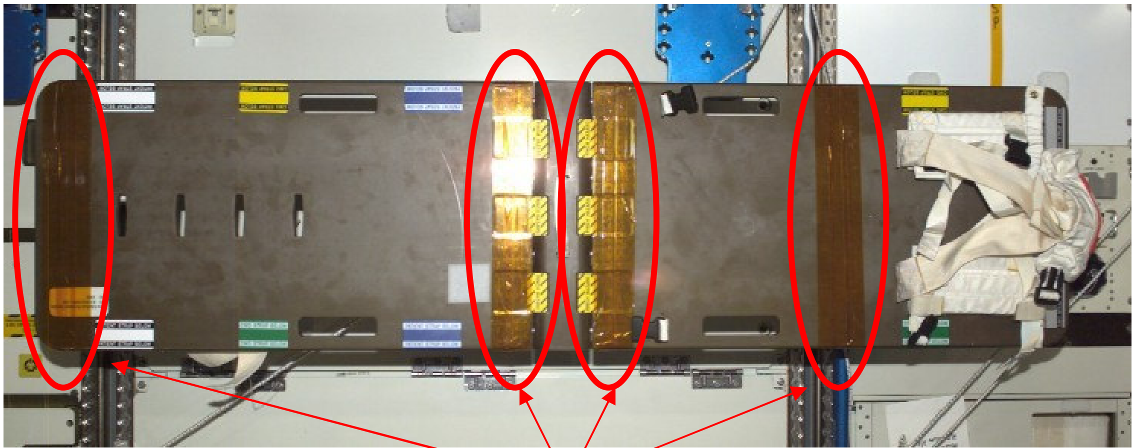
The CMRS Platform is made from Ultem 2300 resin. This material provides high strength, a low dielectric constant, and flame resistance. All edges are rounded to prevent injury.

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 interfaces 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	AED Electrodes Kit
1	SEG52101600-301	AED Assembly	AED
2	SEG52101601-301	Battery Assembly	AED Battery

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Table 4.5.2-2 General Hardware Specifications

Kit and Component List	Mass	Volume	Dimensions	Nominal Stowage Location	Operating Temp	Storage Temp	Operating Pressure
AED (includes installed battery and electrodes kit)	3.3 kg (7.3 lbs.)	7230.5 cm^3 (441.2 in^3)	11.2 x 23.4 x 27.7 cm (4.4 x 9.2 x 10.9 in)	CHeCS: LAB1S4_D1 *	0 to 50 ºC (32 to 122 ºF)	-30 to 60°C (-22 to 140°F)	8.34 to 15.34 psi
Spare Battery	0.43 kg (0.94 lb)	1084 cm^3 (66.15 in^3)	3.56 x 11.4 x 26.7 cm (1.4 x 4.5 x 10.5 in)	CHeCS: LAB1S4_D1 *	0 to 50 ºC (32 to 122 ºF)	20 to 30 ºC (68 to 86 ºF)	8.34 to 15.34 psi

* Deployed as needed

Table 4.5.2-3 Hardware Specific Parameters

Power Specifications	• Battery power only • 12.0 V, 4.5 amp-hours, Lithium Manganese Dioxide (Li/MnO2), nonrechargable • Each battery can produce 440 200-joule shocks, or 1030 minutes of operating time with new battery • Operational battery life is 5 years with new battery and 4 years after 5 years of shelf life • The AED, batteries, and electrodes are scheduled to be replaced every 2 years
General Specifications	• Heart Rate: 20-300 bpm • Charge time after shockable rhythm is detected: <30 sec for three shocks (200, 300, and 360 joules) • Shocks are delivered in the form of a biphasic truncated exponential (BTE) defibrillation waveform
Waveform Display	• Waveform sweep speed – 25mm/sec • Waveform viewing time – minimum 4 sec • Waveform amplitude – 1 cm/mV, nominal
Shock Advisory System	• Good electrode contact is determined through impedance check • ECG analysis is performed • Automatic charging of AED and instructions to caregiver to press the shock button, if a shockable rhythm is detected • 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.

4.5.2.1. AED Unit

Figure 2 shows the top of the AED with which the crew member will interface during patient care. The Advanced Cardiac Life Support (ACLS) Booklet is located in LAB1S4_D1 locker of the CHeCS rack and contains AED and ACLS procedures.

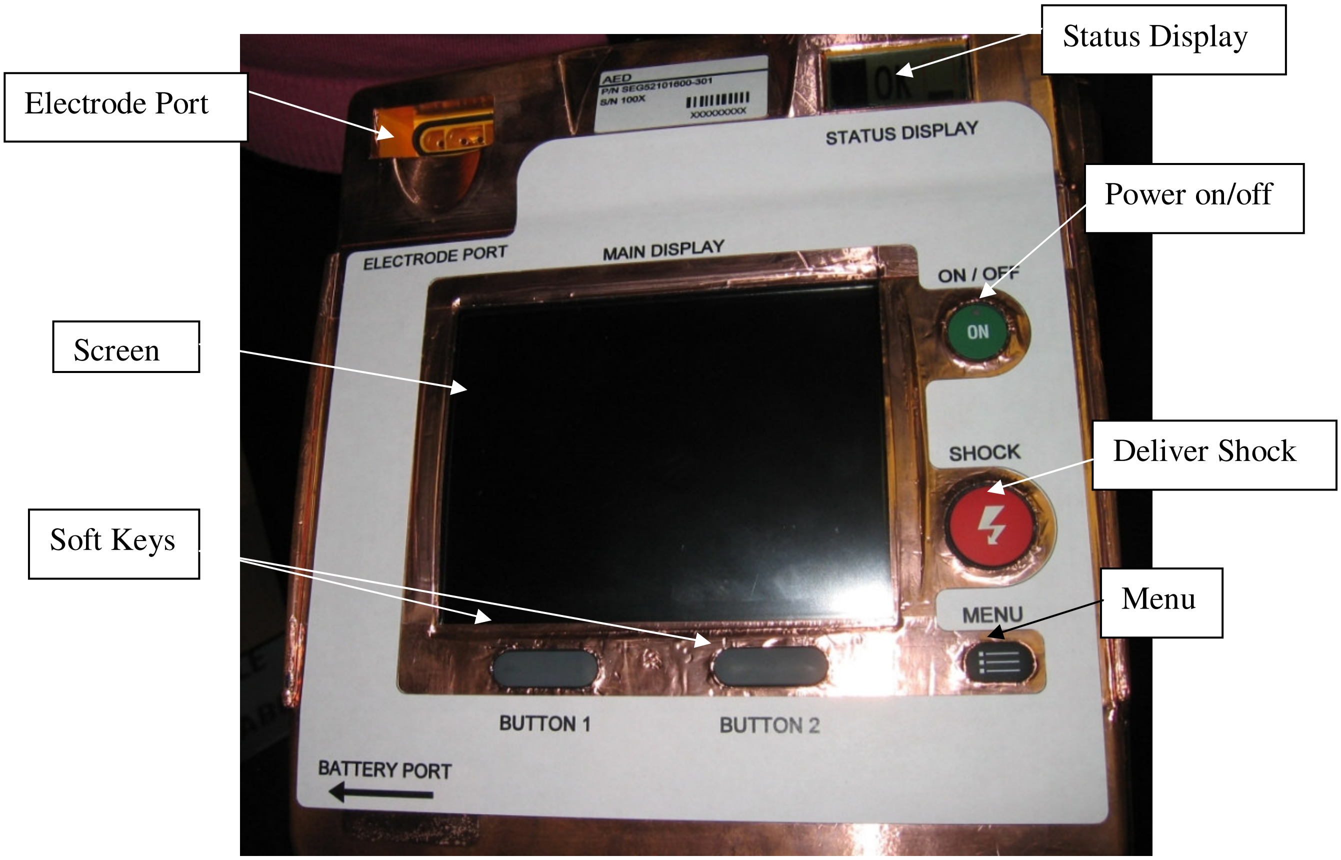

Figure 2. AED Unit

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.

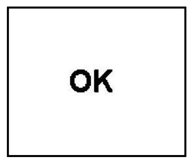

Figure 4. Nominal Operations Symbol

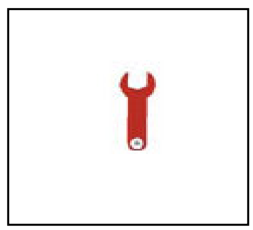

Figure 5. Service Symbol

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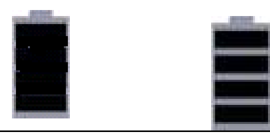
Table 4.5.4.1-1 AED Status

Action	Status Display	Main Display
No battery installed		Blank
Battery inserted, unit runs through a self-check, unit remains off.		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. It has been requested that the initial unit be returned to Houston for analysis when resupplied. 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 transport additional supplies to the ISS. Items will be flown within the kit and remain stowed until needed. 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)
- 9V alkaline batteries (expired -18)
- AA alkaline batteries (expired -20)
- AAA alkaline batteries (expired -10)
- Ultrasound Gel (2)

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Table 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)
HASP	Varies; ≤30lbs.	22/22.5 cm^3 (1350 in^3)	25.4x 25.4 x 34.3 cm (10" x 10" x 13.5")	CHeCS: LAB1S4_ A2			

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

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4.7 ISS Medical Accessory Kit (IMAK)

4.7.1. IMAK Description

The IMAK is designed to be a storage location for all crewmember personal medications, daily vitamins, and other commonly used, medically related crew items. The crewmembers, along with the Increment Flight Surgeon, define the contents of the IMAK. The kit is a 'late stow' hardware and is manifested on all crew rotation flights. The contents of the IMAK are removed on orbit and stowed with the crewmembers personal items. The IMAK is not stored in the CHeCS rack, but sent down empty to be used again on crew rotation missions.

Note: The IMAK is the same design and appearance as the STS MAK and occasionally both the IMAK and the STS MAK will be manifested on the same flight. The contents of the IMAK will be transferred to ISS while the STS MAK will remain on shuttle for use by the shuttle crewmembers.

Figure 1. IMAK

4.7.2. IMAK Contents List and Description

The components of the IMAK will vary on crewmember preference and Increment Flight Surgeon decisions. Usually, the IMAK will contain commonly used, medically related items such as daily vitamins.

Table 4.7.2-1 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)
IMAK	1.4 kg (3 lbs)	5380.2 cm³ (328.3in³)	19 x 11.4 x 12.6 cm (7.5" x 4.5" x 5.0")	All items transferred to ISS; kit ret'd on Shuttle	15-30 ˚C (59-86˚F)		Standard Habitable Module Pressure

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4.7.3. Hardware Interfaces with Vehicle

None.

4.7.4. Resupply Schedule

One IMAK per each crewmember is launched at crew rotation to hold personal medications. The IMAK is also used as a resupply vehicle for 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	Intubating Laryngeal Mask Airway (ILMA) Stabilizing Rod
Endotracheal Tube (ETT)	Surgical Lubricant
Endotracheal Tube connector, 2, size large and small	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	LAB1S4_D1		65-85 °F	Standard Habitable Module Pressure

4.8.2.1. Intubating Laryngeal Mask Airway (ILMA)

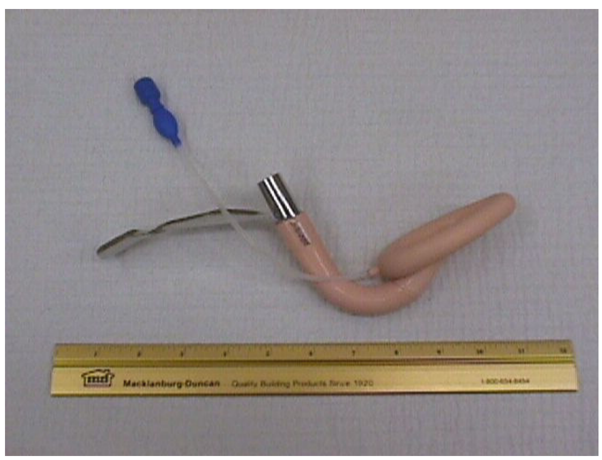


Figure 4. ILMA with inflated cuff

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

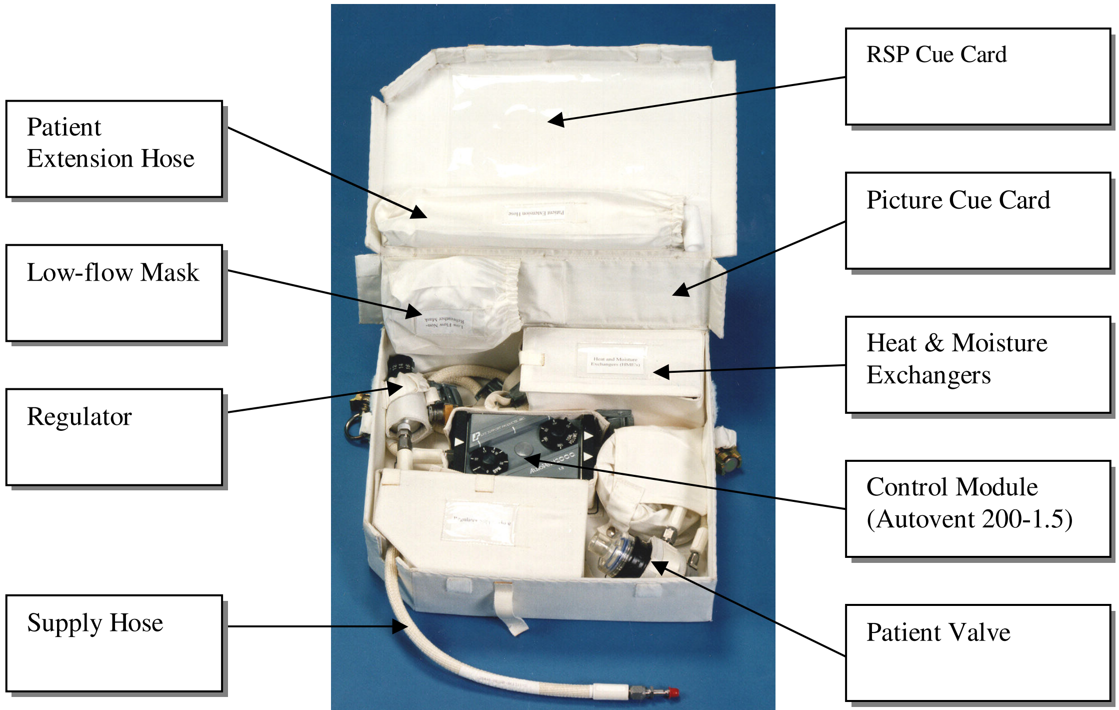
- The crew shall know when to deploy and use the IKA based upon the procedures provided on the Instruction cue card.
- The crew will be trained for proper use (including insertion, ventilation, intubation, and handling) of the Intubation Kit / Airway (IKA).
- The crew will be trained on the proper location and use of the Intubating Laryngeal Mask Airway (ILMA). The Intubation Kit / Airway (IKA) will be readily accessible at all times in the CHeCS Life Support 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.

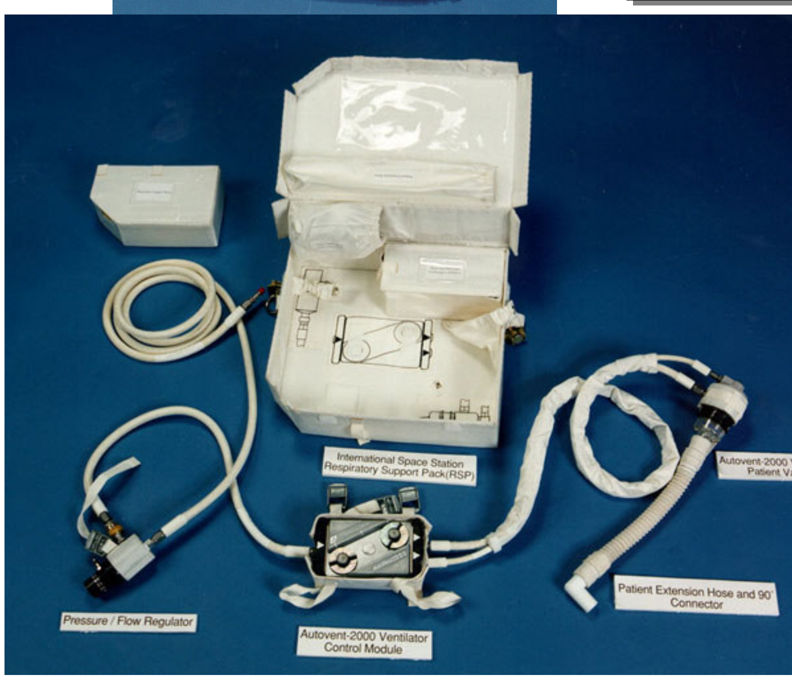
4.9 Respiratory Support Pack (RSP)

4.9.1. RSP Description

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





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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^3 (685.1 in^3)	36.8 x 34.3 x 8.9 cm (14.5" x 13.5" x 3.5")	CHeCS: LAB1S4_D1	4 – 46 ºC (40 – 115 ºF)	0 – 45 ºC (32 –113 ºF)	Standard Habitable Module Pressure

Table 4.9.2-2 Hardware-Specific Parameters

Fluid/Gas Description (with design pressures)	Gaseous O2
Maximum Expected Operating Pressures*	• Regulator: 120 psia • Supply Hose: 120 psia • Control Module: 60 psia • Control Module Supply Hose: 60 psia • Patient Valve (Demand Valve): 60 psia • Patient Valve Control Hose: 60 psia • Patient Valve Supply Hose: 60 psia
Minimum Operating Pressure for Checkout*	• Control Module: 43 psia • Patient Module: 43 psia

* 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.

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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.

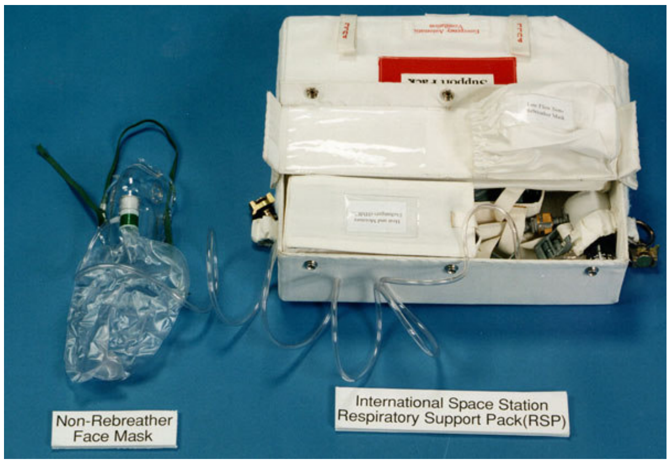

Figure 3. Patient Interfaces

4.9.2.3. Hoses

The Supply Hose (8'10" length) connects to the ISS O_2 bus (any O_2 source: CHeCS Rack, 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

- CHeCS Rack O2 source
- ISS ECLSS O2 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% O2)
- Explosion (due to use of pressurized O2)
- 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 O2 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 O2 level due to the RSP being left unattended, or failing to cease operation

4.10 Variable Oxygen System (VOS)

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

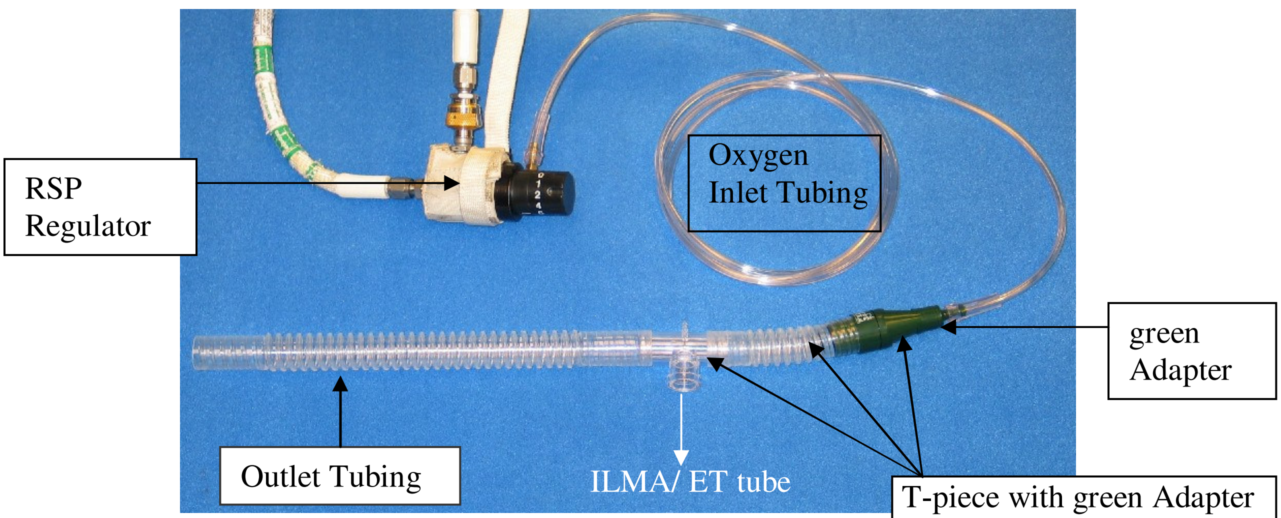

Figure 1. Intubated Patient Configuration

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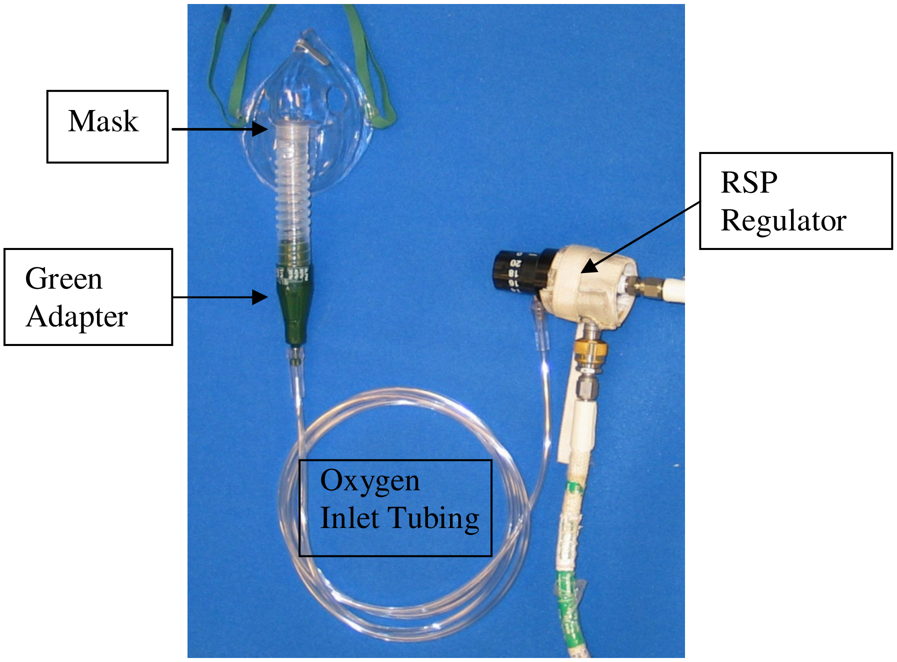

Figure 2. Non-Intubated Patient Assembly

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

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)
VOS	0.345 kg (0.76 lbs)	6262.2 cm^3 (366.96 in^3)	28 x 35.5 x 6.3 cm (11.0"x 13.9" x 2.4")	CHeCS: LAB1S4_ D2	0-60 ºC (0 – 140 ºF)	0-60 ºC (0 – 140 ºF)	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:

- CHeCS Rack O2 source
- 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.

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4.10.5 Data/Commanding Capabilities

None

4.10.6 Hazard Concerns

TBD