Appendix III

Hardware Descriptions

Hardware

This Appendix profiles flight hardware used in life science experiments flown by Ames Research Center and Kennedy Space Center between 1991 and 1995.

Hardware items are listed alphabetically.

The Appendix includes profiles of key flight hardware items built or funded by NASA with:

- major subsystems for each hardware item indicated by an underline and described in more detail in separate entries
- minor subsystems briefly described for each hardware item but not appearing as separate entries.

Flight hardware information was obtained from the open literature, NASA internal reports, and NASA hardware design review summaries.

Each hardware entry contains a description of the flight hardware item and appropriate subsystems; if applicable, a description of any version modification made to the hardware item within the 1991-1995 period; a listing of general specifications (when available); types of data acquisition (if applicable); a brief description of related ground-based hardware; references to documents, publications, and flight missions from which the information was derived; and a full-page labeled illustration. The illustrations in this appendix are not necessarily scale drawings, but they are intended to assist the reader in understanding the general design and operation of the hardware.

For further information regarding recent flight hardware, please contact the Payload and Facilities Engineering Branch of the Life Sciences Division, Ames Research Center, Moffett Field, CA 94035-1000 or the Flight Experiment Project Management Office, Kennedy Space Center, FL 32899.

Hardware Description

The Ambient Temperature Recorder (ATR-4) is a self-contained, battery-powered instrument, approximately the size of a deck of cards. It may be placed in almost any environment (not submersible in liquid) to provide recording of up to four channels of temperature data. Channel 1 is selectable for either internal or external probe temperature sensing. Channels 2–4 are external only and require individual external temperature probes. External probes are flexible to allow the user to place probes at various locations within the sensed environment. Standard length for probes is 3 feet, but they may be longer or shorter, if required.

Data sample rate and number of channels are user-selectable. The total number of samples (32400) is limited by the size of the solid-state memory in the ATR-4. When the memory is full, the recorder stops recording. Stored data may be accessed postflight using a serial interface unit and an IBM-compatible computer. Power for the ATR-4 is provided by two internal batteries. An O-ring seal protects the internal electronics of the ATR-4 from fluids in the environment and permits operation in damp or humid environments, such as an animal habitat.

Specifications

Dimensions: 23 x 41 x 86 mm
Weight: ~135 g
Power: Lithium thionyl chloride batteries, 1 year life
Temp: Range: -40 to +60 °C
Accuracy: ±1 °C
Probes: Integrated circuit sensor, standard length, 3 feet

Data Acquisition

Sampling: every 1.87, 3.75, 7.5, or 15 minutes selectable; internal/external measurement (selectable on 1 channel only); 1 channel: 42 days @1.87-min sampling; 342 days @15 min; 4 channels: 10 days @1.87-min sampling; 85 days @15 min

Related Ground-Based Hardware

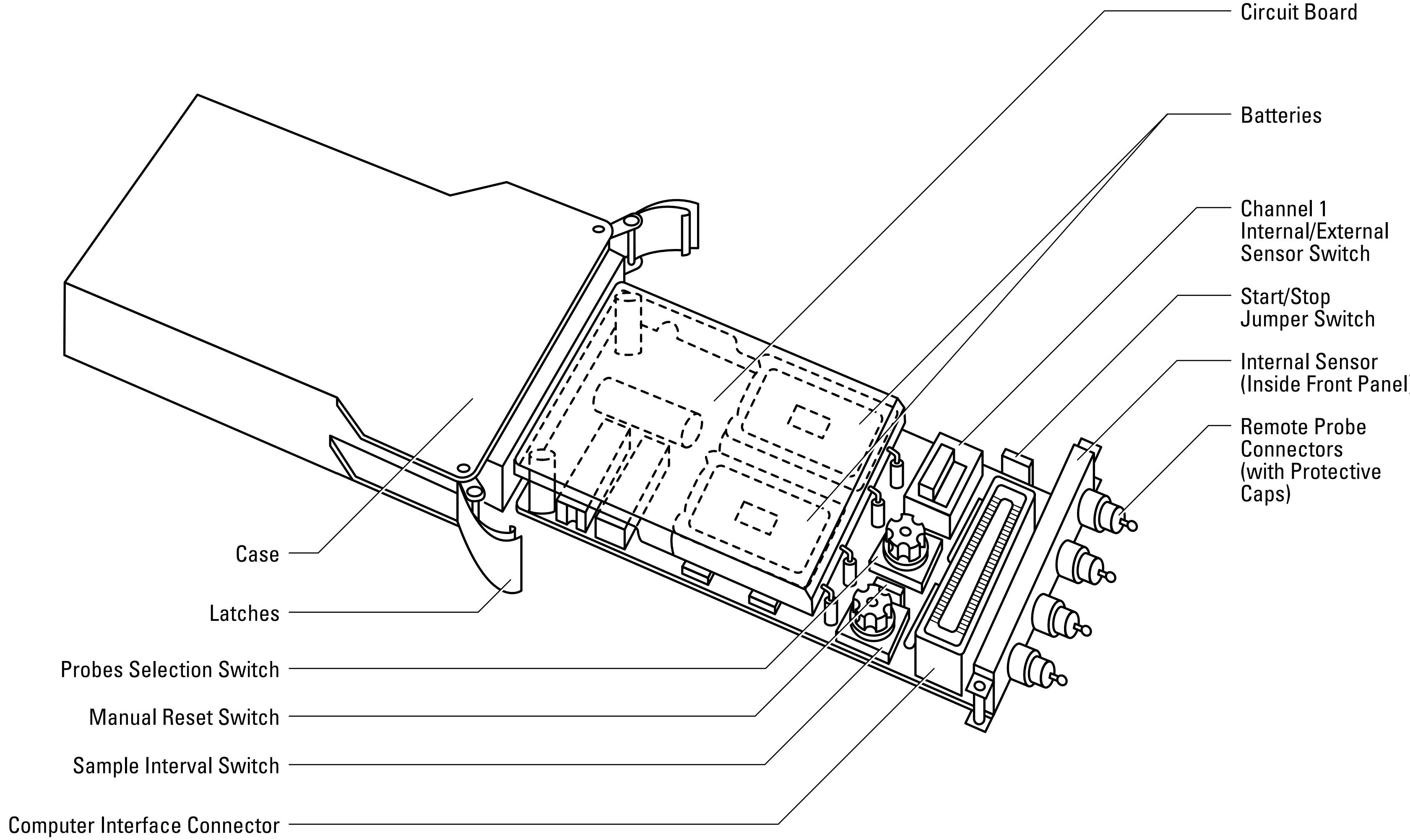
IBM-compatible computer and serial interface unit: The computer and interface unit are used for readout of ATR-4 data.

Hardware Publications

- *Life Sciences Laboratory Equipment (LSLE) On-line Catalog.* NASA, 1998. http://lifesci.arc.nasa.gov:100/lsle/.

Missions Flown 1991-1995

SLS-1/STS-40, PARE.01/STS-48, PARE.02/STS-54, PARE.03/STS-56, IML-1/STS-42, IML-2/STS-65, PHCF/STS-46, SL-J/STS-47, PSE.02/STS-52, PSE.03/STS-57, PSE.04/STS-62, IMMUNE.1/STS-60, IMMUNE.2/STS-63, NIH.R1/STS-66, NIH.R2/STS-70


Circuit Board
Batteries
Channel 1 Internal/External Sensor Switch
Start/Stop Jumper Switch
Internal Sensor (Inside Front Panel)
Remote Probe Connectors (with Protective Caps)
Case
Latches
Probes Selection Switch
Manual Reset Switch
Sample Interval Switch
Computer Interface Connector

Hardware Description

The Animal Enclosure Module (AEM) is a rodent housing facility that supports up to six 250-g rats. The unit fits inside a standard Shuttle middeck locker with a modified locker door. A removable divider plate can provide two separate animal holding areas. The AEM remains in the stowage locker during launch and landing. On orbit, the AEM may be removed partway from the locker and the interior viewed or photographed through a Lexan cover on the top of the unit. With addition of an Ambient Temperature Recorder, temperatures at up to four locations within the unit can be recorded automatically.

Subsystems

Air Quality: Cabin air is exchanged with the AEM through a filter system. Four fans create a slight negative pressure inside the AEM, ensuring an inward flow of air and particulate entrapment by the treated outlet filter. Cabinet air is drawn through front panel inlet slots, then along the side plenum walls to the rear of the AEM, then through the inlet filter, across the cage/animal habitat area, through the exhaust filter, and exits the front of the AEM. High efficiency air (inlet and outlet) filters (electrostatic and phosphoric acid-treated fiberglass pads) prevent the escape of particulate matter into the cabin atmosphere. Treated charcoal inside the filters helps contain animal odor and neutralize urine within the AEM. The filter system is rated for 20 days of odor control.

Lighting: Four internal incandescent lamps (two used as backup) provide illumination and are controlled by an automatic timer to provide a standard 12:12 light/dark cycle. The timer is programmable for other light/dark cycles and a backup battery maintains the timer if AEM power is disrupted. Only two lamps are used during the light cycle to keep cage compartment heating to a minimum. The lamps are covered with clear caps to protect them from animal debris and breakage.

Food: Rodent food bars are attached to four slide-in food bar plates inside the rodent cage. The food, a sterilized laboratory formula (standard or PI formulated), is molded into rectangular bars accessible to the animals at all times during the mission.

Water Refill Box: The AEM accommodates an internal water supply containing four lixit drinking valves and two flexible plastic bladders for water storage. Remaining water can be observed through the Lexan window on top of the water box.

Water Refill Line: The AEM Water Refill Line (WRL) is used for inflight refill of the drinking water in the AEM. It allows direct transfer of potable water from the auxiliary port of the Shuttle Orbiter Galley without the need for a special pumping device.

Specifications

Dimensions: 17(W) x 20(D) x 9.62(H) inches
Weight: 55–60 lbs (including rodents, food, and water)
Power: 28 W (2 lights only)
Temperature: Elevated 3 to 6 °C above on-orbit ambient temperature

Data Acquisition

None, except when used with an Ambient Temperature Recorder

Related Ground-Based Hardware

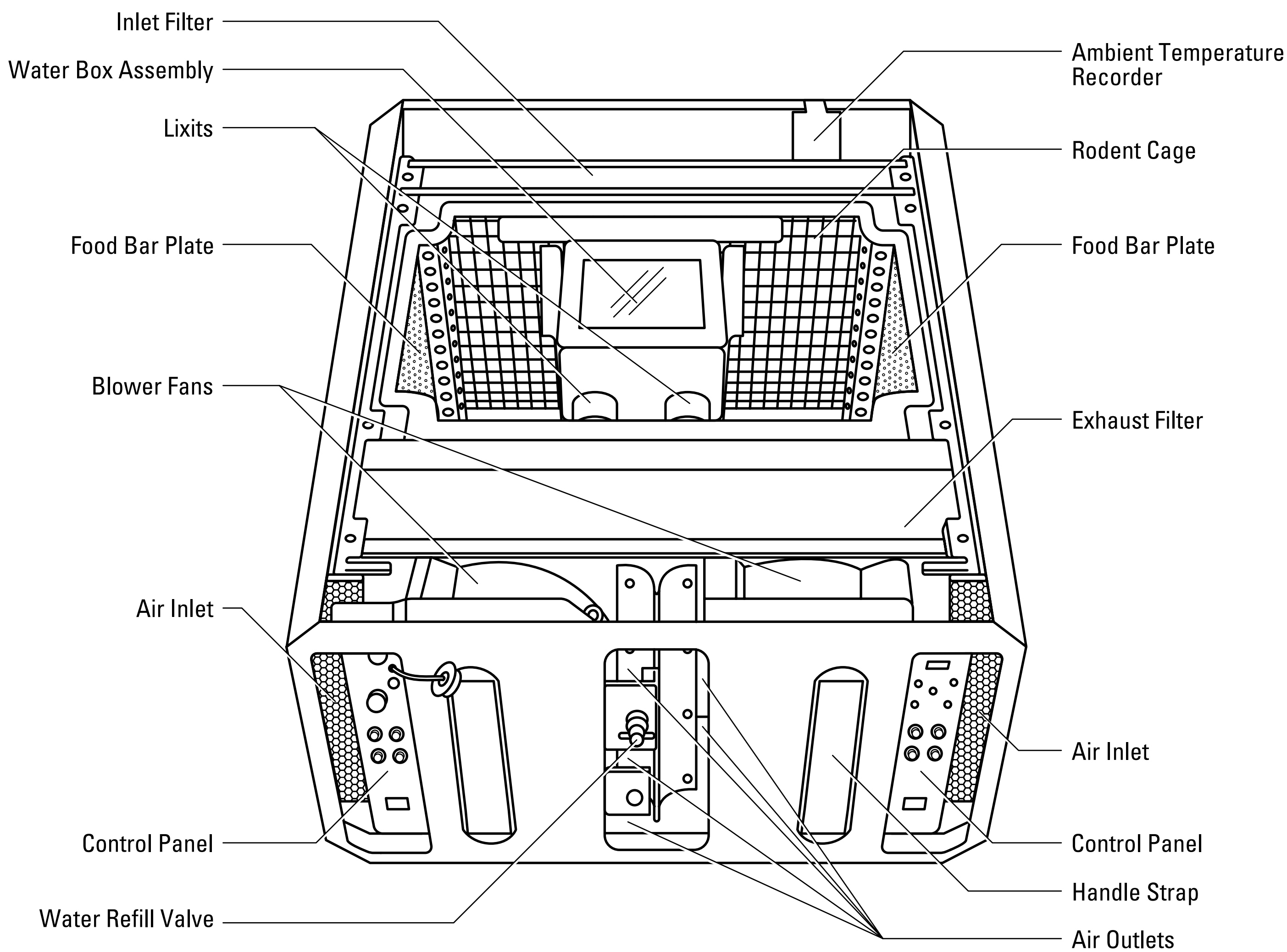
None

Hardware Publications

- Dalton, B.P., G. Jahns, J. Meylor, N. Hawes, T.N. Fast, and G. Zarow: *Spacelab Life Sciences-1 Final Report.* NASA TM-4706, 1995.
- *Life Sciences Laboratory Equipment (LSLE) On-line Catalog.* NASA, 1998. http://lifesci.arc.nasa.gov:100/lsle/.

Missions Flown 1991-1995

SLS-1/STS-40, PARE.01/STS-48, PARE.02/STS-54, PARE.03/STS-56, PSE.02/STS-52, PSE.03/STS-57, PSE.04/STS-62, IMMUNE.1/STS-60, IMMUNE.2/STS-63, NIH.R1/STS-66, NIH.R2/STS-70


Inlet Filter
Water Box Assembly
Lixits
Food Bar Plate
Blower Fans
Air Inlet
Control Panel
Water Refill Valve
Ambient Temperature Recorder
Rodent Cage
Food Bar Plate
Exhaust Filter
Air Inlet
Control Panel
Handle Strap
Air Outlets

Animal Enclosure Module (AEM) Water Refill Box

Hardware Description

The Animal Enclosure Module (AEM) Water Refill Box, storable in one-half of a middeck locker, is supplementary hardware that can be used to replenish drinking water in the AEM for missions longer than 5 days. However, if the water supply has been refilled on orbit, the water usage rate becomes difficult to compute, since the amount of water added cannot be accurately measured. The Refill Box is powered through the AEM via a connector cable.

Specifications

Dimensions: 16.5 x 10 x 6 inches
Weight 10 lbs
Power: 28 W
Capacity: 2300 cc
Interfaces: AEM water fill port, fill power connector

Data Acquisition

None

Related Ground-Based Hardware

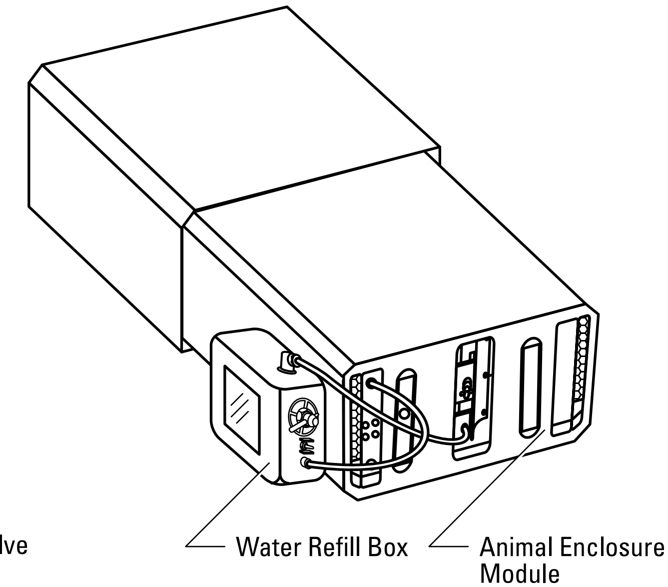
None

Hardware Publications

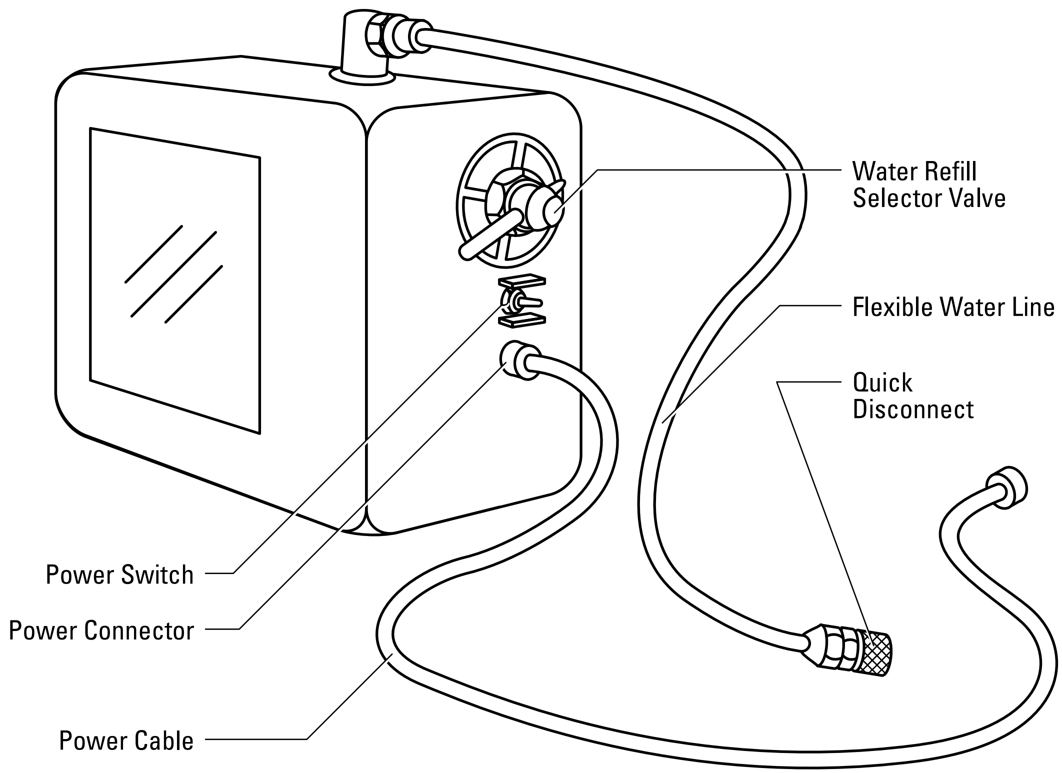
- Dalton, B.P., G. Jahns, J. Meylor, N. Hawes, T.N. Fast, and G. Zarow: *Spacelab Life Sciences-1 Final Report.* NASA TM-4706, 1995.

Missions Flown 1991-1995

SLS-1/STS-40, PARE.01/STS-48, PARE.02/STS-54, PARE.03/STS-56, PSE.02/STS-52, PSE.03/STS-57, PSE.04/STS-62, IMMUNE.1/STS-60, IMMUNE.2/STS-63, NIH.R1/STS-66, NIH.R2/STS-70



Water Refill Box In Use



Water Refill Box Assembly

Hardware Description

The Autogenic Feedback System-2 (AFS-2) is a light-weight, battery-operated, fully ambulatory physiological monitoring system that allows complete freedom of motion for users. It is designed to allow astronauts to monitor their own physiological data so they can consciously alter their physiological responses to help counteract the effects of space motion sickness. It can continuously monitor, display, and record nine channels of physiological data for up to 12 hours on a single set of alkaline batteries. The AFS-2 offers both a Treatment Mode and a Control Mode. In Treatment Mode, physiological data can be viewed on the Wrist Display Unit, while in Control Mode only system status and malfunction indications are displayed. Data are stored on a standard audiocassette using special instrumentation tape.

Subsystems

Sensors: The AFS-2 sensors include a ring transducer to monitor skin temperature and blood volume pulse, a respiration transducer, electrodes for electrocardiography (ECG) and skin conductance, and a triaxial accelerometer for head movement. The Belt Electronics package conditions these signals prior to recording.

Garment Assembly: The Garment Assembly consists of a Garment, a Cable Harness, and a Wrist Display Unit. The Garment is a cotton jumpsuit with Velcro attachment points to secure the Cable Harness and serves as a support structure for the various system sensors and transducers. The Wrist Display Unit displays physiological data, indicates system malfunctions, and notifies the user of a low battery condition.

Belt Assembly: The Belt Assembly consists of a Belt Electronics Package, a Battery Pack, and a TEAC Data Recorder. The Battery Pack provides power for the entire system. The TEAC Data Recorder records analog signals from the Belt Assembly. Data and power for the Data Recorder are provided by the Belt Electronics via the TEAC Interface Cable.

Specifications

Dimensions: N/A
Weight: 2 kg
Power: 4 batteries, 9 V each
Sensors: blood volume pulse (1–200±0.5) skin temperature (70–99.9±1°F), skin conductance level (0.5–50 µMHOs ±2%), respiration (40–60 breaths/min), electrocardiography (40–180 beats/min) and acceleration (±0.25 G±5%)

Data Acquisition

Skin temperature, electrocardiography, respiration, skin conductance level, blood volume pulse/photoplethysmography, xyz-axis acceleration

Related Ground-Based Hardware

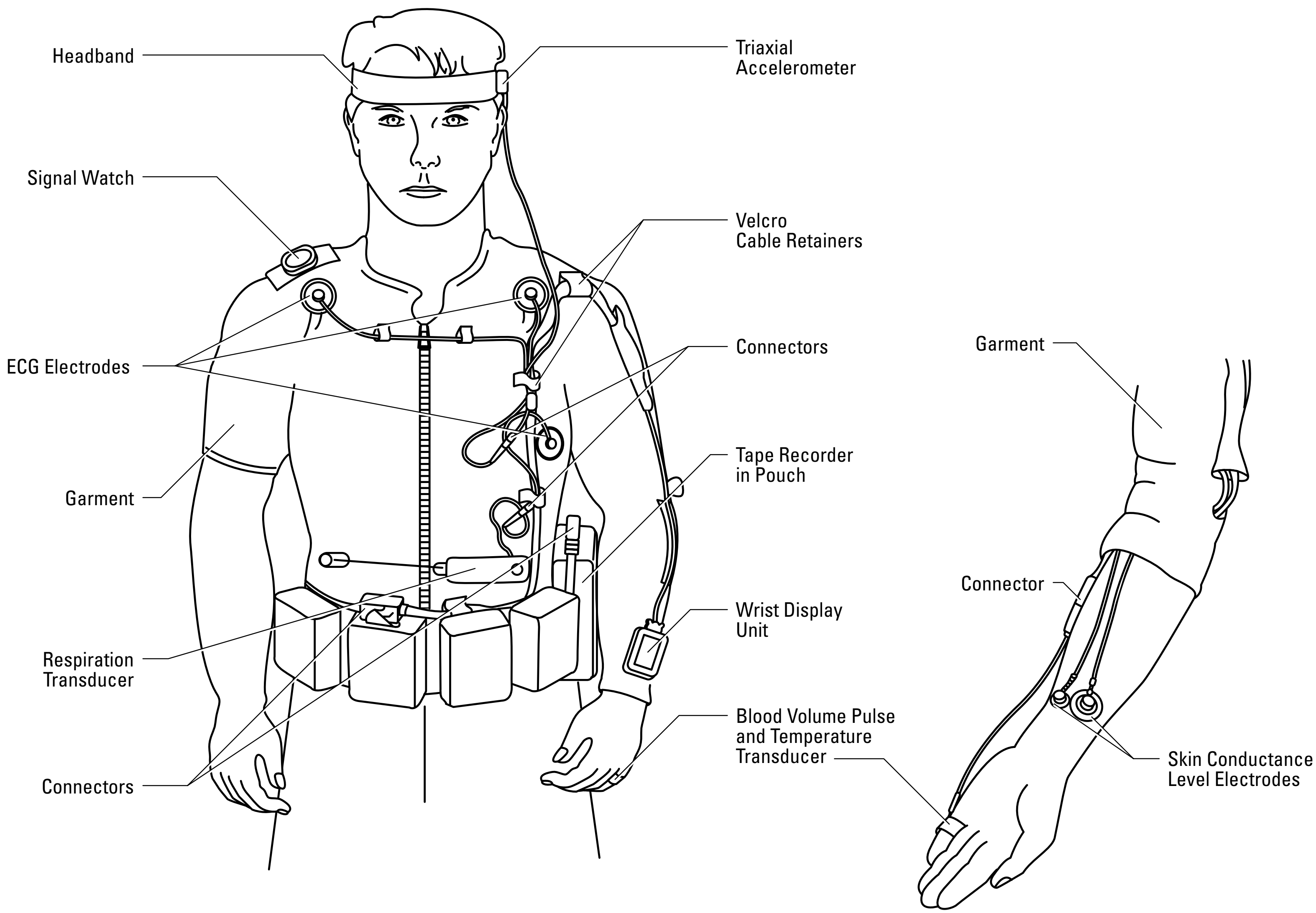
TEAC MR-40 Playback Unit: The unit replays AFS-2 tapes. It reproduces original analog data by demodulating the recorded FM signals.
Data Analysis System: The system digitizes and processes MR-40 analog data.

Hardware Publications

- Cowings, P.S. and W.B. Toscano: *Autogenic-Feedback Training (AFT) As a Preventative Method for Space Motion Sickness: Background and Experimental Design.* NASA TM-108780, 1993, pp. ill.
- Fukushima, A., D. Bergner, and M.T. Eodice: *Autogenic Feedback System-2 (AFS-2) User Manual.* NASA UM-21350, 1995.
- *Life Sciences Laboratory Equipment (LSLE) On-line Catalog.* NASA, 1998. http://lifesci.arc.nasa.gov:100/lsle/.

Missions Flown 1991-1995

SL-J/STS-47


Headband
Triaxial Accelerometer
Signal Watch
Velcro Cable Retainers
ECG Electrodes
Connectors
Garment
Tape Recorder in Pouch
Wrist Display Unit
Respiration Transducer
Blood Volume Pulse and Temperature Transducer
Connectors
Garment
Connector
Skin Conductance Level Electrodes

Hardware Description

The BRIC-100 canister is an anodized aluminum cylinder with threaded lids on each end. The canister provides containment and structural support for experiment-specific hardware and specimens. The canister lids allow passive gas exchange of O_2 and CO_2 through a semipermeable membrane. Two septa are located in the lid to allow gas sampling. If gas exchange is not required, the semipermeable membrane and capture ring can be replaced by an aluminum capture plate to provide a closed experimental environment. The hardware inside the canister consists of nine polycarbonate 100-mm petri plates. The petri plates are held into place by a petri dish cage insert. The cage provides both vibration isolation from the other dishes and the canister and airspace between each petri dish. The BRIC-100 canisters are flown in sets of three, and a standard middeck locker can accommodate up to six BRIC-100 canisters.

Specifications

Dimensions: 114.3 mm x 381 mm
Weight: 4.5 lbs
Power: None

Data Acquisition

None

Related Ground-Based Hardware

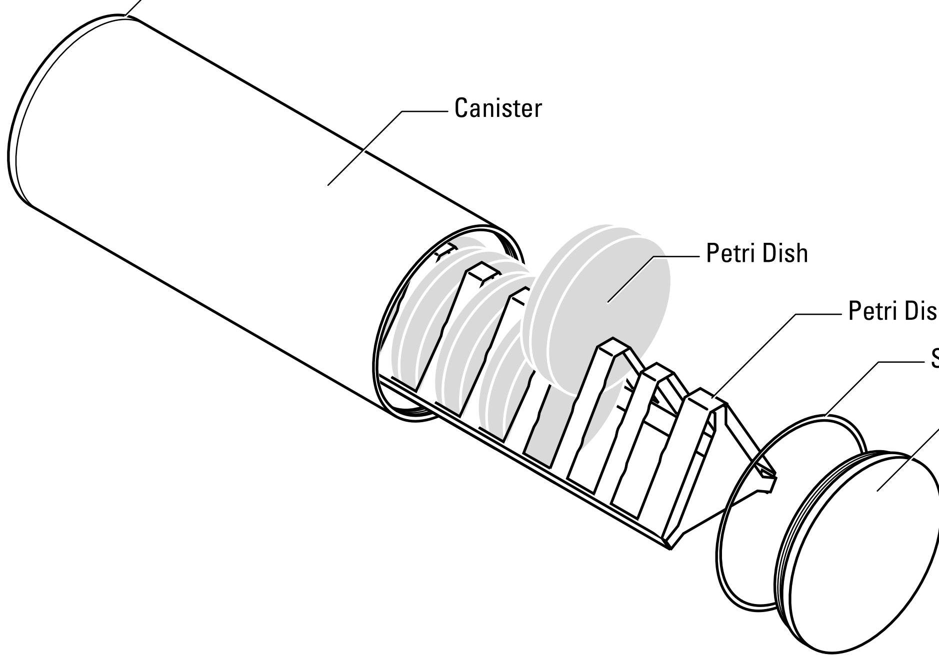
None

Hardware Publications

None

Missions Flown 1991-1995

BRIC-02/STS-64, BRIC-04/STS-70, BRIC-05/STS-70


Bottom Lid
Canister
Petri Dish
Petri Dish Cage Insert
Seal
Top Lid

Hardware Description

The BRIC-60 canister is an anodized aluminum cylinder with an upper and lower chamber. Four pressure relief holes in each chamber accommodate the rapid depressurization requirements of the Space Shuttle while maintaining a light-tight environment inside the canister chambers. This canister will fit inside the Life Sciences Laboratory Equipment (LSLE) gaseous nitrogen (GN_2) freezer. Up to five canisters can be flown at ambient middeck conditions in a standard middeck locker.

Twelve 60-mm petri dishes (total of 24 per canister) or 13 Teflon tubes (total of 26 per canister), for growing seedlings, can be placed inside each canister chamber. Lithium hydroxide (CO_2 absorbent) has also been flown inside these canisters for specimens that produce carbon dioxide (CO_2).

Specifications

Dimensions: 82 mm diam. x 32 mm
Weight: 1.9 lbs
Power: N/A

Data Acquisition

None

Related Ground-Based Hardware

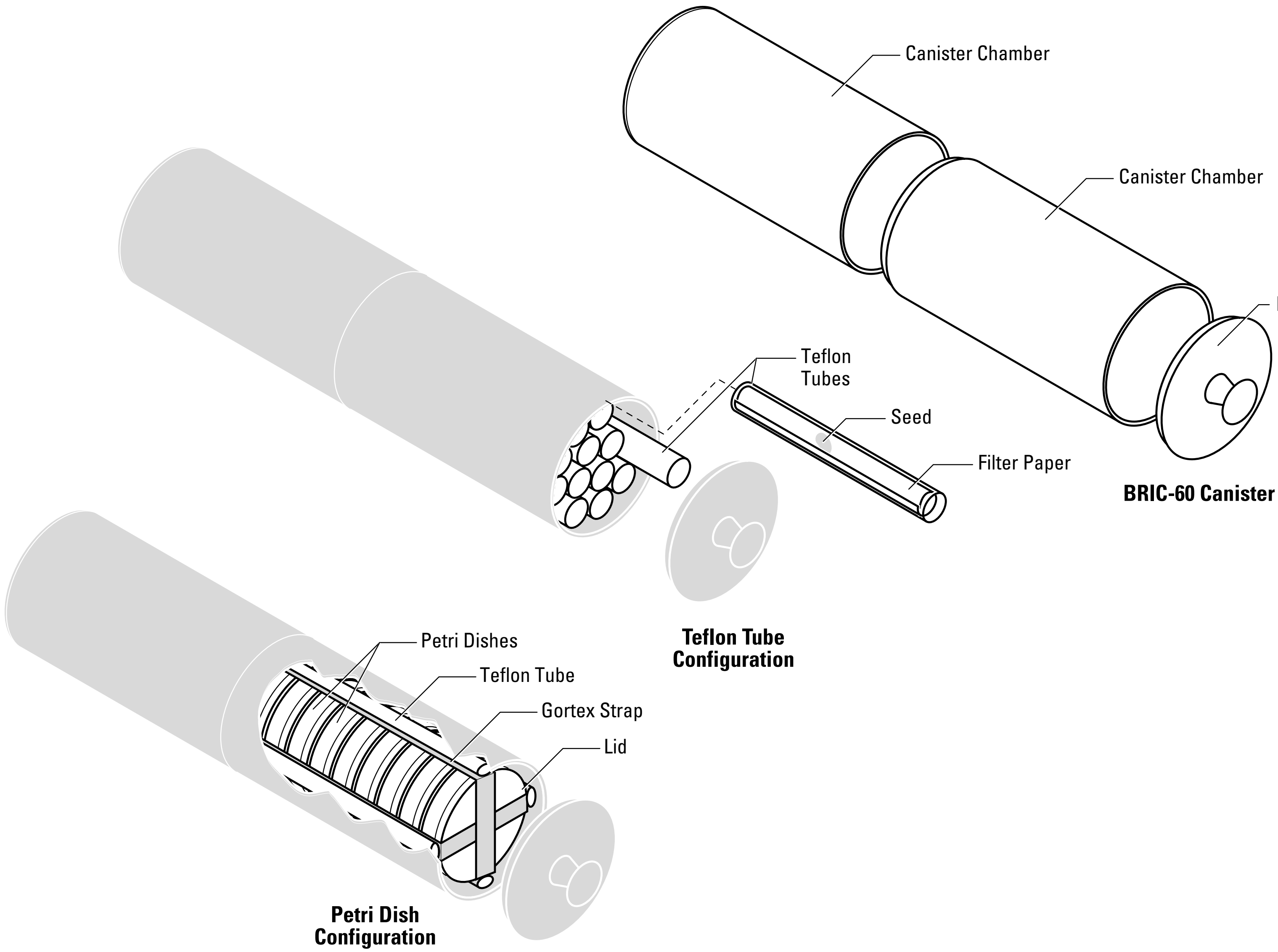
None

Hardware Publications

None

Missions Flown 1991-1995

BRIC-01/STS-68, BRIC-03/STS-63, BRIC-06/STS-69


Canister Chamber
Canister Chamber
Lid
Teflon Tubes
Seed
Filter Paper
BRIC-60 Canister
Teflon Tube Configuration
Petri Dishes
Teflon Tube
Gortex Strap
Lid
Petri Dish Configuration

Hardware Description

Biorack is a reusable, multiuser facility, developed by the European Space Agency (ESA), designed for studying the effects of microgravity and radiation on cellular functions and developmental processes in plants, tissues, cells, bacteria, and small invertebrates. The facility is equipped with a cooler/freezer, two incubators, and a glovebox. Experiment hardware must fit in one of two types of sealed, anodized aluminum containers. Type I containers are 90 x 58 x 24 mm and Type II containers are 79 x79 x 99 mm.

The US1 hardware is designed to study the effects of high-energy ionized particle (HZE) radiation in a biological dosimeter. Organisms can be flown in the configurations described below. US1 hardware made use of both Type I and Type II containers.

Subsystems

Lexan Tubes: Lexan polycarbonate tubes are assembled in four-tube and eight-tube configurations in Type I containers. These tubes maintain the nematodes in liquid buffered saline. The containers also feature CR-39 film to document the tracks made by the radiation, kimfoil sheets to keep the film oxygenated, and Thermoluminescent Detector assemblies to measure radiation received.

Radiation Cartridge Belt: The belt made of Nomex fabric consists of pockets lined with Pyrell foam. Velcro tabs secure the experiment packages. The belt is attached to the Spacelab tunnel to absorb radiation and contains five Type I containers with specimens and one ambient temperature recorder.

Nematode Stack Assembly: Twenty-eight layered assemblies are contained within each Type II container. These assemblies consist of a base support, worm/agarose layers on millipore filter paper, CR-39 film to track the path of radiation, kimfoil sheets, and Teflon sheets to act as a non-stick surface to prevent dislodging the worm/agarose layer postflight when removing the CR-39 film.

Specifications

Dimensions: 6 Type I containers (90 x 58 x 24 mm each); 2 Type II containers (79 x 79 x 99 mm each)
Weight: Unknown
Power N/A

Data Acquisition

None

Related Ground-Based Hardware

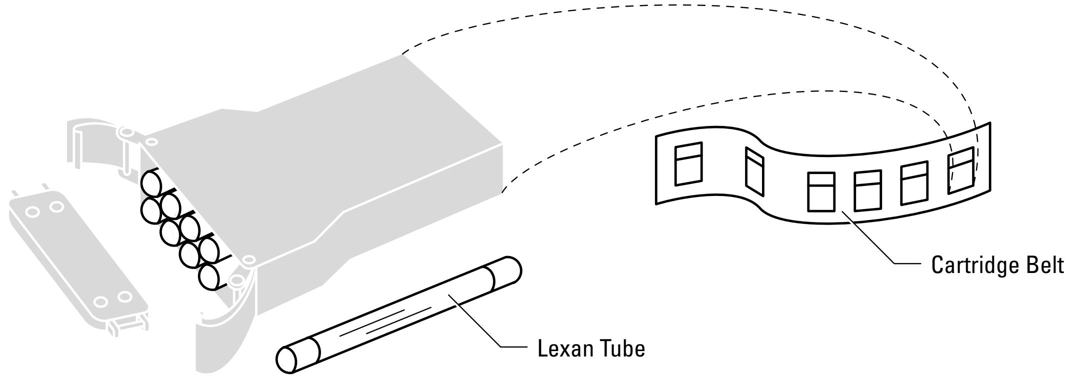
None

Hardware Publications

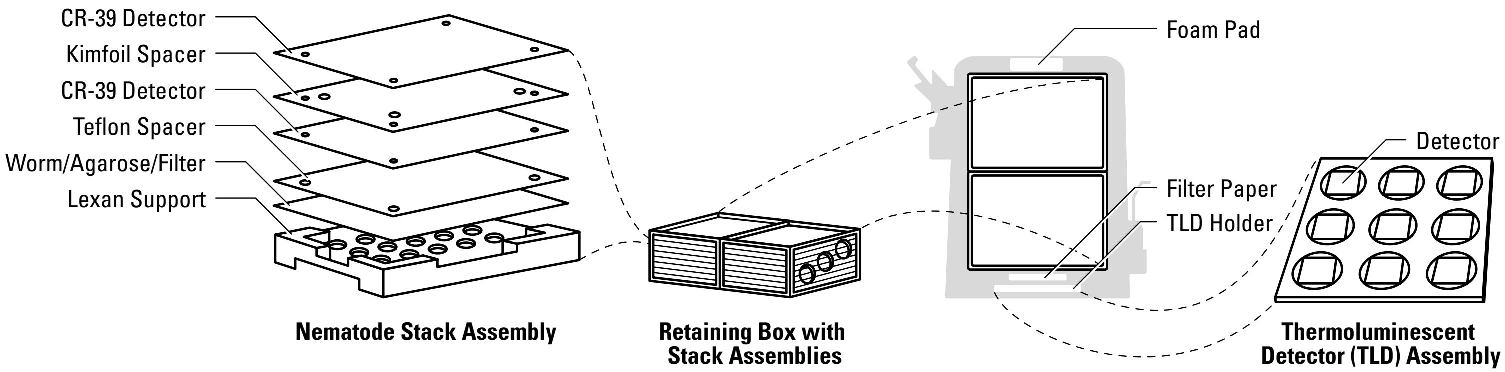
- Nelson, G.A., W.W. Schubert, G.A. Kazarians, G.F. Richards, E.V. Benton, E.R. Benton, and R.P. Henke: Genetic and Molecular Dosimetry of HZE Radiation. In: *Biorack on Spacelab IML-1*, ESA SP-1162. Noordwijk, the Netherlands: ESA Publications Division, March 1995, pp. 41–50.
- *Life Sciences Laboratory Equipment (LSLE) On-line Catalog.* NASA, 1998. http://lifesci.arc.nasa.gov:100/lsle/.

Missions Flown 1991-1995

IML-1/STS-42



Type I Container Hardware and Belt



Type II Container Hardware

Hardware Description

Biorack is a reusable, multiuser facility, developed by the European Space Agency (ESA), designed for studying the effects of microgravity and radiation on cellular functions and developmental processes in plants, tissues, cells, bacteria, and small invertebrates. The facility is equipped with a cooler/freezer, two incubators, and a glovebox. Experiment hardware must fit in one of two types of sealed, anodized aluminum containers. Type I containers are 90 x 58 x 24 mm. Type II containers are 79 x 79 x 99 mm.

The US2 hardware is designed to study the effects of microgravity and radiation on cellular and genetic structures. US2 hardware used only Type I containers.

Subsystems

Cell Chambers: Each double chamber has two culture wells consisting of a Lexan chamber fitted with a movable piston and a molecular layer of silicone to ease piston travel. The yeast plate has two grooved areas into which Lexan rings fit. Prior to fixation, the piston is pushed down to vent the air inside the chamber. Fixative is injected through the piston with a hypodermic syringe.

Culture Assemblies: Four of the double chambers (total of eight culture wells) are placed into a tray and inserted into Type I containers. The tray holding the chambers is fitted with a pad to ensure that the chambers are held adequately in place. These containers are opened only inside the Biorack glovebox.

Specifications

Dimensions: 12 Type I containers (90 x 58 x 24 mm each)
Weight: 924.8 g each
Power: N/A

Data Acquisition

None

Related Ground-Based Hardware

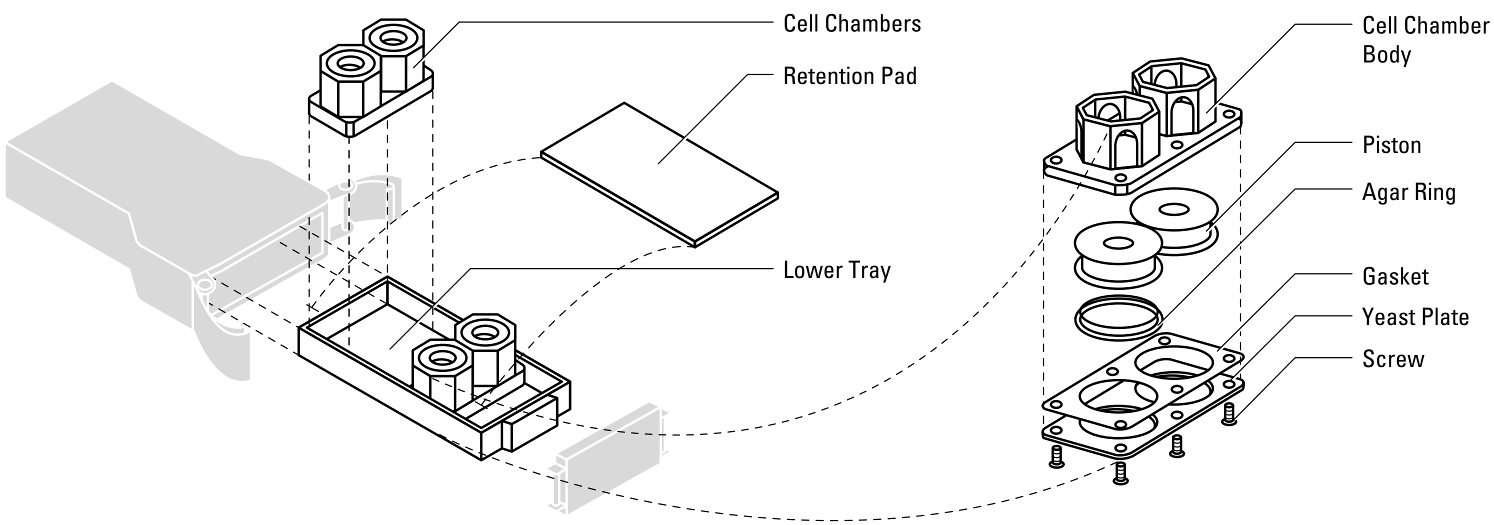
None

Hardware Publications

- Bruschi, C.V. and M.S. Esposito: Cell Division, Mitotic Recombination and Onset of Meiosis by Diploid Yeast Cells during Space Flight. In: *Biorack on Spacelab IML-1*, ESA SP-1162. Noordwijk, the Netherlands: ESA Publications Division, March 1995, pp. 83–93.
- *Life Sciences Laboratory Equipment (LSLE) On-line Catalog.* NASA, 1998. http://lifesci.arc.nasa.gov:100/lsle/.

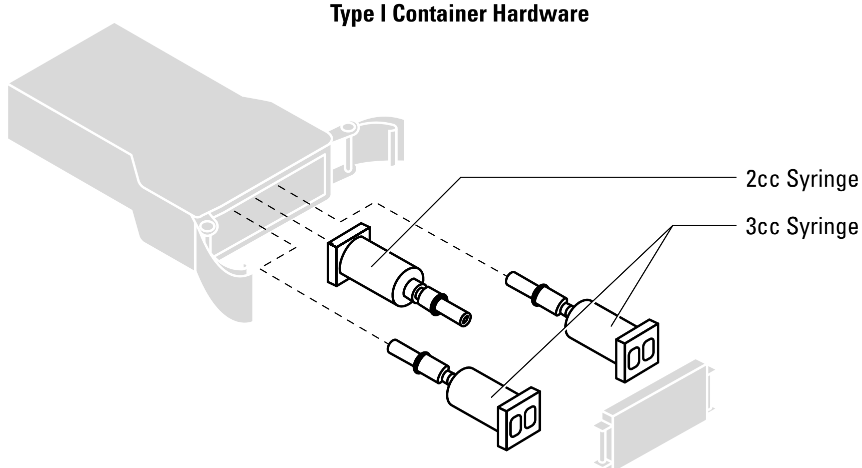
Missions Flown 1991-1995

IML-1/STS-42



Type I Container Hardware

Cell Chamber Assembly



Fixative Syringes

Hardware Description

Biorack is a reusable, multiuser facility, developed by the European Space Agency (ESA), designed for studying the effects of microgravity and radiation on cellular functions and developmental processes in plants, tissues, cells, bacteria, and small invertebrates. The facility is equipped with a cooler/freezer, two incubators, and a glovebox. Experiment hardware must fit in one of two types of sealed, anodized aluminum containers. Type I containers are 90 x 58 x 24 mm and Type II containers are 79 x 79 x 99 mm.

The US3 hardware is designed to study the effects of microgravity on cell cultures. US3 hardware used only Type I containers.

Subsystems

Cell Chambers: The chamber is a Lexan polycarbonate with two wells. In each well is a bubble of a gas exchanging material that expands or collapses as medium is added or removed. A silicon rubber gasket and bottom plate hold cells cultured on coverslips. A deflector ring in the bottom of the chamber prevents fluid forces from dislodging or shearing the cells.

Chamber Assemblies: Four culture chambers (eight wells) are inverted and placed onto a tray inserted in a Type I container. The chamber units are held in place by double-sided tape. Medium exchange and fixation are performed by inserting a hypodermic needle through the gasket and onto the cultures.

Specifications

Dimensions: 20 Type I containers (90 x 58 x 24 mm each)
Weight: Unknown
Power: N/A

Data Acquisition

None

Related Ground-Based Hardware

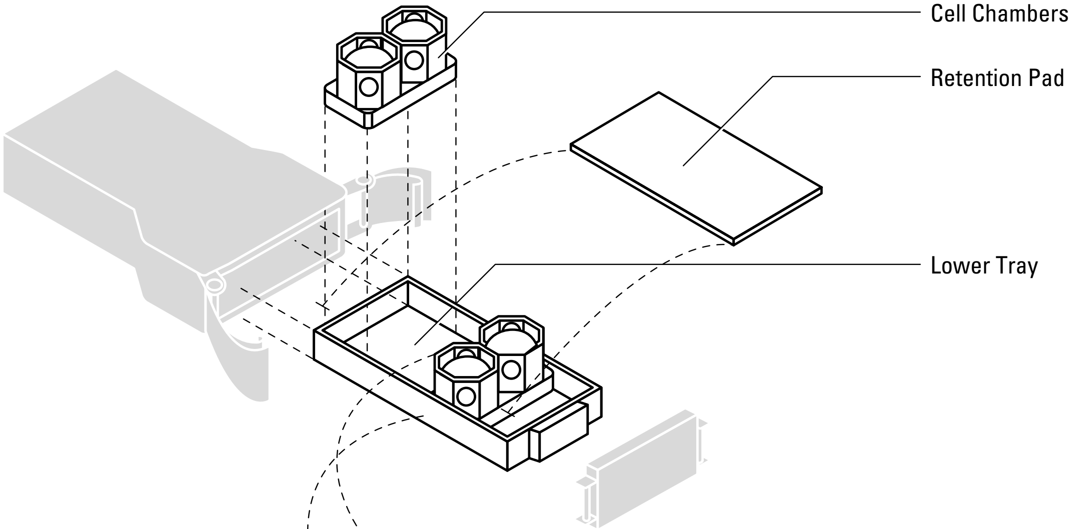
None

Hardware Publications

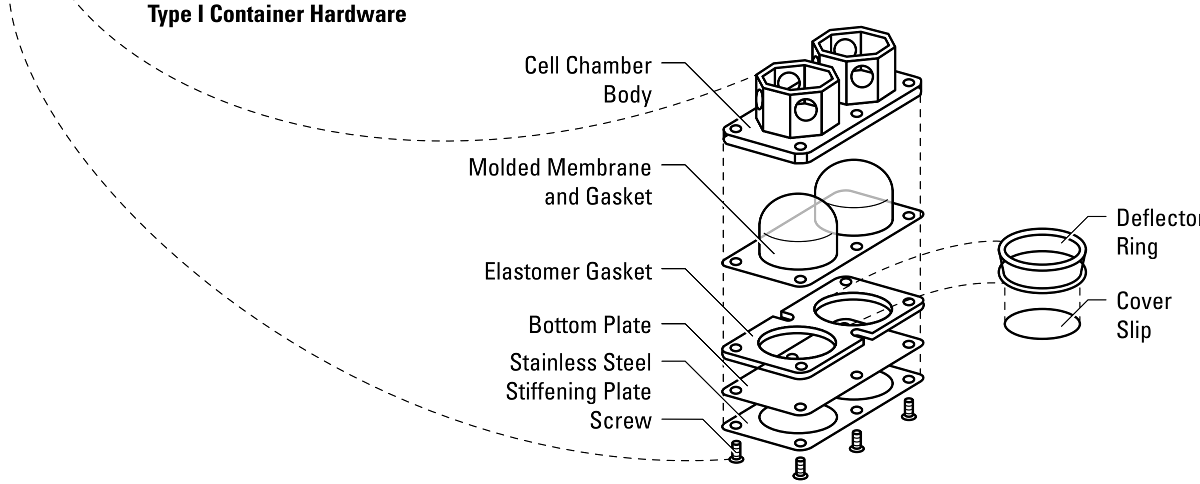
- Duke, P.J., D. Montufar-Solis, and E. Daane: Chondrogenesis in Cultures of Embryonic Mouse Limb Mesenchyme Exposed to Microgravity. In: *Biorack on Spacelab IML-1*, ESA SP-1162. Noordwijk, the Netherlands: ESA Publications Division, March 1995, pp. 115–127.
- *Life Sciences Laboratory Equipment (LSLE) On-line Catalog.* NASA, 1998. http://lifesci.arc.nasa.gov:100/lsle/.

Missions Flown 1991-1995

IML-1/STS-42



Type I Container Hardware



Cell Chamber Assembly

Hardware Description

The Syringe Racks are storage devices for use with the Biorack US3 experiment hardware. The racks are designed to hold the syringes that are used to perform medium exchange and fixation on the cell cultures. The racks, made of Lexan polycarbonate, are designed in three different configurations. Each fits in a different location: the Middeck Locker Stowage Insert, the cooler, and the freezer. The Cooler Rack is designed to hold 40 syringes filled with replacement medium. The Stowage Rack is designed to hold the replacement medium syringes that are transferred from the Cooler Rack following Biorack activation. The Freezer Rack is designed to store the syringes containing removed conditioned medium.

Specifications

Dimensions: Unknown
Weight: Unknown
Power: N/A

Data Acquisition

None

Related Ground-Based Hardware

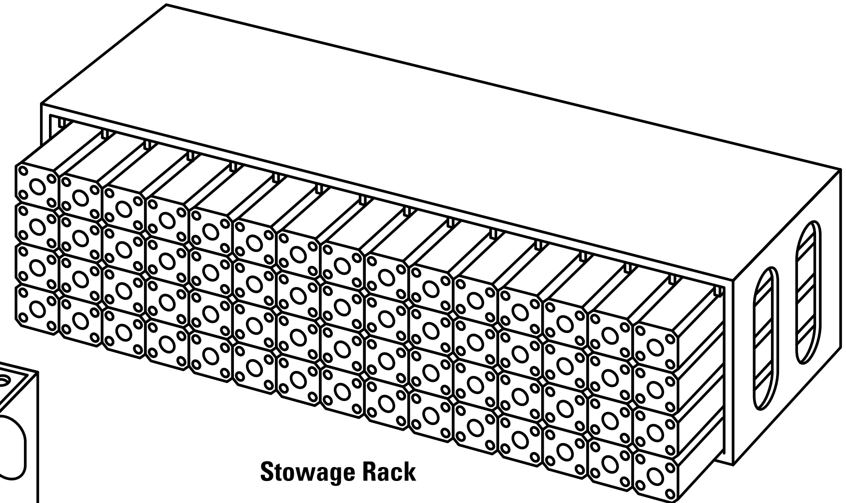
None

Hardware Publications

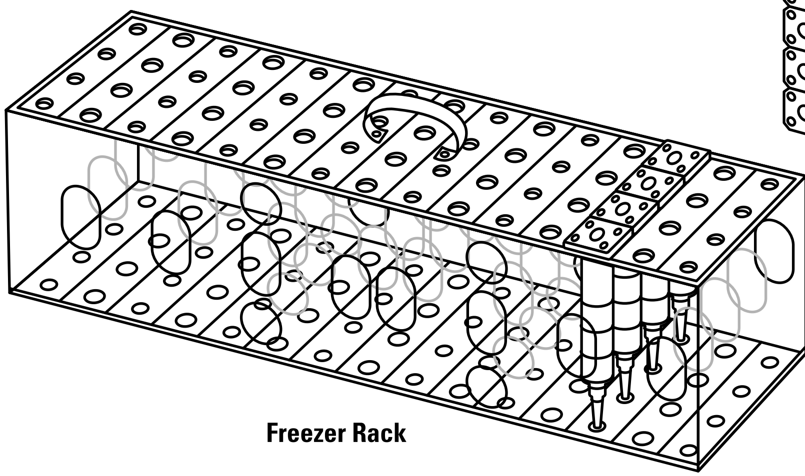
- Duke, P.J., D. Montufar-Solis, and E. Daane: Chondrogenesis in Cultures of Embryonic Mouse Limb Mesenchyme Exposed to Microgravity. In: *Biorack on Spacelab IML-1*, ESA SP-1162. Noordwijk, the Netherlands:ESA Publications Division, March 1995, pp. 115–127.

Missions Flown 1991-1995

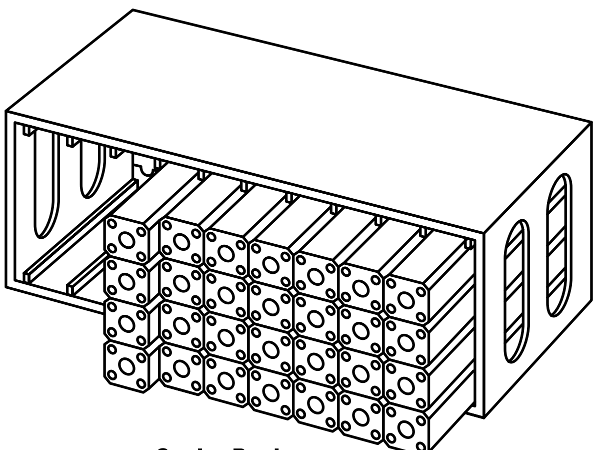
IML-1/STS-42



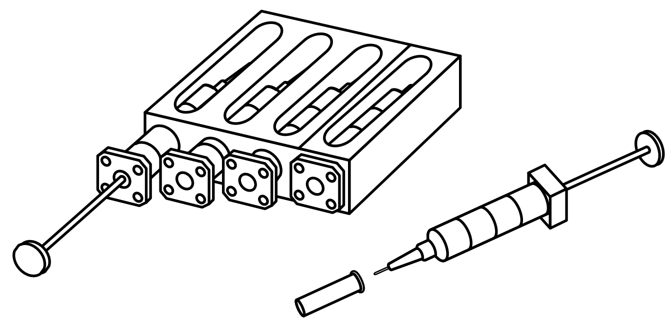
Stowage Rack



Freezer Rack



Cooler Rack



Syringe Assemblies
and Holder

Hardware Description

The Cosmos 2229 flight hardware suite is a highly integrated combination of NASA and Russian systems. The hardware supports neuromuscular, neurovestibular, and circadian rhythm/temperature (CR/T) experiments by U.S. and Russian investigators. Substantial ground-based hardware was developed for pre-and postflight testing, calibration, and data collection.

Subsystems

Head Electronics Assembly (HEA): The HEA provides interface points for head-mounted physiologic sensors and preconditioning for data signals. These signals include eye position, vestibular nuclei response (VNR), electroencephalogram (EEG), electrooculogram (EOG), brain temperature, as well as the following Russian signals: pO_2, electrostimulation, rheophlethysmography, and intracranial pressure (ICP). The assembly also serves as a platform for mounting head motion velocity sensors.

The NASA-developed components of the HEA are three circuit boards: the mother, daughter, and baby boards. These boards are stacked on the Russian-supplied base mounting ring, which is fixed to the primate's skull. The entire assembly is enclosed by the Russian-supplied cranial cap.

Circadian Rhythm/Temperature (CR/T) Hardware: The CR/T hardware consists of a sensor array, a combined signal processor and data recorder unit, and an interconnect box. The sensors measure the following parameters: motor activity, ambient temperature, brain temperature, and three channels of skin temperature. The signal processor records the above parameters, as well as Russian-supplied heart rate and deep body temperature signals. The interconnect box provides an interface between the sensors and the signal processor. The CR/T hardware is battery-powered.

Neuromuscular Hardware: The neuromuscular hardware consists of a tendon force sensor, six electromyogram (EMG) electrodes, and associated signal conditioning circuitry. A Tendon Force Compensation Module provides temperature compensation and voltage scaling.

Neurovestibular Hardware: Two angular rate sensors, one each for yaw and pitch, are mounted on the cranial cap to measure head motion velocity.

Power Supply: The power supply, located within the Russian preamplifier box, derives its power from the Russian spacecraft power source of 27 VDC. It provides power to all NASA systems other than the CR/T hardware.

Specifications

Dimensions: N/A
Weight: N/A
Power: N/A

Data Acquisition

N/A

Related Ground-Based Hardware

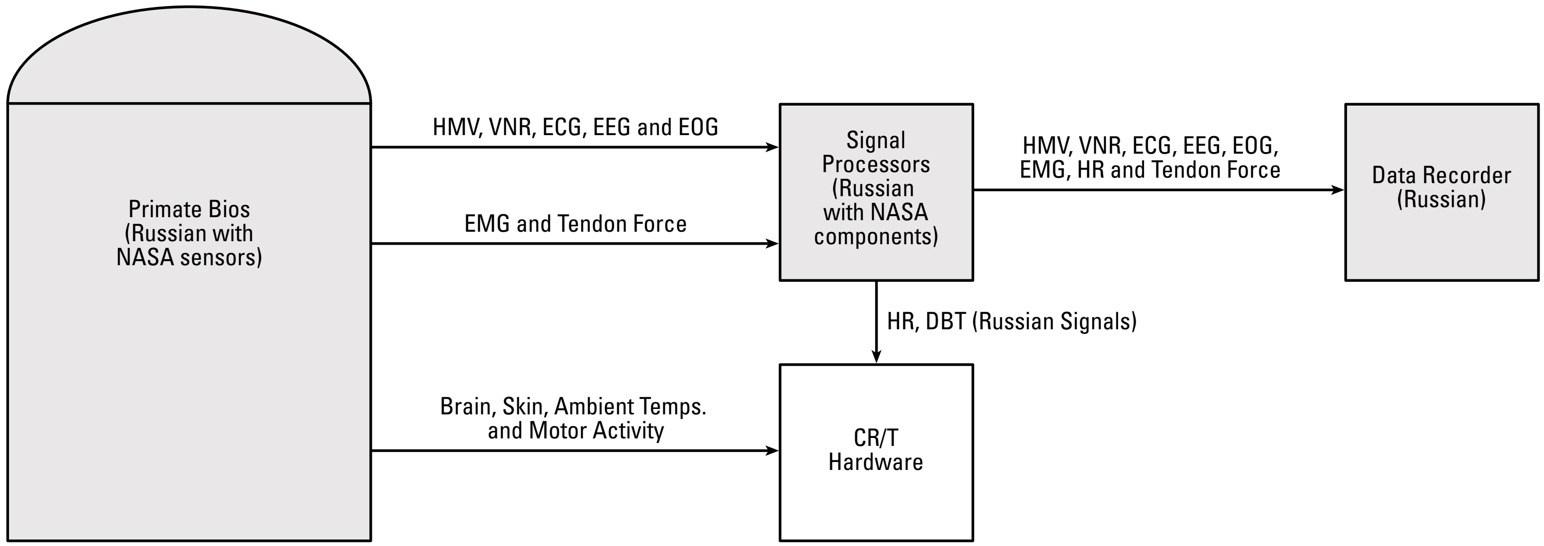
Head Electronics Signal Simulator (HESS): The HESS is used for testing of the Head Electronics Assembly.

Hardware Publications

- Connolly, J.P., M.G. Skidmore, and D.A. Helwig. *Final Reports of the U.S. Experiments Flown on the Russian Biosatellite Cosmos 2229.* NASA TM-110439, 1997, pp. 35–46.

Missions Flown 1991-1995

Bion 10/Cosmos 2229



[Shaded areas indicate predominantly Russian hardware items.]

Cosmos 2229 Circadian Rhythm/ Temperature Hardware

Hardware Description

The Circadian Rhythm/Temperature (CR/T) hardware is an enhanced version of the system flown on the Cosmos 2044 mission. NASA-provided equipment includes sensors and signal conditioning equipment to measure skin temperature, brain temperature, ambient temperature, and motor activity.

Subsystems

Sensors: Motor activity is monitored by a piezoelectric sensor attached to the monkey's restraint jacket. Three thermistors attached directly to the monkey's ankle, thigh, and temple measure skin temperature. The thigh and ankle sensors are glued to the skin and then taped in place to provide additional support. Brain temperature is recorded by means of an electrode implanted superior to the caudate nucleus of the brain. The sensor contains a microbead thermistor encased in 25-gauge stainless steel tubing with leads to the Head Electronics Assembly. Ambient temperature in the Biocosmos capsule is monitored by a thermistor located at the bottom of the primate chair. Heart rate is derived from the Russian electrocardiogram (ECG) implant signal by a Russian R-wave detector. The output signal connects to the Circadian Rhythm/Temperature Signal Processor (CR/T-SP). Body temperature is measured by a Russian-supplied telemetric sensor implanted subcutaneously in the axilla, which provides data as a frequency output of the sensor, proportional to body temperature.

Signal Processing: All parameters are recorded by the CR/T Signal Processor (CR/T-SP), which functions as a self-contained signal-processing and digital data storage device. It conditions incoming signals for processing and stores data for later recovery by a ground-based computer. Data collection and storage is controlled using a commercial VITARTS/VITACORD software package. An interconnect point between the sensors and the CR/T-SP is provided by the CR/T Interface Box (CR/T-IB).

Power Supply: Power for the CR/T system is supplied by 16 batteries (9 volt) and a precision 5-volt regulator.

Specifications

Dimensions: N/A
Weight: N/A
Power: 16 batteries, 9 volts each; 5-volt regulator

Data Acquisition

Motor activity; brain, skin, ambient, and axillary temperatures; heart rate

Related Ground-Based Hardware

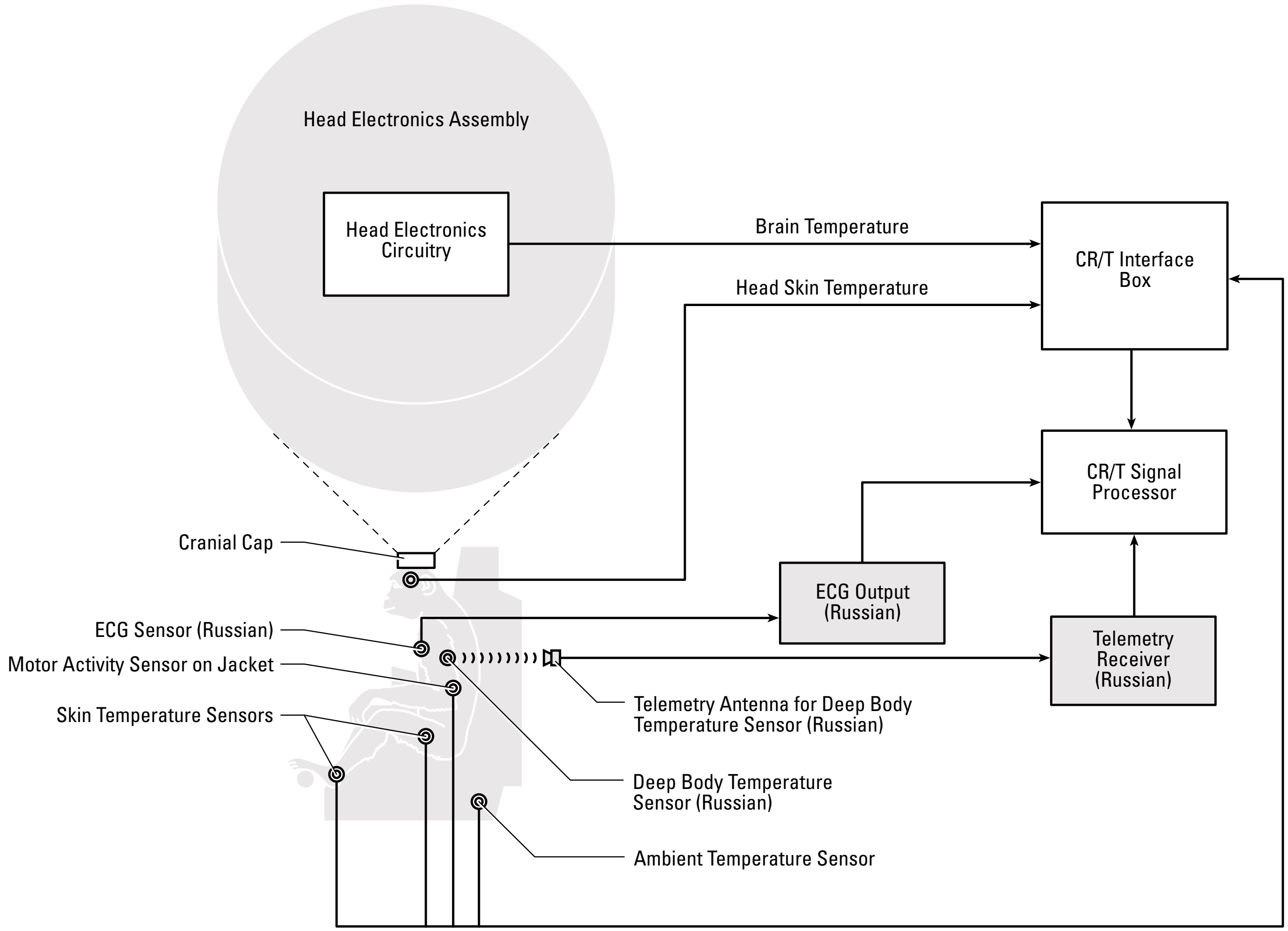
Ground Readout Unit (GRU): The GRU tests the operation of the CR/T-SP. It is also used to begin data sampling and to recover data stored in the CR/T-SP. The GRU consists of an IBM compatible computer, a CR/T Interface Board, and a printer. Like the CR/T-SP, the GRU runs the VITARTS/VITACORD software.

Hardware Publications

- Connolly, J.P., M.G. Skidmore, and D.A. Helwig: *Final Reports of the U.S. Experiments Flown on the Russian Biosatellite Cosmos 2229.* NASA TM-110439, 1997, pp. 36–37, 42.

Missions Flown 1991-1995

Bion 10/Cosmos 2229



[Shaded areas indicate predominantly Russian hardware items.]

Hardware Description

The equipment for the neuromuscular experiments aboard Cosmos 2229 includes implants and preamplifiers for electromyogram (EMG) signals and implants, transducers, and preamplifiers for tendon force measurements. EMG and tendon force data are logged by the Russian Data Recorder.

Subsystems

EMG Electrodes: The EMG implants are bipolar intramuscular electrodes made of very fine multi-stranded, teflon-coated, stainless steel wires. For the Cosmos 2229 mission, six electrodes were implanted in four sites.

EMG/ECG Boards: Located in the Russian Preamplifier Box, the circuit boards provide preamplification of the EMG electrode signals, which are used to analyze foot pedal, locomotor, and postural motor control.

Tendon Force Sensor Assembly: The Tendon Force Buckle, an active strain gauge half-bridge, is surgically implanted in the subject for measurement of tendon force. The Tendon Force Compensation Module, providing temperature compensation and voltage scaling, makes up the other half of the bridge. The sensor and the module are connected by an integral cable. Tendon activity is achieved through subject use of the Russian Foot Pedal hardware.

Tendon Force Signal Conditioner Board: Located in the Russian Amplifier and Test Control Box, the circuit board provides excitation to the Tendon Force Sensor as well as offset, gain, and filtering of the signal derived from the sensor.

Specifications

Dimensions: N/A
Weight: N/A
Power: 27 VDC
Maximum Strain: 40 lbs (tendon force)

Data Acquisition

Electromyogram data, tendon force data

Related Ground-Based Hardware

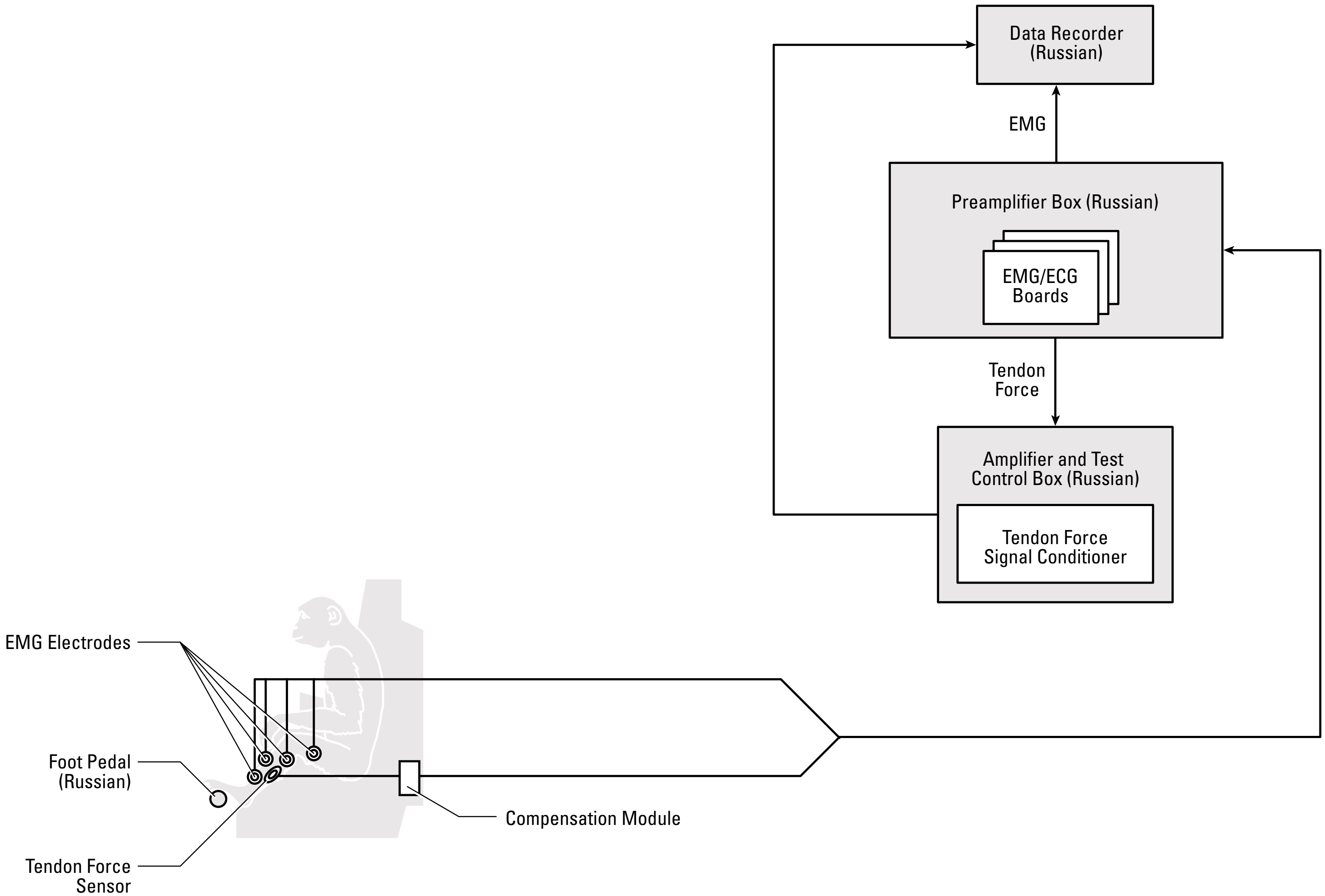
Ground Test Unit-2 (GTU-2): The GTU-2 is used to test the tendon force and EMG/ECG boards.
Lab Test Unit (LTU): The LTU is used for ground-based animal studies requiring EMG/ECG and tendon force measurements. The LTU has hardware identical to the flight suite, contains EMG/ECG and tendon force boards, and provides preamplification of the EMG/ECG and tendon force signals.

Hardware Publications

- Gregor, R.J. and T.A. Abelew: Tendon Force Measurements and Movement Control: a Review. *Medicine and Science in Sports and Exercise*, vol. 26(11), November 1994, pp. 1359–1372.
- Connolly, J.P., M.G. Skidmore, and D.A. Helwig: *Final Reports of the U.S. Experiments Flown on the Russian Biosatellite Cosmos 2229.* NASA TM-110439, 1997, pp. 38, 42.

Missions Flown 1991-1995

Bion 10/Cosmos 2229



[Shaded areas indicate predominantly Russian hardware items.]

Hardware Description

The Cosmos 2229 neurovestibular hardware measures vestibular nuclei response (VNR) and direction and velocity of primate head movement, driven by rotational and oscillating devices and the associated neurovestibular response due to microgravity exposure.

Subsystems

Angular Rate Sensors: These sensors, one each for pitch and yaw, measure head motion velocity (HMV) and are mounted on the outside of the Cranial Cap.

HMV Signal Conditioner: The conditioner receives input from the HMV sensors and provides output voltage levels proportional to the pitch and yaw angular rates. The pitch and yaw outputs are then routed to the Russian Final Amplifier Box.

Amplifiers and Preamplifiers: Supplied in the form of hybrid integrated circuits, the amplifiers and preamplifiers include a multiplexing VNR amplifier, which preconditions a total of seven signals; two logic signals, which control a multiplexer in selecting among four serially switched inputs (for recording on a Russian recorder channel); and an EEG/EOG hybrid, which conditions electroencephalogram (EEG) and electrooculogram (EOG) signals.

Specifications

Dimensions: N/A
Weight: N/A
Power: 27 VDC

Data Acquisition

Head motion velocity (pitch and yaw), vestibular nuclei response

Related Ground-Based Hardware

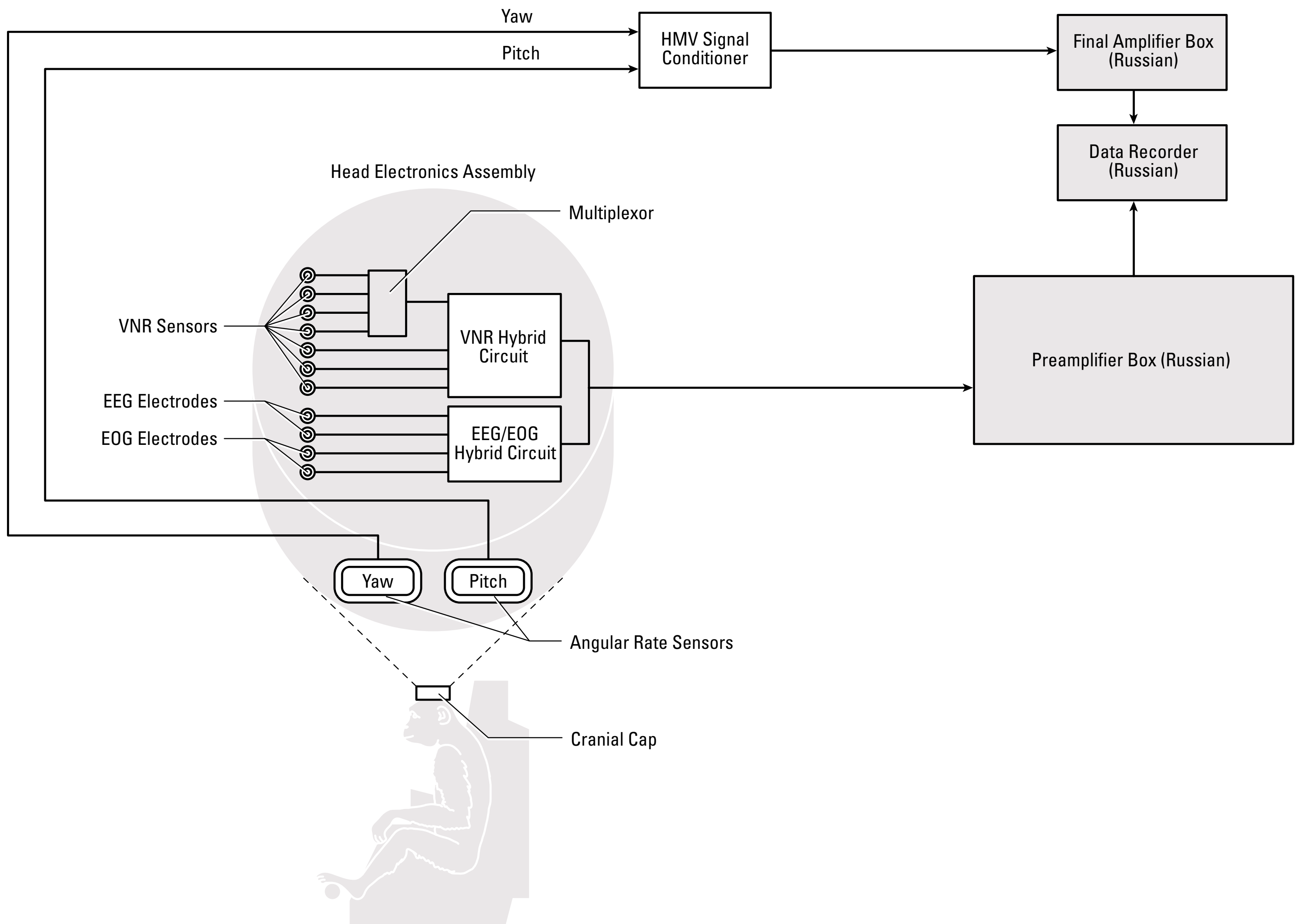
Four-axis Vestibular and Optokinetic Rotators: The rotators are used pre- and postflight to present neurovestibular stimuli.
Multi-axis Rotator: The rotator is used for pre- and postflight studies of primate eye position, VNR, and vestibular primary afferent response.
Portable Linear Sled (PLS): The PLS is used pre- and postflight for measurements during horizontal oscillations of specified frequency and sinusoidal acceleration.
Ground Test Unit-1 (GTU-1): The GTU-1 is used pre- and postflight for equipment testing and data recording.

Hardware Publications

- Connolly, J.P., M.G. Skidmore, and D.A. Helwig: *Final Reports of the U.S. Experiments Flown on the Russian Biosatellite Cosmos 2229.* NASA TM-110439, 1997, pp. 37, 40–41.

Missions Flown 1991-1995

Bion 10/Cosmos 2229



[Shaded areas indicate predominantly Russian hardware items.]

Hardware Description

The Dissecting Microscope supports general life sciences experiments requiring capabilities such as examination, dissection, and image recording of tissues and other specimens. The microscope is modular and stowed when not in use. During operations, it is deployed in the General Purpose Work Station and secured using Velcro.

Subsystems

Zeiss Stereomicroscope, Model SV 8: The microscope features a continuously variable zoom of 8–64 X magnification. It includes an adapter to accommodate a video camera.

Video Camera: The video camera records images during inflight experiment operations, which can be downlinked in real time.

Video Interface Unit (VIU): The VIU supplies power to the video camera and converts the Spacelab-provided video synchronization signal from balanced to single-ended format for use by the camera. Additionally, the VIU simultaneously converts the video output of the camera to a balanced, differential output for recorders and downlink.

Dissecting Microscope Lighting System: The lighting system provides the incident lighting required for viewing through a bifurcated fiberoptic bundle. A cooling system, prime and backup 160 W halogen lamps, and protective inlet and outlet screens are included.

Specifications

Dimensions: Approx 48.26 (H) x 20.32 (W) x 25.40 (D) cm
Weight: 10 kg (all parts as above) (22 lbs)
Power: 28 VDC power, approx 15 W total

Data Acquisition

Video

Related Ground-Based Hardware

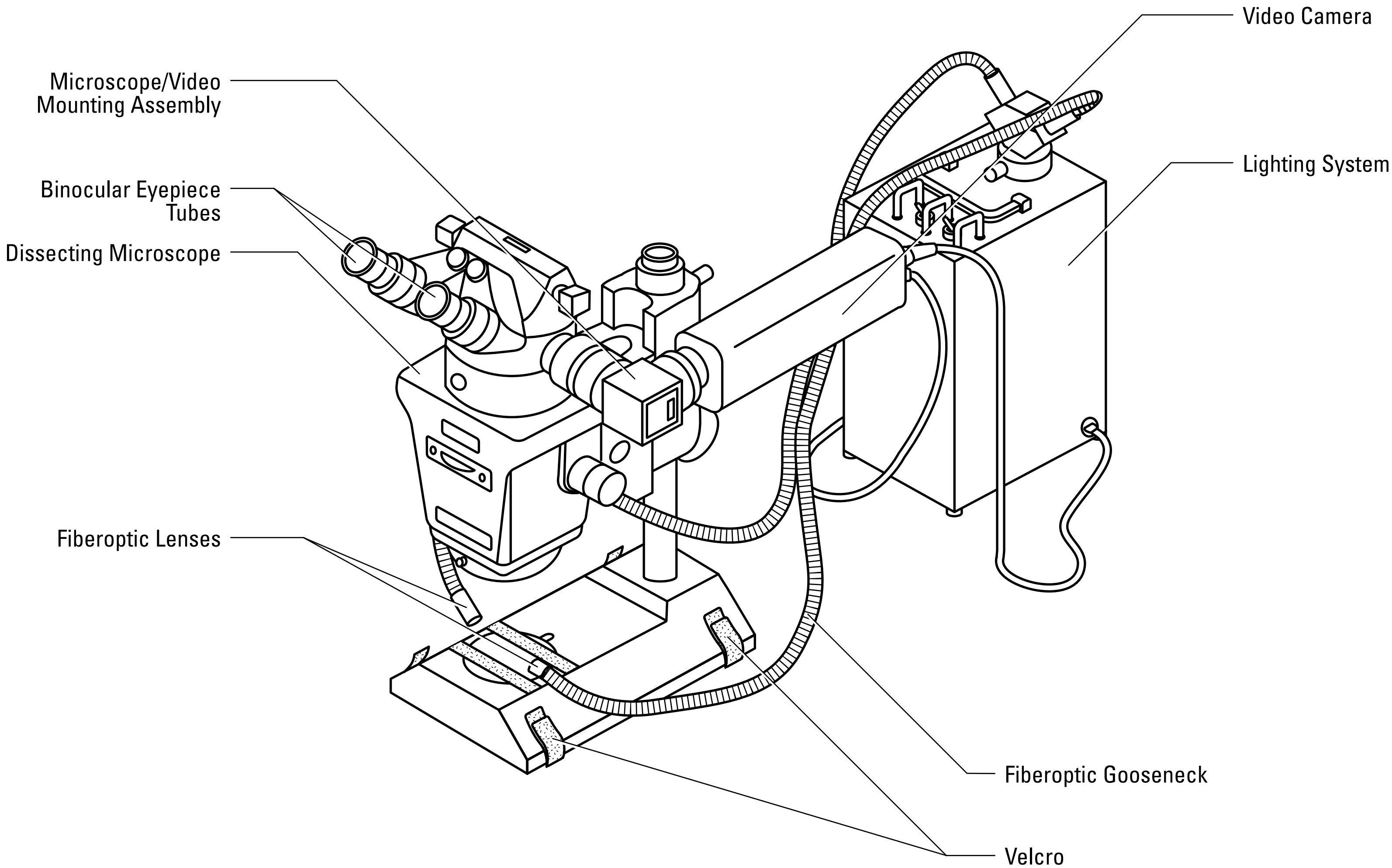
None

Hardware Publications

- *Life Sciences Laboratory Equipment (LSLE) On-line Catalog.* NASA, 1998. http://lifesci.arc.nasa.gov:100/lsle/.

Missions Flown 1991-1995

SL-J/STS-47



Video Camera
Microscope/Video Mounting Assembly
Lighting System
Binocular Eyepiece Tubes
Dissecting Microscope
Fiberoptic Lenses
Fiberoptic Gooseneck
Velcro

Hardware Description

The Frog Environmental Unit (FEU) provides a ventilated and temperature-controlled habitat for four female frogs as well as groups of developing embryos. A centrifuge inside the FEU provides an artificial Earth 1-G environment and can accommodate up to 28 Egg Chamber Units (ECUs). A separate compartment inside the FEU provides exposure to microgravity conditions for an additional 28 ECUs. Together, these systems offer the capability for simultaneous side-by-side experiments consisting of both a 0-G "treatment" group and a 1-G "control" group.

Subsystems

Adult Frog Box/ Frog Box Chamber: The box can house four adult female frogs and is divided into two compartments, with each compartment accommodating two frogs. The frog compartments are lined with a soft, absorbent material to prevent skin abrasion. Frogs are kept moist with Ringer's solution, a solution of chlorides of sodium, potassium, and calcium that is isotonic to animal tissue. The frog box slides into the FEU and mates with an air supply via quick disconnects. An aquarium-style air pump provides ventilation.

Egg Chamber Units (ECU): Egg chamber units consist of three Lexan pieces assembled to form an incubation chamber for the growing embryos. The eggs are placed on a stainless steel grid inside an egg basket and fitted onto the eyepiece unit. The eyepiece features a viewport for examining embryos using a microscope and video equipment. The chambers may be filled with Ringer's solution and can accommodate injections of fixatives or other materials.

Power and Control Systems: The Power Conditioning Unit (PCU) accepts power from the Spacelab and distributes it to the various FEU subsystems. The PCU controls and indicators provide for set-up, monitoring, and operation of the FEU.

Centrifuge: The centrifuge provides an artificial gravity force of 1 G for onboard egg chambers. It has a double row of slots, color-coded to match the egg chambers.

Kits: The Human Chorionic Gonadotrophin (HCG)/Sperm Kit contains separate syringes filled with HCG and Ringer's solution and Sperm Packages for holding sperm suspension and whole frog testes. The Egg Chamber Operations Kit holds forceps and petri dishes for egg handling. Ringer's Kits contain separate syringes for Ringer's solution and a mixture of Ringer's and Ficoll. Fixation Kits contain separate syringes for two types of fixative: a dilute acetic acid/dichromate buffer and formaldehyde. The Fixed Egg Chamber Kits contain boxes for holding egg chambers after fixation, as well as extra syringes for fixation.

Specifications

Dimensions: 33.24 H x 19 W x 28.45 D inches
Weight: ~130 kg
Power: ~185 W, 28 VDC
Temperature: 18 °C during the ovulation cycle, 21 °C after egg fertilization, adjustable by ±1 °C in 1/2 °C increments

Data Acquisition

12 channels of analog data: temperatures from the 3 main FEU compartments, fluid loop water temperature, electronics box air temperature.
Single channel of Pulse Code Modulation data: centrifuge rpm information, discrete hardware status.

Related Ground-Based Hardware

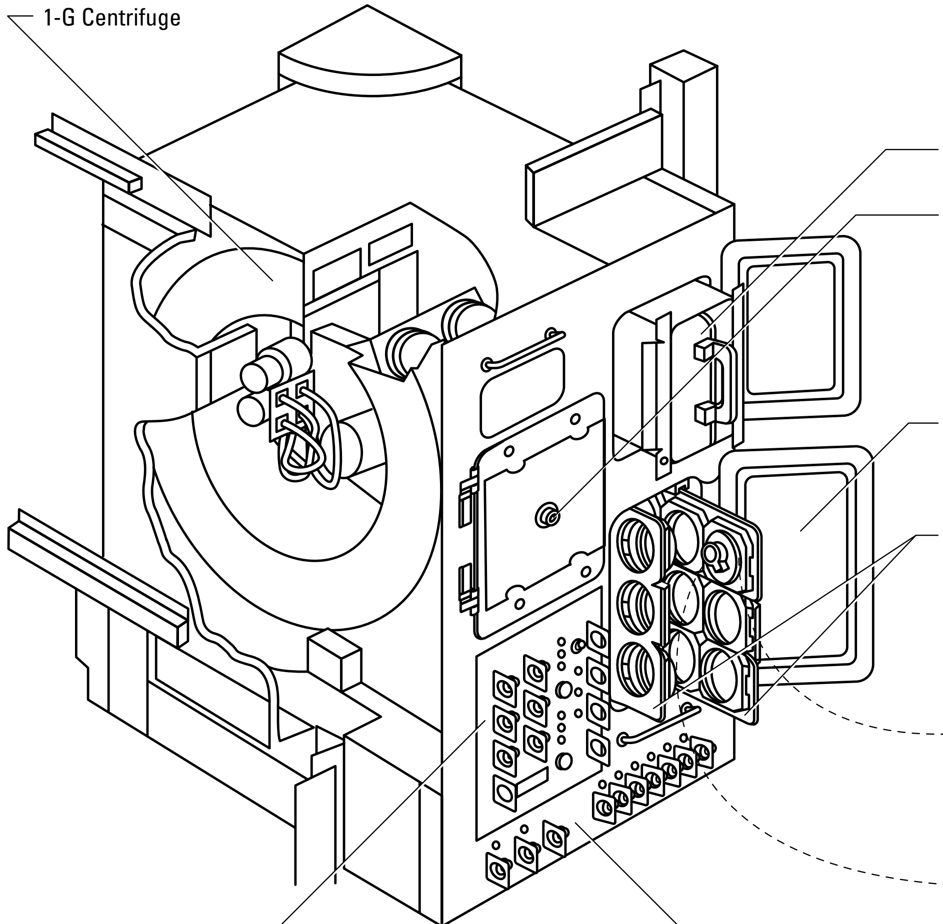
Engineering Development Unit (EDU): The EDU is a fully functional nonflight version of the FEU, used as a training and demonstration unit.

Hardware Publications

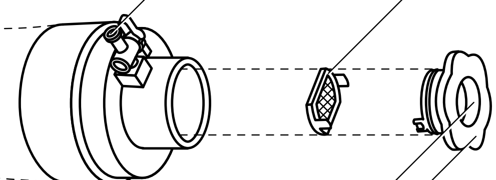
- Schmidt, G.K., S.M. Ball, T.M. Stolarik, and M.T. Eodice: *Development and Flight of the NASA Ames Research Center Payload on Spacelab-J.* NASA TM-112273, July 1993.
- *Life Sciences Laboratory Equipment (LSLE) On-line Catalog.* NASA, 1998. http://lifesci.arc.nasa.gov:100/lsle/.

Missions Flown 1991-1995

SL-J/STS-47



Frog Environmental Unit



Egg Chamber Unit

Hardware Description

The Gas Exchange Measurement System (GEMS) is designed to measure plant photosynthesis, respiration, transpiration, and other environmental parameters within the Russian Svet Greenhouse on the Mir space station.

Subsystems

Leaf Bag Assemblies: Within the Svet growth chamber, these assemblies enclose the aerial parts of the plants and the gaseous environment immediately around them. Each assembly consists of a biax nylon bag with a hard polycarbonate top, held to its base by telescoping aluminum legs. Sensors within the bags measure light levels, leaf temperature, and air temperature.

Air Filtration and Integration Assembly: Located outside of the Svet growth chamber, this assembly ensures that the concentration of gases in the air leading to the Leaf Bags is uniform. It consists of an aluminum top holding a biax nylon integration bag, an air filter, and a blower fan.

Gas Analyzer System (GAS): The GAS measures infrared absorption of CO_2 and H_2O in the air entering and exiting the Leaf Bag Assembly. It can also measure air flow rate, air temperature, and air pressure. Measurements are made every 3 seconds and detect CO_2 and H_2O differences of 1/5000 for accurate net photosynthesis (Pn) and transpiration determination.

Moisture Probe Packing Bundle (MPPB): The MPPB contains sensor probes placed in groups along the plant rows of the Svet root module. Each sensor probe contains an internal heater and temperature sensor. The heating and cooling profiles of the probes allow determination of soil moisture content.

Environmental Data System (EDS) and Data Collection and Display System: The EDS receives, encodes, and stores data from environmental sensors in various GEMS subsystems, including the Leaf Bag Assemblies, the GAS, and the Svet root module. It also controls fan speed and collects data from the soil moisture probes, once inserted in the Svet root module. All data are stored in and displayed on the Data Collection and Display System, an IBM model 750c notebook computer with software to control GEMS functions. Calibrated data are displayed in English and Russian.

Power Distribution System: This system transforms 27 VDC Mir power to the various voltages required by the GEMS electronic units and provides switchable control of other electronic components.

Water Flow Meters: The meters measure Svet water injection volume, allowing accurate water balance measurements to be made on the Svet root modules.

Specifications

Dimensions: N/A
Weight: 39 kg
Power: 4 amps (maximum continuous current)
Air Flow Range: adjustable 5–50 L/min (each leaf chamber)
Air Pressure Range: cabin pressure
Humidity Range: cabin humidity

Data Acquisition

CO_2, H_2O, O_2 and light levels; leaf, air, and soil temperature; soil moisture; air pressure and flow rate; absolute pressure; humidity; water injection volume

Related Ground-Based Hardware

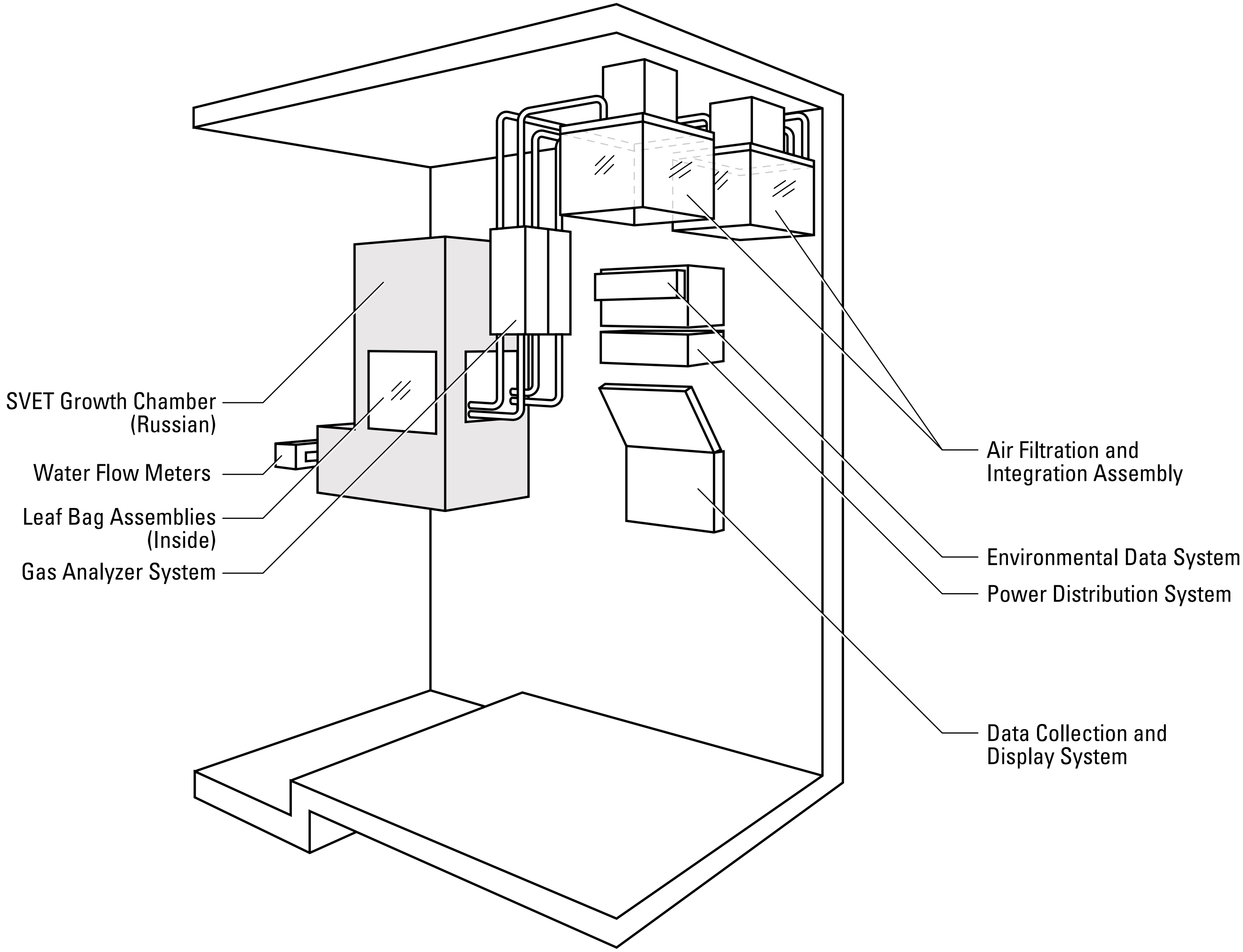
None

Hardware Publications

- Salisbury, F.B., G.E.Bingham, W.F.Campbell, D.L. Carman, D.L. Bubenheim, B. Yendler, and G. Jahns: Growing Super-Dwarf Wheat in Svet on Mir. *Life Support & Biosphere Science*, vol. 2, 1995, pp. 31–39.

Missions Flown 1991-1995

NASA/Mir Phase 1A/STS-71/STS-74


SVET Growth Chamber (Russian)
Water Flow Meters
Leaf Bag Assemblies (Inside)
Gas Analyzer System
Air Filtration and Integration Assembly
Environmental Data System
Power Distribution System
Data Collection and Display System

Hardware Description

The General Purpose Transfer Unit (GPTU) permits transfer of rodents in cages from the Research Animal Holding Facility (RAHF) to the General Purpose Work Station (GPWS). The GPTU has a Lexan frame with a sliding access door that interfaces with both the RAHF and the GPWS. A Tyvek sock attached to the frame encloses the rodent cage during transfer. The GPTU is specifically designed to provide a second level of particulate containment. For interface with the RAHF, an adapter is required.

Specifications

Dimensions: Frame: 12 x 8 x 3 inches, Sock: 25 x 15 inches
Weight: 4.1 lbs
Power: N/A

Data Acquisition

None

Related Ground-Based Hardware

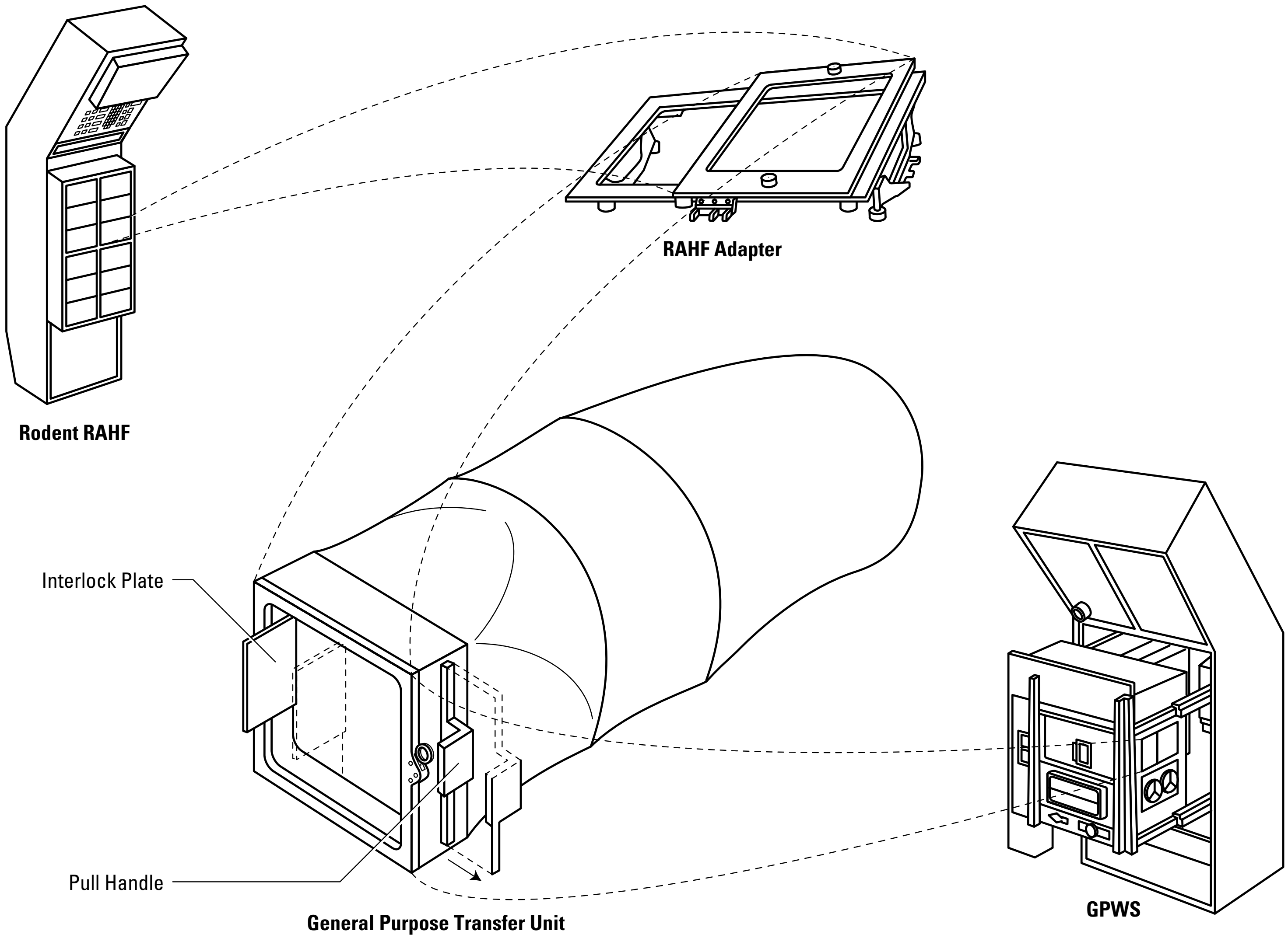
None

Hardware Publications

- Bonting, S.L. Animal Research Facility for Space Station Freedom. *Advances in Space Research*, vol. 12(1), 1992, pp. 253–257.
- *Life Sciences Laboratory Equipment (LSLE) On-line Catalog.* NASA, 1998. http://lifesci.arc.nasa.gov:100/lsle/.

Missions Flown 1991-1995

SLS-1/STS-40, SLS-2/STS-58


Rodent RAHF
RAHF Adapter
Interlock Plate
Pull Handle
General Purpose Transfer Unit
GPWS

Hardware Description

The General Purpose Work Station (GPWS) is a multipurpose support facility for conducting general laboratory operations within the Spacelab. The GPWS supports biological experiments, biosampling, and microbiological experiments, and it serves as a closed environment for containment while routine equipment repair or other inflight operations are performed. The GPWS provides the essential working space and accommodates the laboratory equipment and instruments required for many life sciences investigations. Housed in a Spacelab double rack, the GPWS is self-contained, apart from power, data, and cooling interfaces.

Subsystems

Cabinet: The rack-mounted, retractable cabinet provides laboratory work bench accommodations, including airflow, power, and lighting. The front door of the cabinet allows large experimental hardware to be transferred inside during flight. Ports on the front and side of the cabinet allow two crew members to simultaneously perform tasks inside the cabinet using gauntlets. The entire cabinet may be locked into one of three extended positions during use or fully recessed into the rack for stowage. Waste may be deposited in a disposal compartment through rubber slits on the rear wall of the internal work volume.

Containment Control System: The system is designed to clean the air within the work volume and provide biohazard protection. It includes a circulation blower, a main Trace Contaminant Control System (TCCS) canister, a vent canister, High Efficiency Particulate Air (HEPA) filters, absorbent fiberglass blotter pads, and a manually-operated Air Diverter Valve. The GPWS incorporates two modes of operation: normal, for nominal operations, and recirculation, to facilitate cleanup in the event that fluid and debris are released into the cabinet.

Electrical System: The electrical system accepts AC/DC power from the Spacelab for experiment-related equipment. Panels on the front and inside the cabinet volume contain power switches and temperature controls.

Thermal Control System: The Thermal Control System controls air temperature inside the cabinet, which can be maintained between 20 and 29 °C. Caution indicators are illuminated when the system fails to maintain the cabinet air temperature to within 2 °C of a set point.

Specifications

Dimensions: Occupies 1 Spacelab/ESA double rack
Weight: 343.25 kg (765 lbs)
Power: 50 W experiment power, total consumption 500 W
Work Space: 27.9 x 24 x 22 inches

Data Acquisition

None

Related Ground-Based Hardware

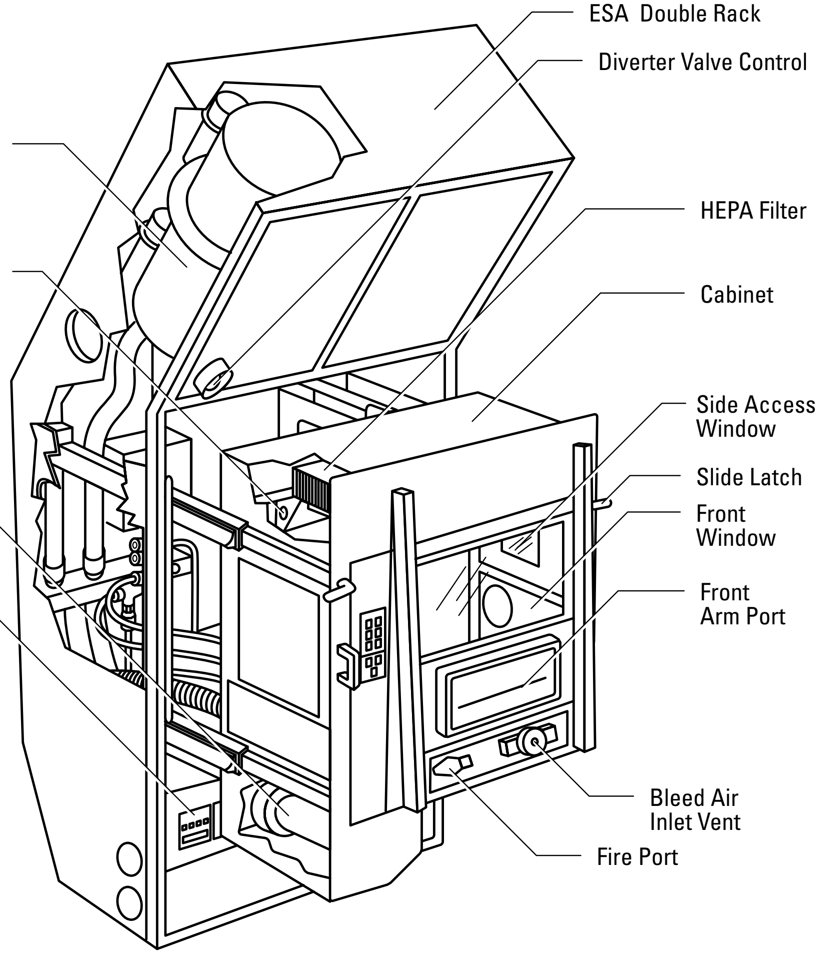
None

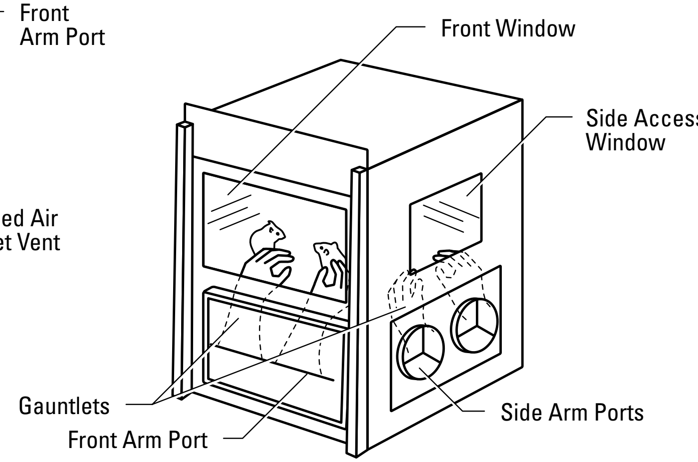
Hardware Publications

- Dalton, B.P., G. Jahns, J. Meylor, N. Hawes, T.N. Fast, and G. Zarow: *Spacelab Life Sciences-1 Final Report.* NASA TM-4706, August 1995.
- Savage, P.D., W.E. Hinds, R. Jaquez, J. Evans, and L. Dubrovin: *Experiment Kits for Processing Biological Samples Inflight on SLS-2.* NASA TM-4685, 1995.
- Schmidt, G.K. and A.A. Flippen: *A Chemical Containment Model for the General Purpose Work Station.* SAE Technical Paper Series 941286, June 1994.

Missions Flown 1991-1995

SLS-1/STS-40, SLS-2/STS-58, SL-J/STS-47





Side View of Cabinet

Gravitational Plant Physiology Facility (GPPF)

Hardware Description

The Gravitational Plant Physiology Facility (GPPF) supports plant studies within the Spacelab. The facility is designed to perform two specific gravitational plant physiology experiments, but it may be adapted to various gravitropic, phototropic, circumnutational, or other studies. Capabilities include 1-G controls and video monitoring.

Subsystems

Plant Cubes: The seeds are planted into small wells in a tray containing a commercial potting mixture. The trays are placed in a light-tight cube, which attaches to the rotors or the Recording and Stimulus Chamber. The cubes are constructed to allow infrared video of the plants inside. The cubes also have a septum for gas sampling and are available in two configurations with varying number of planting wells.

Control Unit: The Control Unit distributes power to experiment hardware and controls the functions of GPPF instruments, which are displayed on a TV monitor.

Culture Rotor: The Culture Rotor contains two 1-G centrifuges to simulate Earth gravity. Each rotor contains 16 plant cubes and is individually controlled by the Control Unit. Plant cubes are placed on the rotors prior to transfer to other GPPF instruments.

Test Rotor: The Test Rotor operates in the 0–1.5 G range. The system includes an internally-mounted, infrared-sensitive video camera head. As the plant cubes rotate, they move in succession across the video camera field of view to permit time lapse video recording of plant bending.

Recording and Stimulus Chamber (REST): Within the REST, plants in four plant cubes can be time-lapse videotaped before and after exposure to blue light, using infrared recording. The camera takes 9-second exposures every 10 minutes.

Video Tape Recorders: Two redundant video tape recorders are used to record images from the REST and Test Rotor cameras. They record the same information to ensure successful data collection.

Mesocotyl Suppression Box (MSB): Within the MSB, seedlings are exposed to a red light spectrum for up to 10 minutes, which suppresses the growth of the mesocotyl to ensure uniform and straight growth of the plant and to prevent interference in the study of the gravitropic response.

Plant Holding Compartment (PHC): The thermally regulated PHC contains gas sampling syringes, rotor counterweights, plant cubes, and a kit containing seeds and planting implements.

Specifications

Dimensions: Occupies 1 Spacelab double rack
Weight: 181.75 kg (without stowage)
Power: Unknown
Temperature: 18 to 22.5 ± 1 °C

Data Acquisition

Video, temperature, doors open, rotor activity

Related Ground-Based Hardware

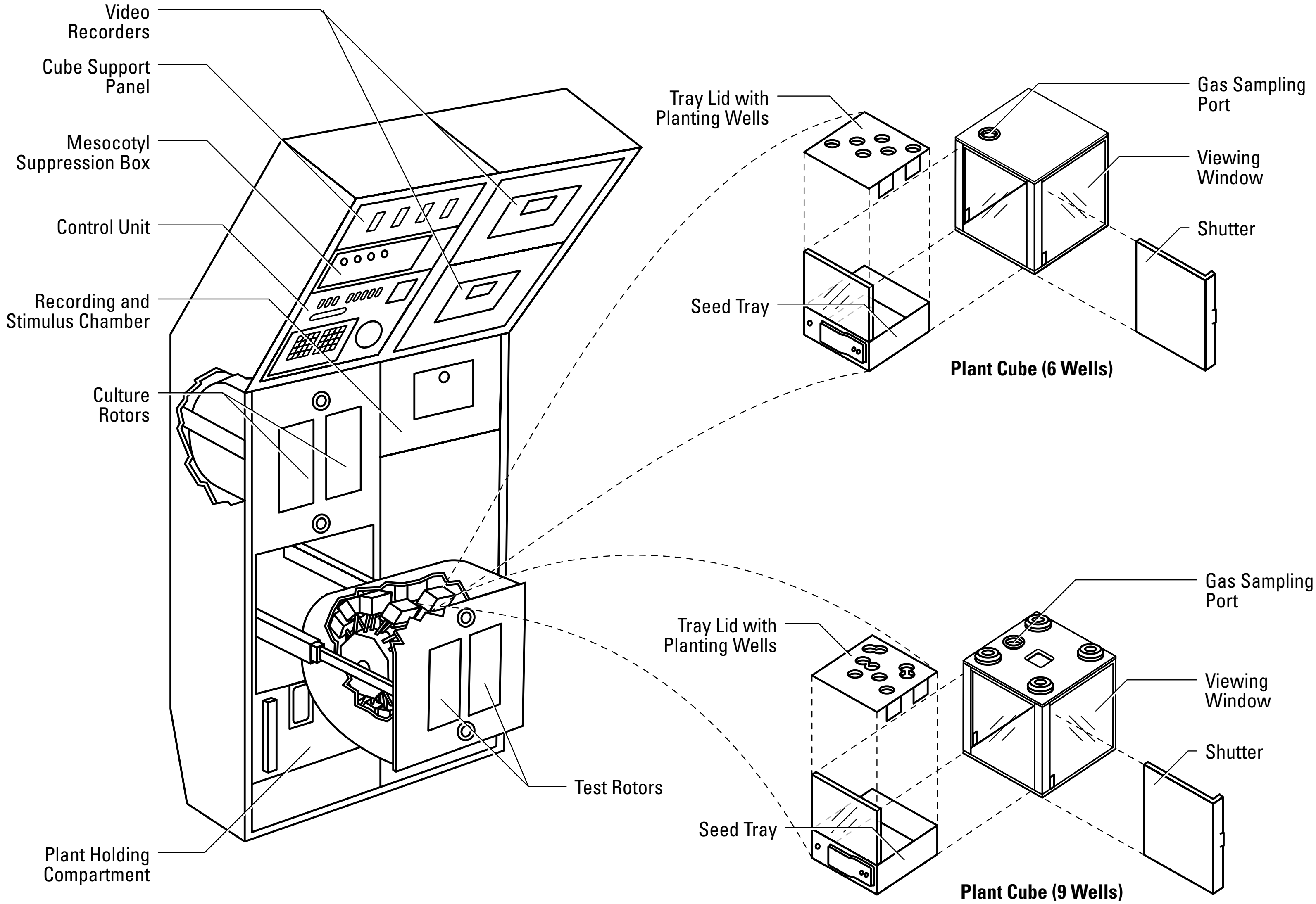
None

Hardware Publications

- Heathcote, D.G., D.K. Chapman, A.H. Brown, and R.F. Lewis: The Gravitational Plant Physiology Facility: Description of Equipment Developed for Biological Research in Spacelab. *Microgravity Science and Technology*, September 1994, vol. 7(3), pp. 270–275.
- Rudolph, I.L., R.L. Schaefer, D.G. Heathcote, and D.K. Chapman: Development of Spaceflight Experiments: I. Biocompatibility Testing—the IML-1 Experience (abstract). *American Society of Gravitational Space Biology Bulletin*, vol. 6(1), October 1992, p. 47.
- A.H. Brown: *Gravitropic Responses of Plants in the Absence of a Complicating G-Force.* NASA TM-4353, February 1992, pp. 3–12.

Missions Flown 1991-1995

IML-1/STS425


Video
Recorders
Cube Support
Panel
Mesocotyl
Suppression Box
Control Unit
Recording and
Stimulus Chamber
Culture
Rotors
Plant Holding
Compartment
Test Rotors
Tray Lid with
Planting Wells
Seed Tray
Gas Sampling
Port
Viewing
Window
Shutter
Plant Cube (6 Wells)
Tray Lid with
Planting Wells
Seed Tray
Gas Sampling
Port
Viewing
Window
Shutter
Plant Cube (9 Wells)

GPPF: Middeck Ambient Stowage Insert (MASI)/Plant Carry-On Container (PCOC)

Hardware Description

Both the Middeck Ambient Stowage Insert (MASI) and the Plant Carry On Container (PCOC) are support hardware for the Gravitational Plant Physiology Facility (GPPF) experiments. The MASI is designed to hold soil trays, while the PCOC holds plant cubes.

Each is constructed of a standard aluminum box, with a hinged cover and latches mounted inside the lid. Inside the lid of the box is an Ambient Temperature Recorder to automatically sense and record internal temperatures during the mission, a hex key, and seed strips. The portion of the box below the lid contains five layers of experiment support hardware. These are packages of experiment soil trays and experiment plant cubes, which are used within the GPPF. The entire package is protected by Pyrel foam into which the soil trays and plant cubes are inserted. They are further contained by Nomex straps and tape.

Specifications

Dimensions: PCOC: 50.3 x 43.5 x 24.0 cm
MASI: 37 x 11 x 9 cm
Weight: PCOC: 8.64 kg (with foam packing)
MASI: 2.24 kg
Power: N/A

Data Acquisition

None

Related Ground-Based Hardware

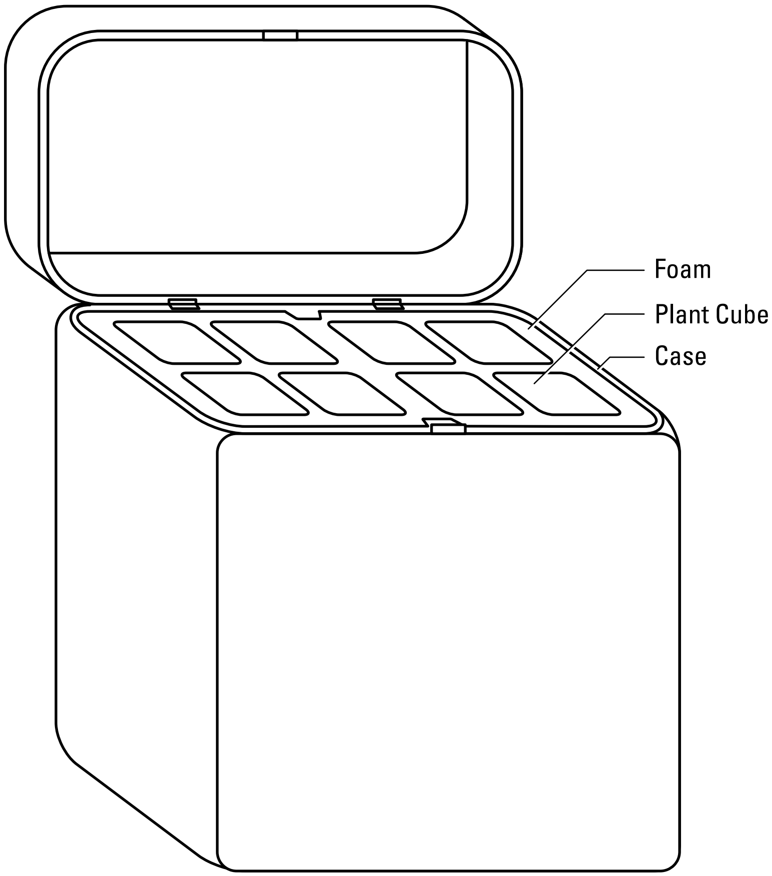
None

Hardware Publications

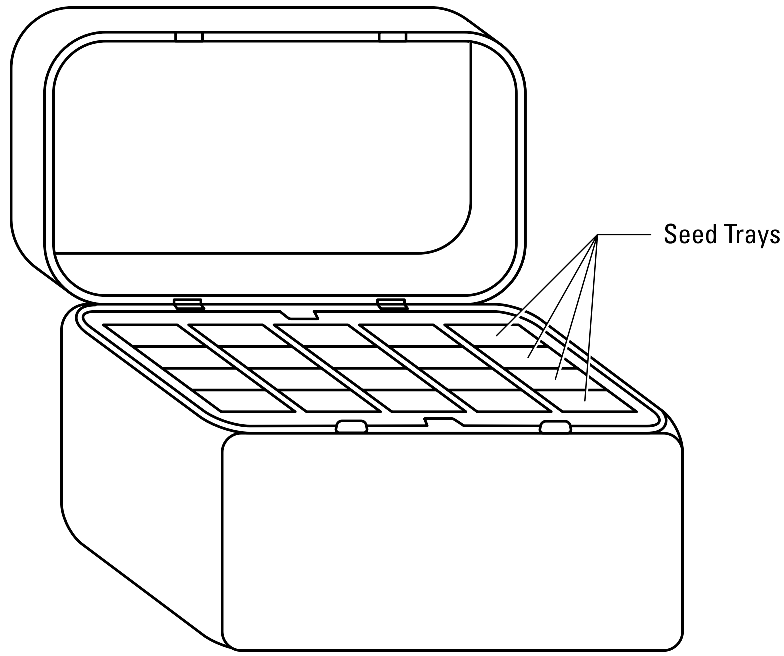
None

Missions Flown 1991-1995

IML-1/STS-42



Plant Carry-On Container



Middeck Ambient Stowage Insert

Hardware Description

The four Jellyfish Kits contain the necessary materials to maintain jellyfish during flight, measure the radiation dose, and apply fixative to specimens. The kits must be stored in climate-controlled containment during flight to provide a constant 28 °C ambient temperature for the specimens. Various hardware items are available to support experiment activities.

Subsystems

Jellyfish Bags/Kits: Jellyfish are maintained in polyester bags with polyethylene lining filled with artificial sea water, at a ratio of 1:3, air:solution. The bags are carefully cleaned and tested for biocompatibility prior to use. Kit #1 contains nonoperative single compartment bags that do not require crew manipulation on orbit. Lithium fluoride radiation rod dosimeters are added to six of the 18 bags in Kit #1 before they are heat-sealed. Kit #2 contains eight multicompartment syringe/bag assemblies with one to three syringes of fixative attached (three-syringe/bag assembly illustrated). Each syringe bag has two outer bags for containment and is individually tetherable to prevent it from floating away during experiment operations in microgravity. Kit #3 is used to hold the fixed specimens from Kit #2. Kit #4 contains small specimen flasks containing the jellyfish in artificial sea water. The 40 cc culture flasks are made of optically clear polyethylene and are used for videotaping jellyfish swimming patterns in microgravity.

Chemical Delivery System (CDS): The Chemical Delivery System (CDS) offers the capability to introduce chemicals to the jellyfish during flight. The CDS consists of syringes mounted via plastic housing to polyethelene-lined Kapak bags. The system is cleaned and tested for biocompatibility before launch. Inner and outer plastic bags provide triple containment.

Specifications

Dimensions: N/A
Weight: 20.48 lbs total
Power: N/A
Capacity: 186 cc and 100 jellyfish/bag
Temperature: constant 28 °C

Data Acquisition

None

Related Ground-Based Hardware

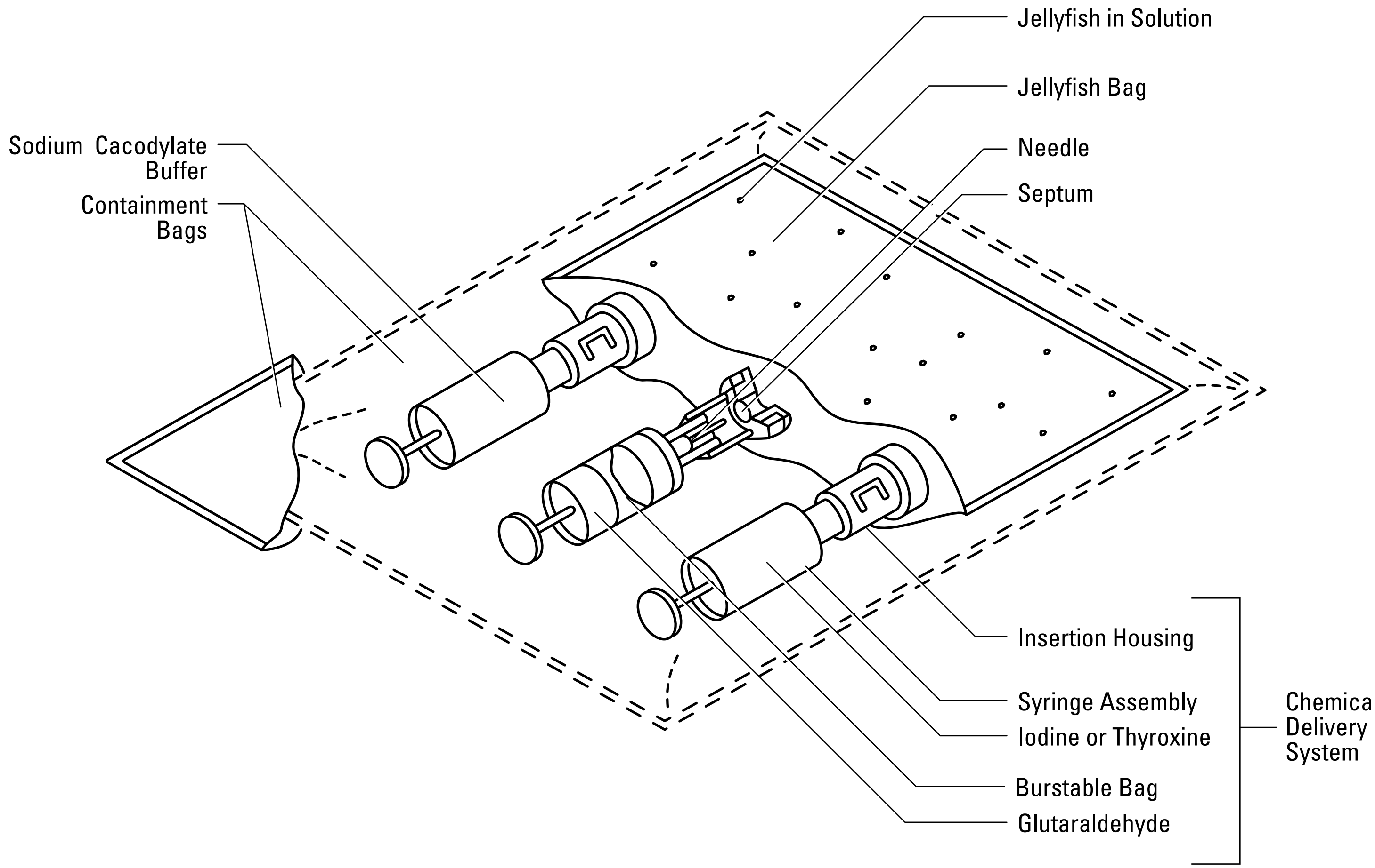
None

Hardware Publications

- *Life Sciences Laboratory Equipment (LSLE) On-line Catalog.* NASA, 1998. http://lifesci.arc.nasa.gov:100/lsle/.

Missions Flown 1991-1995

SLS-1/STS-40


Jellyfish in Solution
Jellyfish Bag
Needle
Septum
Sodium Cacodylate Buffer
Containment Bags
Insertion Housing
Syringe Assembly
Iodine or Thyroxine
Burstable Bag
Glutaraldehyde
Chemical Delivery System

Hardware Description

Several NASA-designed kits were provided for the NASA/Mir avian developmental biology experiments collectively titled "Incubator," which used the Russian IMBP incubator, and the plant biology experiment titled "Greenhouse," which used the Russian Svet Greenouse and the NASA/P.I.-provided Gas Exchange Measurement System (GEMS).

Fixative Kits (Incubator): Fixative Kits consist of double-layered, double-clamped plastic bags that hold the required volume of paraformaldehyde fixative. The design allows the crew member to introduce into the bag the quail egg to be fixed while precluding exposure of the crew member to the fixative. Each of the fixative bags are enclosed in turn by a large outer bag, also clamped. The bags are stored within an aluminum box. Each box holds 16 fixative bags.

Harvest Kit: The kit includes instruments for harvesting the plants. Among other elements, these instruments include long probes (overall, 40 cm; probe arm, 32 cm) with small scissors or tweezers on one end.

Fixative Kit (Greenhouse): These bags of chemical fixative contain a solution developed and tested by Dr. Campbell at Utah State University, based on a formula of MacDowell and Trump: 4 parts formaldehyde; 1 part glutaraldehyde, buffered with Na_2PO_4, adjusted to pH 7.2 with NaOH; and sodium azide added to prevent fungal growth. Like the incubator fixative bags, each bag is triple sealed to prevent the release of hazardous chemicals into the cabin atmosphere.

Glovebag Kit: The glovebag is a large, clear plastic bag that allows a single user access to its interior through two rubber gloves on the front surface of the bag. A small airlock entry port is located at the rear of the bag, which allows the crew member to insert samples into the glovebag. The entry port can be rolled up and clamped shut, if necessary.

Filter/Pump Kit: The kit consists of a filter and pump for evacuating the air inside the glovebag, in case of a hazardous fixative spill.

Dry Stowage Kit: The dry stowage kit includes plastic bags containing silica gel as desiccant. The kit stows plant samples not placed into chemical fixatives.

Observation Kit: The kit includes the camera bracket and ruler/color chart to be included in photographs. The camera itself is not part of the kit.

Logbook Kit: The logbook is used to record crew observations.

Specifications

Dimensions: N/A
Weight: N/A
Power: N/A

Data Acquisition

None

Related Ground-Based Hardware

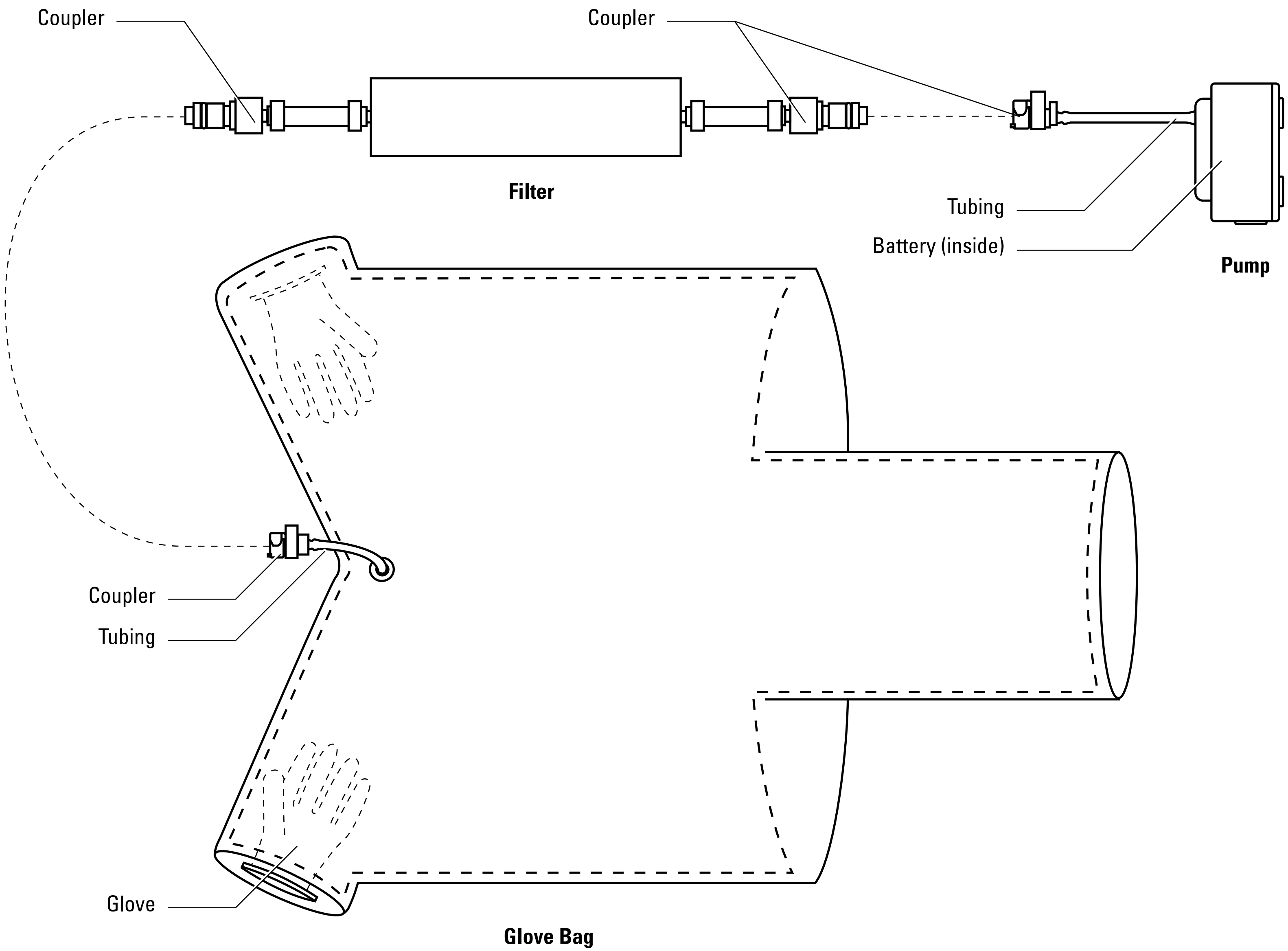
None

Hardware Publications

- *Life Sciences Laboratory Equipment (LSLE) On-line Catalog.* NASA, 1998. http://lifesci.arc.nasa.gov:100/lsle/.

Missions Flown 1991-1995

NASA/Mir Phase 1A/STS-71/STS-74


Coupler
Coupler
Filter
Tubing
Battery (inside)
Pump
Coupler
Tubing
Glove
Glove Bag

Hardware Description

The camcorder is a commercial 8-mm model. It has a two-thirds inch built-in Cathode Ray Tube (CRT) to act as a viewfinder or tape playback screen. The 8-mm tapes record both audio and video and run for 2 hours. Screw-on filters and wide conversion and teleconversion lenses can be added.

Along with standard features, the camera is equipped with a uni-directional microphone, a zoom lever with macro button, a focus ring and focus selector, a white balance selector to enable accurate recording of colors, a high speed shutter selector to properly capture fast-moving objects, a backlight compensation button, an AF/Zone Select button to provide automatic focusing within a selected zone in the viewfinder, and a counter memory button to enable locating the same scene for repeated viewing.

When used for filming the jellyfish experiment on SLS-1, the camcorder was mounted on a multiuse bracket assembly, which also held a jellyfish specimen flask at a fixed distance. This enabled accurate, steady focusing and filming of the movement of the jellyfish in microgravity.

Specifications

Dimensions: 4.8 x 5.4 x 10.2 inches
Weight: 1.2 kg
Power: 12 VDC battery pack

Data Acquisition

Video

Related Ground-Based Hardware

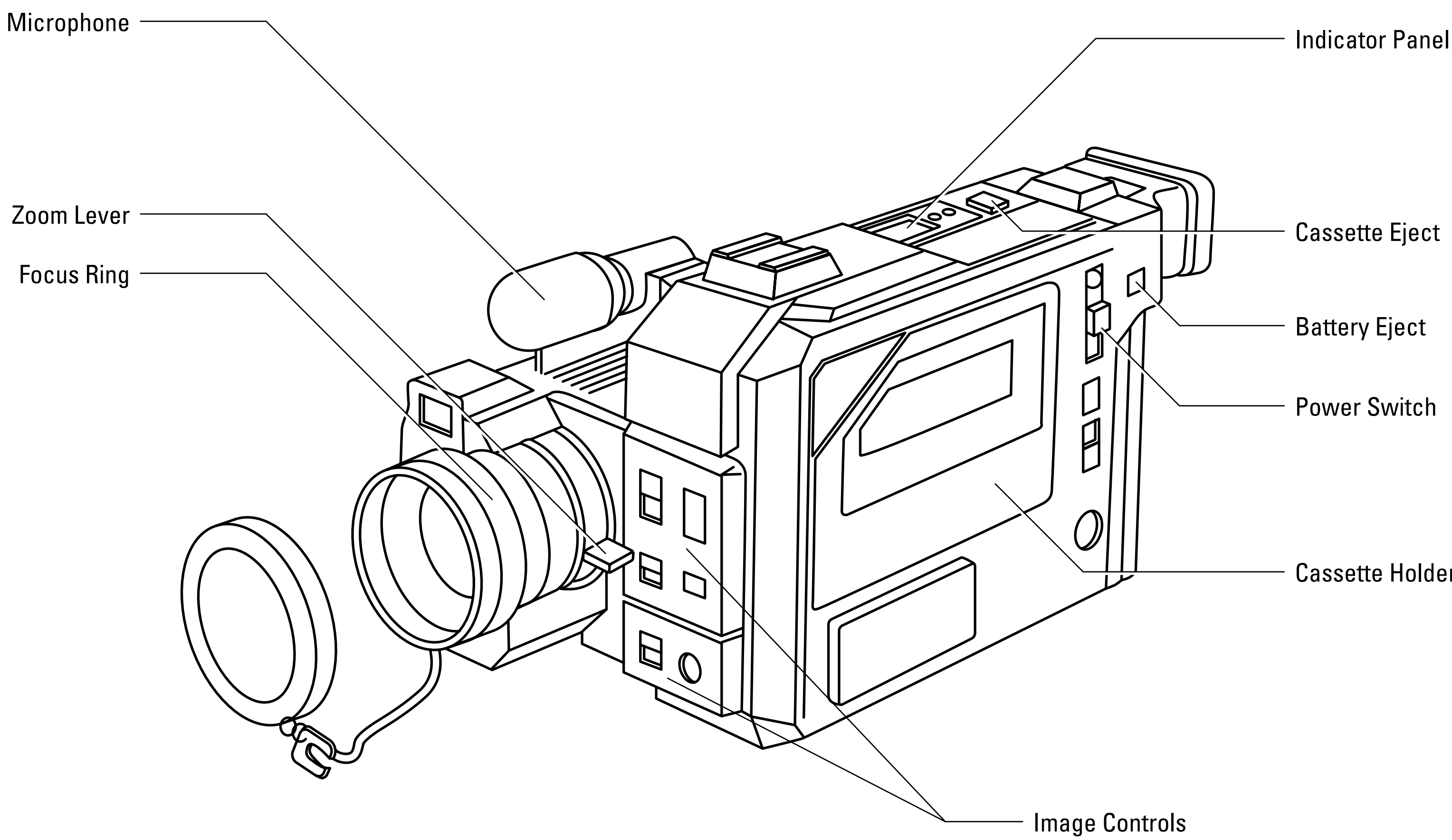
None

Hardware Publications

- Dalton, B.P., G. Jahns, J. Meylor, N. Hawes, T.N. Fast, and G. Zarow: *Spacelab Life Sciences-1 Final Report.* NASA TM-4706, August 1995, p. 10.

Missions Flown 1991-1995

SLS-1/STS-40


Microphone
Zoom Lever
Focus Ring
Indicator Panel
Cassette Eject
Battery Eject
Power Switch
Cassette Holder
Image Controls

Hardware Description

The Plant Growth Unit (PGU) is a self-contained system designed to support whole plant growth. The PGU occupies a single middeck locker and can be configured with either six Plant Growth Chambers (PGC) or five PGCs and the Atmospheric Exchange System (AES).

Subsystems

Plant Growth Chambers (PGC): The Plant Growth Chambers (PGCs) are the containers in which experiment subjects are grown. Each PGC consists of a Teflon-coated, anodized-aluminum base and Lexan cover secured to the base by four screws. A thermistor is inserted into the center of each base.

Atmospheric Exchange System (AES): The AES replaces one of the PGCs and circulates filtered air through four of the chambers.

Electrical System: The PGU operates on electrical power supplied by the Space Shuttle. When external power is interrupted, a non-rechargeable battery pack maintains power to the data acquisition electronics and tape recorder.

Temperature Control System: Temperature is controlled by heat from three PGU lamps and one strip heater as well as the flow of middeck cabin air through the unit. Temperature within each PGC is measured by a thermistor or temperature probe. The difference between the set point temperature and the average temperature is used by the control electronics to regulate the speed of the two cooling fans that circulate cabin air through the PGU. To maintain the desired temperature when the lamps are switched off, the strip heater is activated and the fans continue to run. The temperatures of the six PGCs and the ambient temperature are measured every 15 minutes and automatically recorded on the data tape.

Lighting System: Lamps are located within the interior of the PGU to simulate a day/night cycle (16 hours on, 8 hours off). The PGU lighting system consists of a bank of three fluorescent lamps containing Duratest Vitalite phosphor lenses, a reflector, an aluminum housing, and associated circuitry.

Data Acquisition System: Data formatting circuits arrange digitized temperature and light status signals into a serial form and data time tags in days, hours, and minutes. Data are recorded every 15 minutes on the tape recorder.

Specifications

Dimensions: 411 x 226 x 483 mm
Weight: 67 lbs
Power: 28 VDC

Data Acquisition

Temperature, lights on/off

Related Ground-Based Hardware

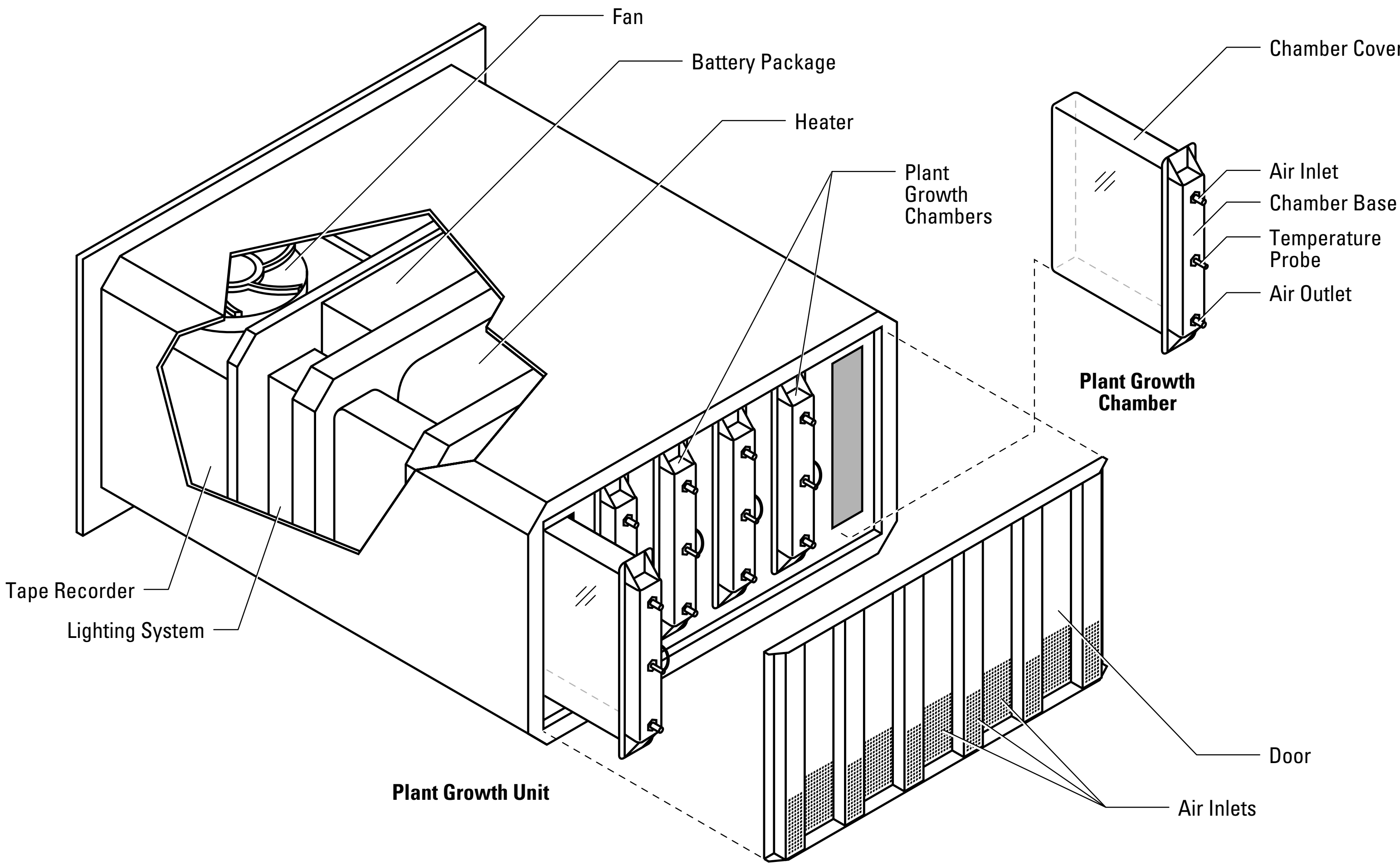
None

Hardware Publications

None

Missions Flown 1991-1995

CHROMEX-01/STS-29 (1989), CHROMEX-02/STS-41 (1990), CHROMEX-03/STS-54, CHROMEX-04/STS-51, CHROMEX-05/STS-68, CHROMEX-06/STS-63


Fan
Battery Package
Heater
Plant
Growth
Chambers
Chamber Cover
Air Inlet
Chamber Base
Temperature
Probe
Air Outlet
Plant Growth
Chamber
Tape Recorder
Lighting System
Plant Growth Unit
Door
Air Inlets

Hardware Description

The Atmospheric Exchange System (AES) replaces one of six standard Plant Growth Chambers in the Plant Growth Unit (PGU) and circulates filtered cabin air by means of a pump through four of the chambers. The fifth serves as a control chamber with no air flow. An alarm circuit is triggered when there is inadequate flow through the AES or low voltage to the primary circuit. A built-in passive radiation dosimeter collects data on the radiation environment of the PGU.

Subsystems

Filter Cartridge: The AES filter cartridge contains absorbents within a stainless steel tube. The cartridge passively regulates CO_2 by flowing the air stream over a lithium hydroxide (LiOH) bed. Some air can bypass this bed via the bypass tube, where no CO_2 is removed. The flow rate is variable from 0 to 20 L per hour. The desired flow split, and therefore the desired CO_2 concentration, is obtained by installing a variable restriction orifice in the bypass line. The total air stream subsequently passes through a trace contaminant control bed consisting of Zeolite, activated carbon, and Purafil. Porous metal discs are used for bed retention and separation, with the inlet disc providing dust filtration.

Specifications

Dimensions: 6 x 22 x 22.5 mm
Weight: 3 lbs
Power: 12 VDC

Data Acquisition

Radiation dosimeter

Related Ground-Based Hardware

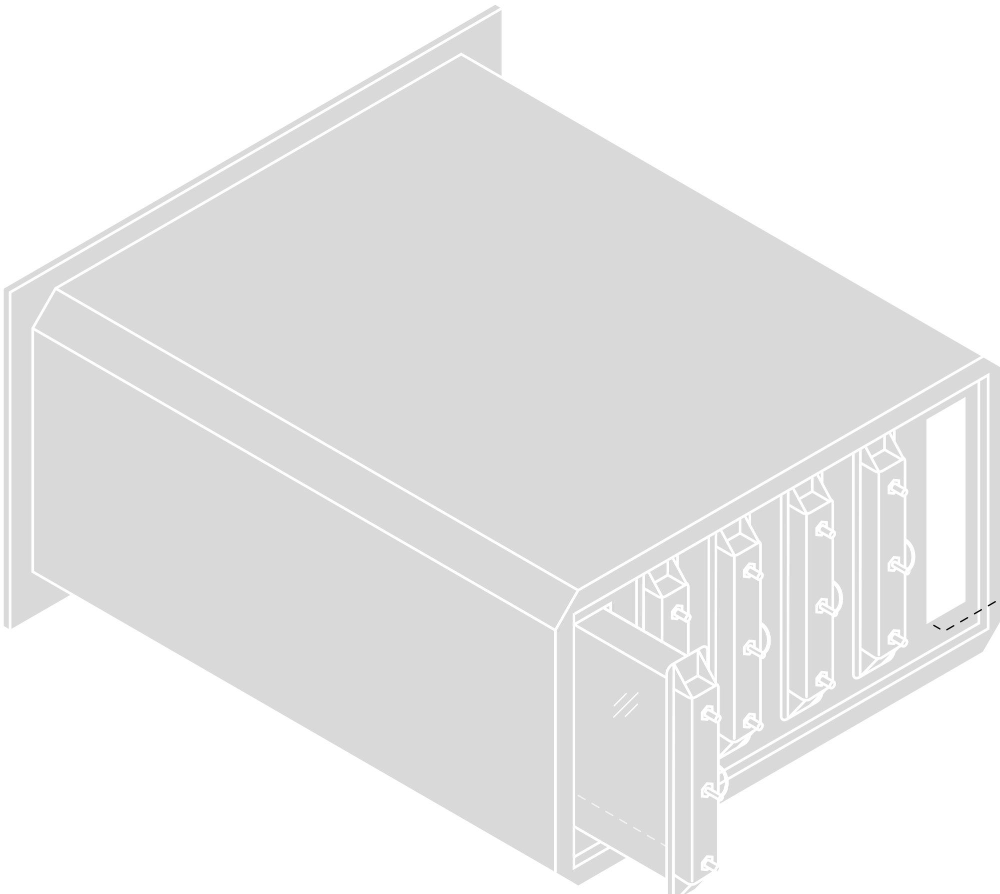
None

Hardware Publications

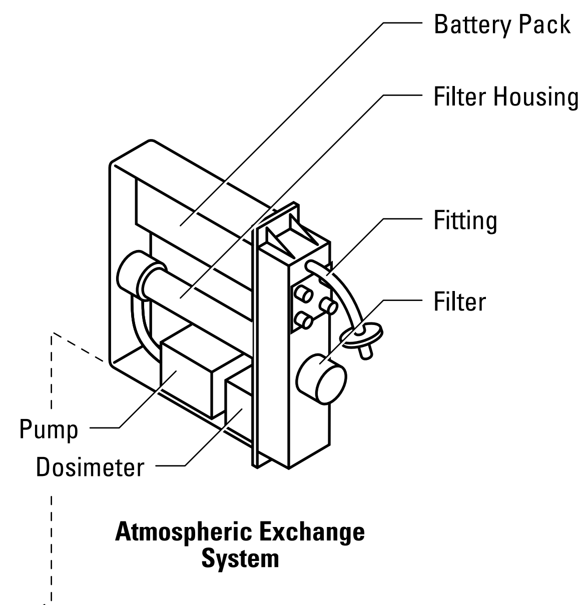
None

Missions Flown 1991-1995

CHROMEX-01/STS-29 (1989), CHROMEX-02/STS-41 (1990), CHROMEX-05/STS-68



Plant Growth Unit



Atmospheric Exchange System

Hardware Description

The Refrigerator/Incubator Module (R/IM) is a temperature-controlled holding unit flown in the Shuttle middeck. It can be used in place of a standard middeck stowage locker or mounted to the Spacelab Middeck Experiment rack.

The R/IM uses a solid-state heat pump to maintain a cooled or heated internal environment. A fan circulates cabin air through the heat pump/heat sink and is exhausted through ducts in the top and bottom surfaces of the unit's outer shell. Air is not circulated within the internal cavity. A vent valve on the front door automatically controls internal pressure. To accommodate experiments, rail guides and fasteners are provided as a means of mounting up to six shelves of experiment hardware. The interior of the R/IM is divided into two holding cavities.

Specifications

Dimensions: 46 x 47.6 x 27.3 cm
Weight: 19.35 kg
Power: 84 W @ 28 ± 4 VDC

Data Acquisition

None

Related Ground-Based Hardware

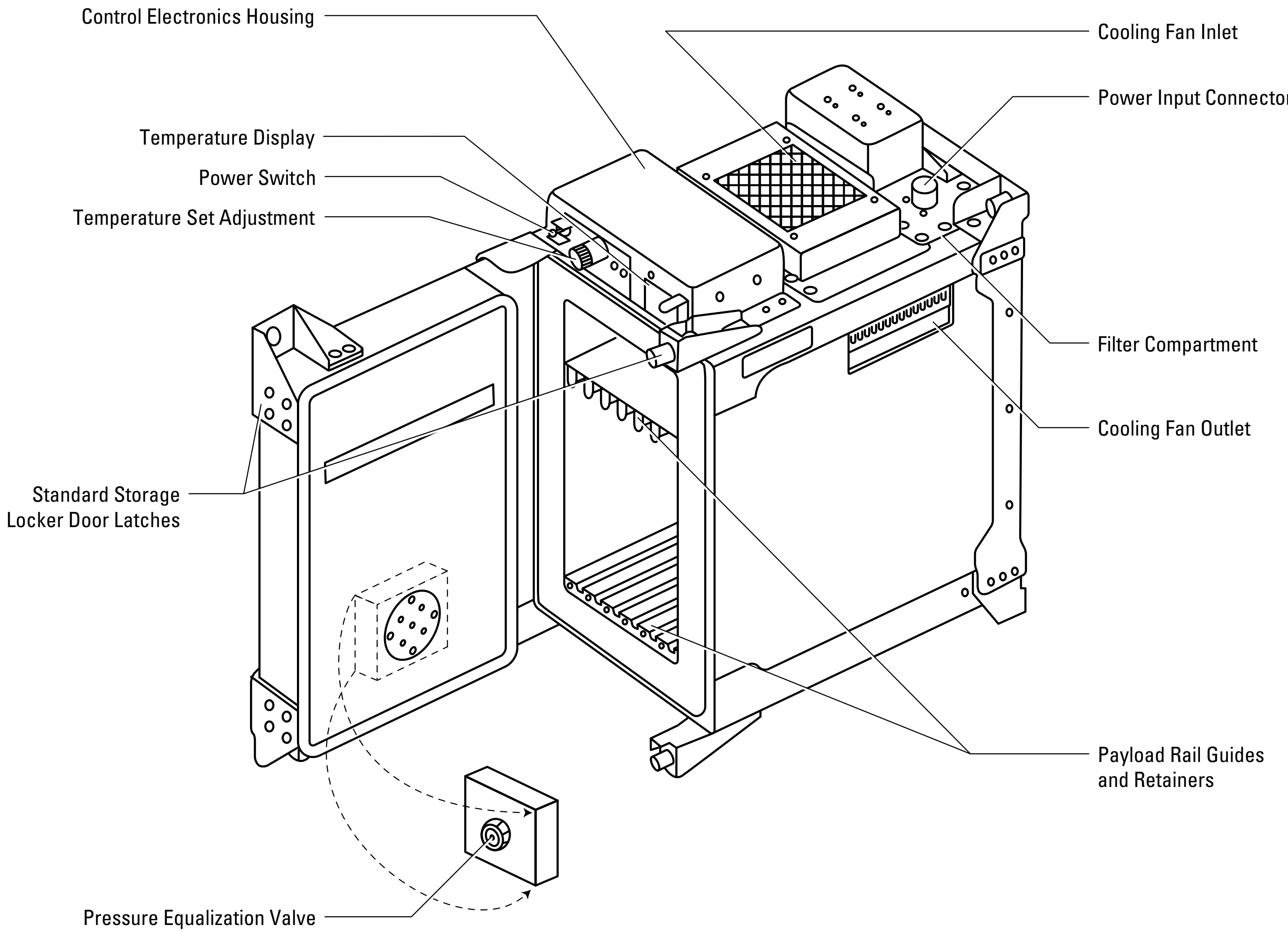
None

Hardware Publications

- Bugg, C.E.: *Protein Crystal Growth.* NASA TM-4353, February 1992, pp. 219–224.

Missions Flown 1991-1995

SLS-1/STS-40, IML-2/STS-65, PHCF/STS-46, SL-J/STS-47



Control Electronics Housing
Cooling Fan Inlet
Power Input Connector
Temperature Display
Power Switch
Temperature Set Adjustment
Filter Compartment
Cooling Fan Outlet
Standard Storage Locker Door Latches
Payload Rail Guides and Retainers
Pressure Equalization Valve

Hardware Description

The Research Animal Holding Facility (RAHF) is an animal habitat for general use within the Spacelab. Animal-specific cages are inserted, as needed, to provide appropriate life support for rodents. Cages can be removed from the RAHF to allow inflight experiment procedures to be conducted.

Subsystems

Rodent Cage: The Rodent Cage Module contains 12 cage assemblies, with each cage housing two rats separated by an internal divider for a total capacity of 24 rats. The cages are removable inflight for transfer to a General Purpose Work Station using the General Purpose Transfer Unit to maintain particulate containment.

Environmental Control System (ECS): The ECS controls temperature and air circulation within the cages and contributes a level of odor and particulate containment to the RAHF system.

Feeding/Waste Management Systems: Rodent food bars are supplied automatically on a demand basis. Directed airflow continuously draws liquid and solid wastes into a waste tray at the bottom of each animal cage where bacterial growth is controlled and odors are neutralized.

Water System: The Water System provides pressurized water via lixits to the rats, while measuring the quantity of water delivered.

Inflight Refill Unit (IRU): For SLS-2, the IRU is used to obtain and transport water from the orbiter middeck galley to the RAHF Water System.

Lighting System: Rat cage illumination is provided on a 12:12 day/night cycle. Each cage lamp provides approximately 2.1 lumens of light at cage floor level. The light cycle for each quadrant of cage assemblies (four cages) can be independently controlled, manually or via an adjustable timer.

Data System: The Data System collects three types of data. Temperature, humidity, water pressure, and air pressure across ECS fans (air flow) are collected as Analog data. Heating, cooling, lighting, and a drinking water out of limit condition are collected as Discrete data. Water delivery and activity are collected as Pulse-code Modulated data. All data are passed to the Spacelab data system for display, recording, and downlink to the ground. Data displayed on board include environmental status, water consumption, and activity. A special subset of data is routed to launch control center computers for display during late access loading and until launch.

Specifications

Dimensions: Occupies 1 Spacelab double rack
Weight: 280 kg (616 lbs)
Power: 324 W, continuous operation (maximum thermal load); 850 BTU/hr
Capacity: 24 Rodents

Data Acquisition

Analog: temperatures, relative humidity, water tank pressure, fan pressure rise; Discrete: heating, cooling, lighting, drinking water out-of-limit; Pulse-code modulated: water consumption, activity

Related Ground-Based Hardware

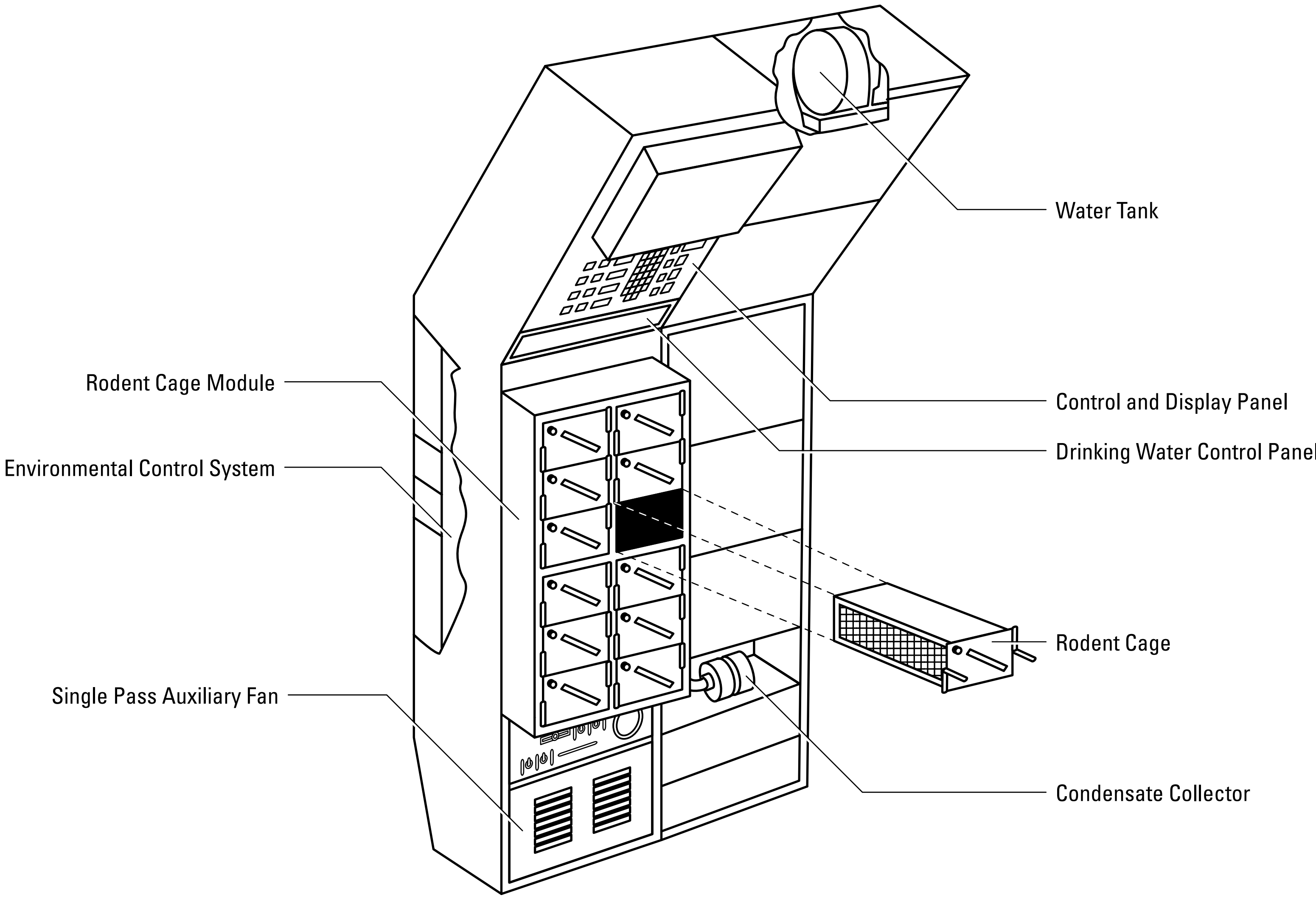
Ground Data System: Computers and associated peripherals are used to acquire, process, store, and monitor data coming from the RAHF during ground testing.

Hardware Publications

- Dalton, B.P., G. Jahns, J. Meylor, N. Hawes, T.N. Fast, and G. Zarow: *Spacelab Life Sciences-1 Final Report.* NASA TM-4706, August 1995.
- Savage, P.D., M.L. Hines, and R. Barnes: *An Inflight Refill Unit for Replenishing Research Animal Drinking Water.* NASA TM-4684, 1995.

Missions Flown 1991-1995

SLS-1/STS-40, SLS-2/STS-58


Water Tank
Rodent Cage Module
Control and Display Panel
Drinking Water Control Panel
Environmental Control System
Rodent Cage
Single Pass Auxiliary Fan
Condensate Collector

Hardware Description

The RAHF Environmental Control System (ECS) is mounted on the back of the cage module to circulate conditioned air through the cages. Air temperature is controlled. Carbon dioxide is removed and oxygen replenished by exchange of air with the Spacelab.

Subsystems

Air Circulation: Two propeller fans pull cabin air from the RAHF cage module and return a portion of the circulating air to the cabin through a filter and a charcoal bed, which removes odors and particulate matter. These two filters bacteriologically isolate the animals and crew and ensure that the RAHF maintains a slightly negative pressure with respect to the cabin. Air within the RAHF is circulated by a cluster of four propeller fans. To ensure containment of free-floating particulates, the Single Pass Auxiliary Fan maintains negative pressure within the RAHF when a cage is removed.

Temperature Control: The RAHF uses a bang-bang type electronic system with a controllable set point to modulate Thermo-electric Units (TEUs) and fans for cooling and electric resistance elements for heating to provide temperature control. Fans direct bypass air through the cold side of a Pelita-type TEU to cool cage module air, which is remixed with circulating air prior to return to the cages. The Spacelab experiment cooling loop provides a heat sink for the TEU. Water condensing on the TEU is guided by a hydrophilic coating and capillary action to the trailing edges of the TEU cooling fans in the aircore. Water, with some air, is sucked from the trailing edge of the aircore and pumped by a water separator into a condensate collector bottle, which is changed out by the crew as required. A thermoswitch located on the inlet water header of the TEU shuts down the TEU in case of loss of Spacelab cooling water flow and subsequent TEU overheating. The air is warmed, as necessary, by a heater located in the main circulation airflow stream.

The RAHF is equipped with its own auxiliary pump, since the Spacelab coolant circulating pump is not on prior to and during launch or during descent. The auxiliary pump is connected to the ECS system to provide cooling during these periods.

Specifications

Dimensions: N/A
Weight: N/A
Power: Varies depending on load between 30 to approx. 300 W
Temperature Range: 20 to 29 °C
Humidity Range: 30% to 70% RH, not directly controlled
Max CO_2 Partial Pressure: 0.2%, not directly controlled
Min O_2 Partial Pressure: 20%, not directly controlled
Cage Air Flow: Average 6.5 CFM

Data Acquisition

Analog: air temperatures, cooling water temperature, relative humidity, fan pressure rise; Discrete: heating, cooling; Pulse-code modulated: water consumption, activity

Related Ground-Based Hardware

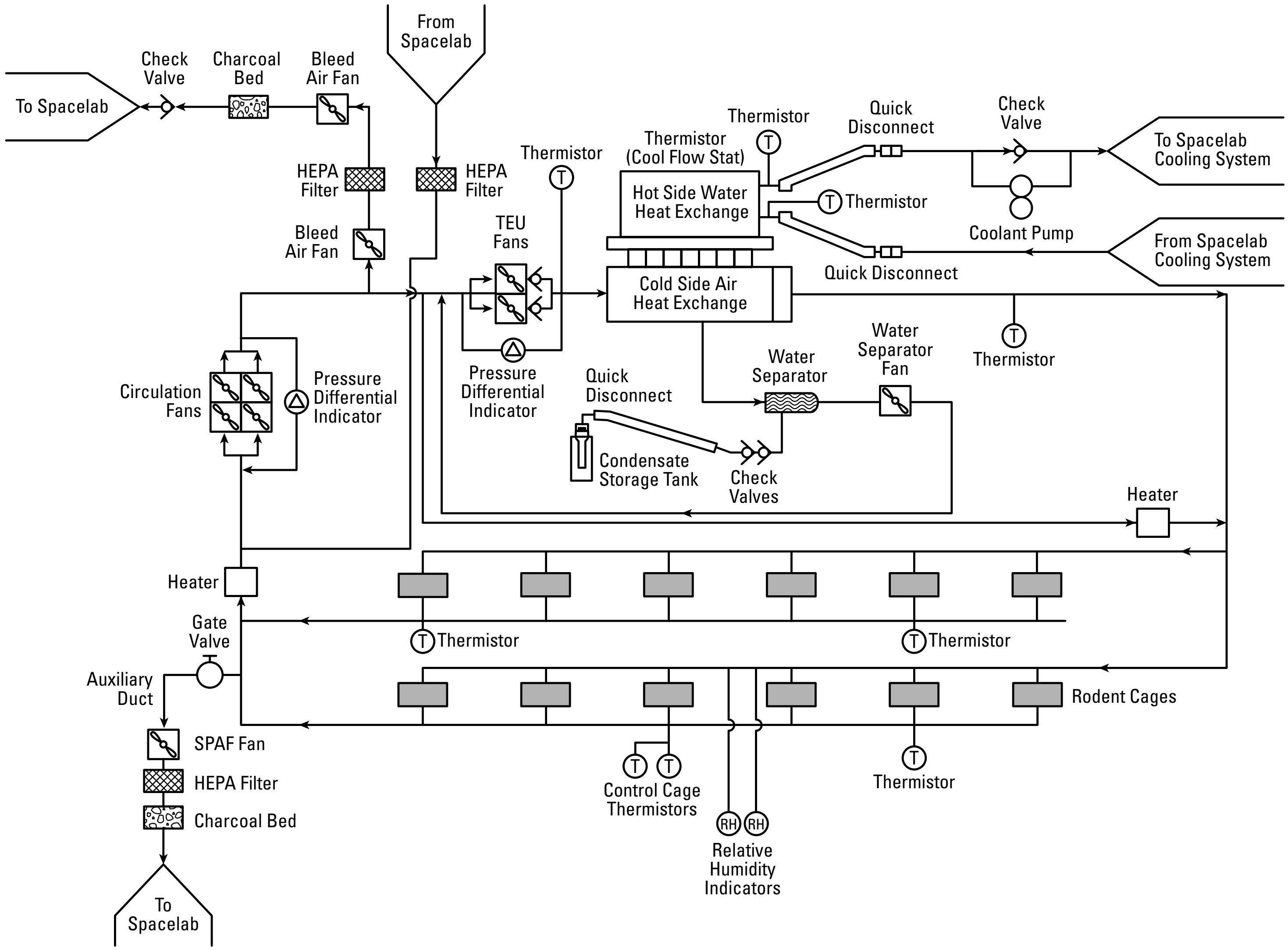
None

Hardware Publications

None

Missions Flown 1991-1995

SLS-1/STS-40, SLS-2/STS-58


From Spacelab
To Spacelab
Check Valve
Charcoal Bed
Bleed Air Fan
HEPA Filter
HEPA Filter
Bleed Air Fan
Thermistor
Thermistor (Cool Flow Stat)
Thermistor
Quick Disconnect
Check Valve
To Spacelab Cooling System
Hot Side Water Heat Exchange
Thermistor
Coolant Pump
From Spacelab Cooling System
TEU Fans
Quick Disconnect
Cold Side Air Heat Exchange
Circulation Fans
Pressure Differential Indicator
Pressure Differential Indicator
Quick Disconnect
Water Separator
Water Separator Fan
Thermistor
Condensate Storage Tank
Check Valves
Heater
Heater
Gate Valve
Thermistor
Thermistor
Auxiliary Duct
Rodent Cages
SPAF Fan
HEPA Filter
Charcoal Bed
Control Cage Thermistors
Thermistor
RH
RH
Relative Humidity Indicators
To Spacelab

Hardware Description

Rodent Feeder: Rodent food is supplied *ad libitum* in the form of a rectangular diet bar mounted in the feeder. The bars are advanced into the feeder alcove as one is consumed by the rat. The removable feeder cassette contains two food bars, one servicing the forward cage, the other servicing the back cage. The crew changes the food bars by removing and replacing the feeder cassette without removing the animals or cages. On a scheduled basis, the crew measures food consumption using built-in measurement tapes.

Waste Management: A waste collection tray is attached by slides to the bottom of each cage. For missions longer than 10 days, trays may be changed without removing cages from the cage module. Airflow through the top of the cage directs waste products into the waste trays.

The course grid of the cage floor allows animal debris to pass into the waste tray. Below this grid, a feces tray screen traps feces, and urine is trapped by an absorbent Bondina filter located immediately below the feces tray grid. This filter is treated with phosphoric acid to reduce urine pH, thus inhibiting the production of ammonia from the decomposition of urine. Below the absorbent filter is a fibre pad layer into which is bonded charcoal dust. Below the charcoal pad is a Filtrete layer, formed with polypropylene, that serves as a hydrophobic barrier, followed by a final 150-micron stainless-steel mesh. Feces and urine are also dried by recirculating airflow to inhibit decomposition.

Specifications

Dimensions: 0.9 x 1.187 x 16 inches (foodbar)
Weight: 350 g (foodbar)
Power: N/A

Data Acquisition

Food consumption

Related Ground-Based Hardware

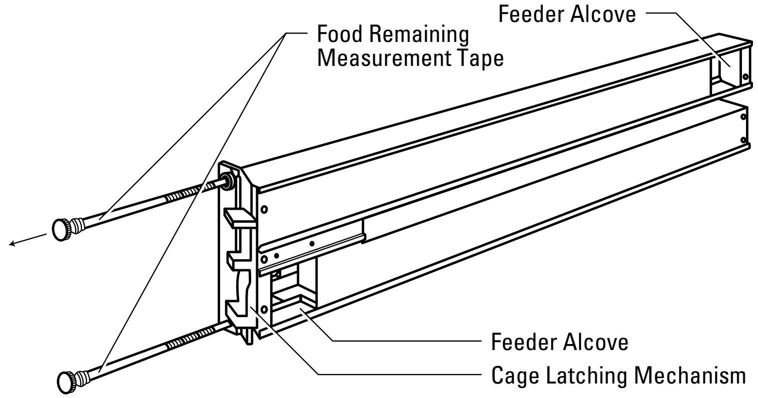
None

Hardware Publications

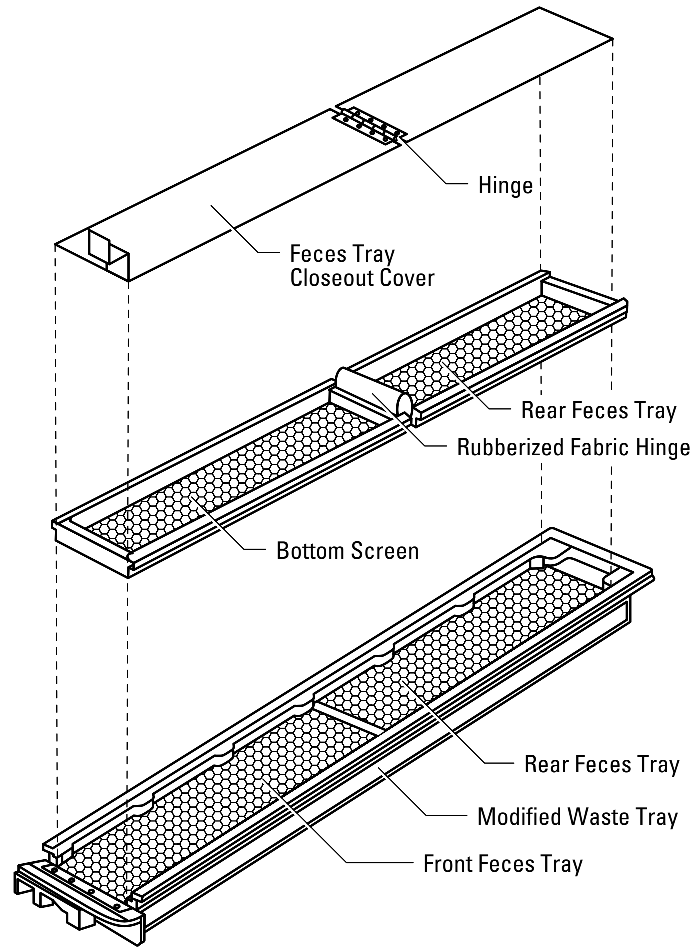
None

Missions Flown 1991-1995

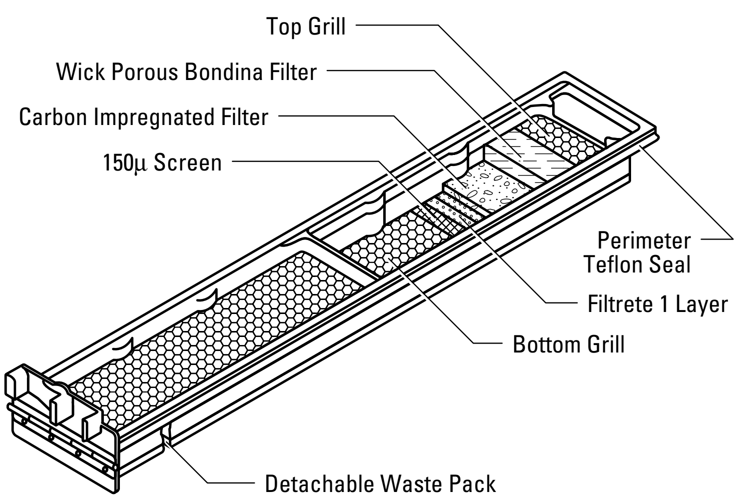
SLS-1/STS-40, SLS-2/STS-58



Rodent Cage Feeder Assembly



Waste Tray with Closeout Cover



Rodent Cage Waste Tray Filtration

Hardware Description

If necessary, refill water for the Research Animal Holding Facility (RAHF) drinking water system is obtained from the orbiter middeck galley using the Inflight Refill Unit (IRU) for transport to the Spacelab. Excess water is disposed of through the Middeck Waste Collections System. The IRU consists of two major subsystems: the Fluid Pumping Unit and the Collapsible Water Reservoir. A tether for the IRU is provided to meet Shuttle safety requirements.

Subsystems

Fluid Pumping Unit (FPU): The FPU is contained within a Nomex cloth pouch for ease in storage and transport. It is composed of the pump/motor, piping, sensors, and supporting structure required to pump water through the IRU system. The FPU's positive displacement pump contains an integral motor designed for continuous operation. A motor drive control governs pump speed by regulating the motor input voltage. A current limiting device is also provided. Power is not required when filling the system but is required at the RAHF when transferring water to the water tank and when disposing of excess water. Two counters are provided that mechanically indicate the number of liters of water pumped (resettable) and total liters pumped (not resettable).

Collapsible Water Reservoir (CWR): The CWR, also contained within a Nomex cloth, is a flexible, stowable bag, which contains the water for transfer. The main body is constructed of two layers. The inner bladder is made from a polyether polyurethane material compatible with potable water and the outer bladder is made of a Kevlar reinforced urethane to provide pressure holding capability and to provide protection against accidental cuts and tears. A panel of urethane is attached to both sides of the CWR to limit its expanded height. A thermoplastic hose with a quick disconnect mates with the FPU.

Hose/Adapter Accessories: An adapter is provided to enable the dumping of excess water into the orbiter Waste Collection System with a quick disconnect at the IRU end and a twist lock connection to the waste system.

Specifications

Dimensions: 15 x 10 x 12 inches
Weight: 30 lbs dry
Power: 28 VDC: 90 W (only required during RAHF fill)
Pumping Capacity: 1.8 L per minute
Holding Capacity: 6 L, maximum pressure of 20 psi

Data Acquisition

None

Related Ground-Based Hardware

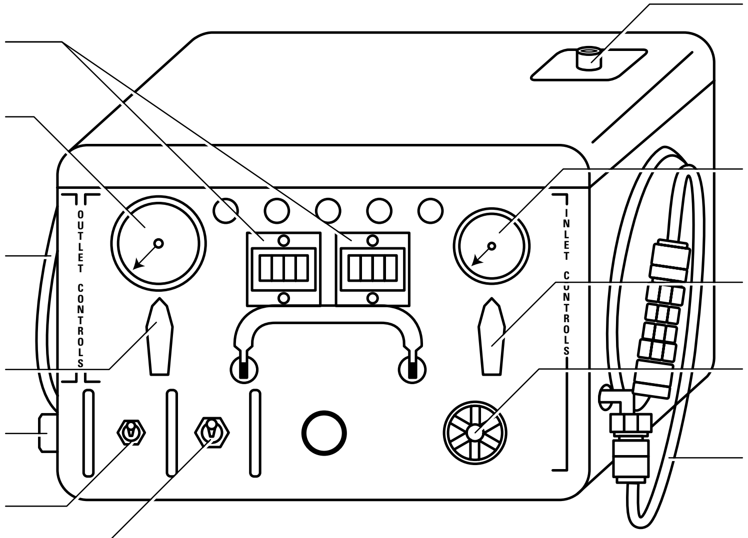
None

Hardware Publications

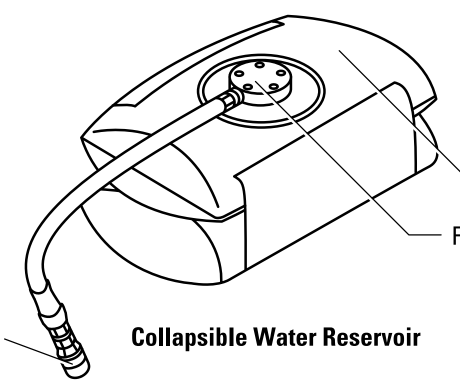
- Savage, P.D., M.L. Hines, and R. Barnes: *An Inflight Refill Unit for Replenishing Research Animal Drinking Water.* NASA TM-4684, 1995.

Missions Flown 1991-1995

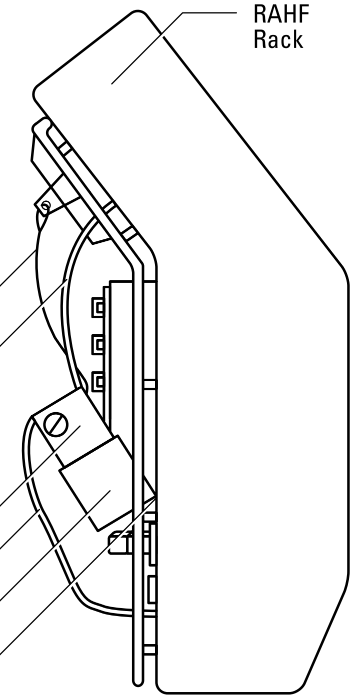
SLS-2/STS-58



Fluid Pumping Unit



Collapsible Water Reservoir



Tethered Configuration

Hardware Description

Each rodent cage houses two rats. Cages are constructed of anodized aluminum side and rear walls, perforated metal floors, and screened-top doors to permit air circulation (top to bottom). Rodent cages are designed with a polycarbonate front window backed with a stainless mesh to keep rodents from rubbing against the window. The cages have a stainless steel mesh partition creating two compartments, one for each rat. Both front and back rats may be viewed by opening a front cover.

Cage tops are hinged to allow access to the animals. Each cage also contains a feeder and a waste tray to contain urine and feces (see separate records). Each rat cage contains activity monitors to record general movement using an infrared light source and sensor. Each time an animal breaks the light beam, a counter automatically advances one count. These signals are recorded and periodically transmitted to the ground to ensure animal well-being.

Specifications

Dimensions: 10.5 x 11.5 x 28 cm/compartment
Weight: 5.63 kg (w/feeder)
Power: Approx 0.1 W/cage for Activity Monitor
Capacity: 2 rodents

Data Acquisition

Activity

Related Ground-Based Hardware

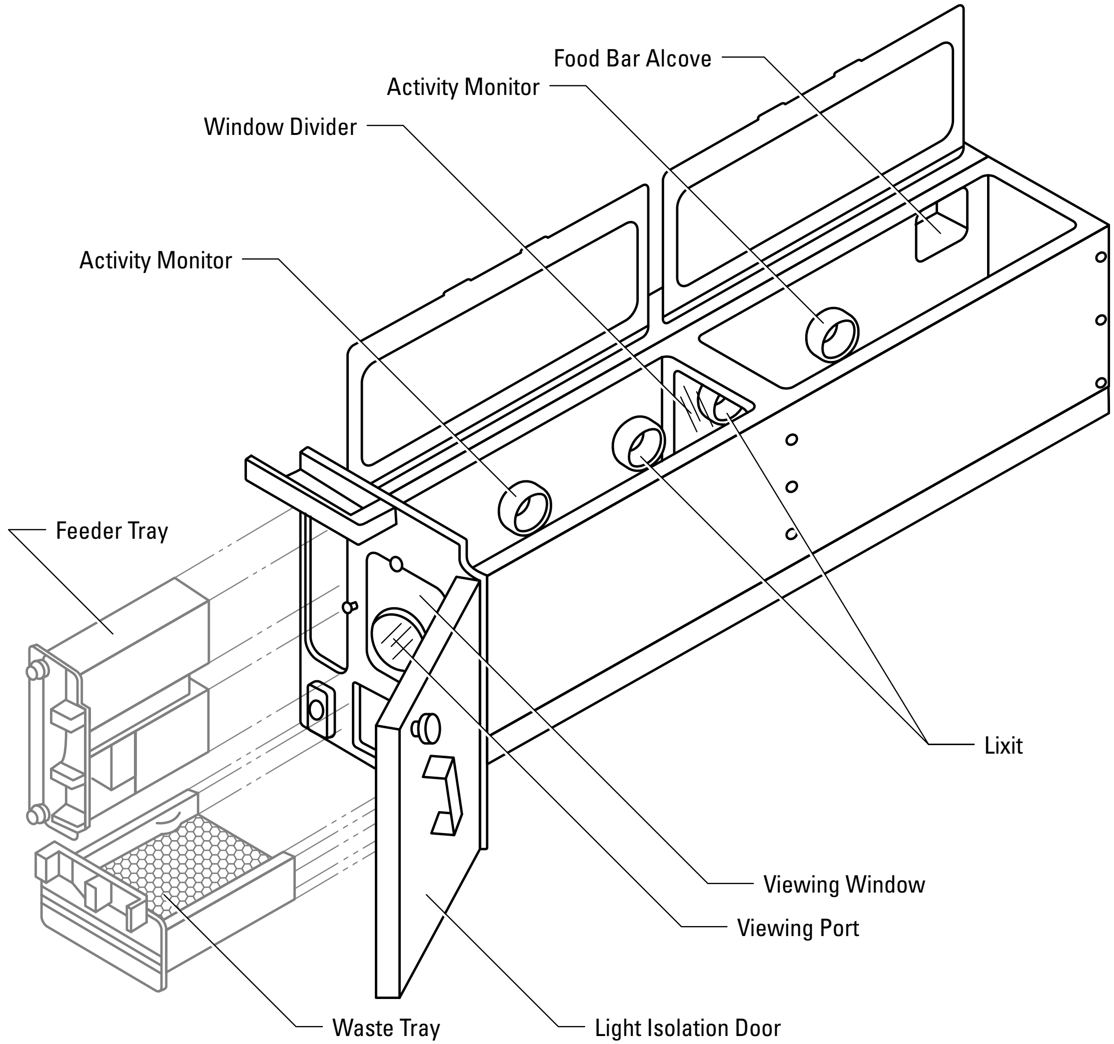
Cage Airflow Checkout Fixture: The system is used to measure air pressure drop across a rodent RAHF cage at a specified airflow rate.

Hardware Publications

- Corbin, B.J., L.A. Baer, R.E. Grindeland, and M. Vasques: Developmental Testing of the Advanced Animal Habitat to Determine Compatibility with Rats and Mice. *Journal of Gravitational Physiology*, vol. 2(1), 1995, pp. P141–P142.

Missions Flown 1991-1995

SLS-1/STS-40, SLS-2/STS-58


Food Bar Alcove
Activity Monitor
Window Divider
Activity Monitor
Feeder Tray
Lixit
Viewing Window
Viewing Port
Waste Tray
Light Isolation Door

Hardware Description

The RAHF *ad libitum* watering system consists of a pressurized bladder tank, pressure regulator, water delivery system, and water consumption counters. The delivery system includes 24 sets of solenoids, pressure switches, and accumulators that deliver aliquots of water to lixit valves in the cages for the animals.

Subsystems

Self-Pressurized Bladder Tank: A two-camber gas side pressure tank maintains water system pressure and provides the force to move water from the drinking water tank through the system to the cage. As water is used, a flexible diaphragm collapses across the water volume while the gas side expands. The quantity of the water remaining in the tank is monitored via a water pressure transducer.

Pressure Regulator: A pressure regulator maintains downstream water pressure to the drinking water manifold.

Drinking Water Manifold: Water flows in the manifold assembly and via a solenoid into a 0.5-ml accumulator. When consumption reduces accumulator pressure sufficiently, a pressure switch initiates a refill of the accumulator. When water pressure in the accumulator rises sufficiently, a high pressure switch stops water flow until the next consumption-initiated cycle. A count is registered and sent to the data system each time this cycle is carried out. If there is a loss of electrical power or a failure of a solenoid valve or pressure switch, water can be made available to the cage by manually pulling out a small knob on the affected valve. In this mode, water is made available to the cage but no electrical signals indicate water consumption.

Lixit Valves: A lixit provides a “water ball” in the cage, which is replenished as the animal tongues the spigot. Lixits are mounted on a service bar located within the cage side wall.

Version Modifications: For SLS-1, water delivered from the tank was forced through an iodinator, an iodine charged resin bed, to provide nominal iodine levels to ensure water was uncontaminated. An additional valve was added in order to bypass the pressure regulator in the event of a malfunction. Also, a valve was added for drain and fill operations.

For SLS-2, the iodinator was removed due to drying and flaking of the bed and subsequent contamination of the water. In this case, iodine is manually added to the drinking water before being pumped into the water tank.

Specifications

Dimensions: N/A
Weight: N/A
Power: Approx 12 W/activated solenoid plus portion of data system power
Water Capacity: 9.5 l

Data Acquisition

Water consumption

Related Ground-Based Hardware

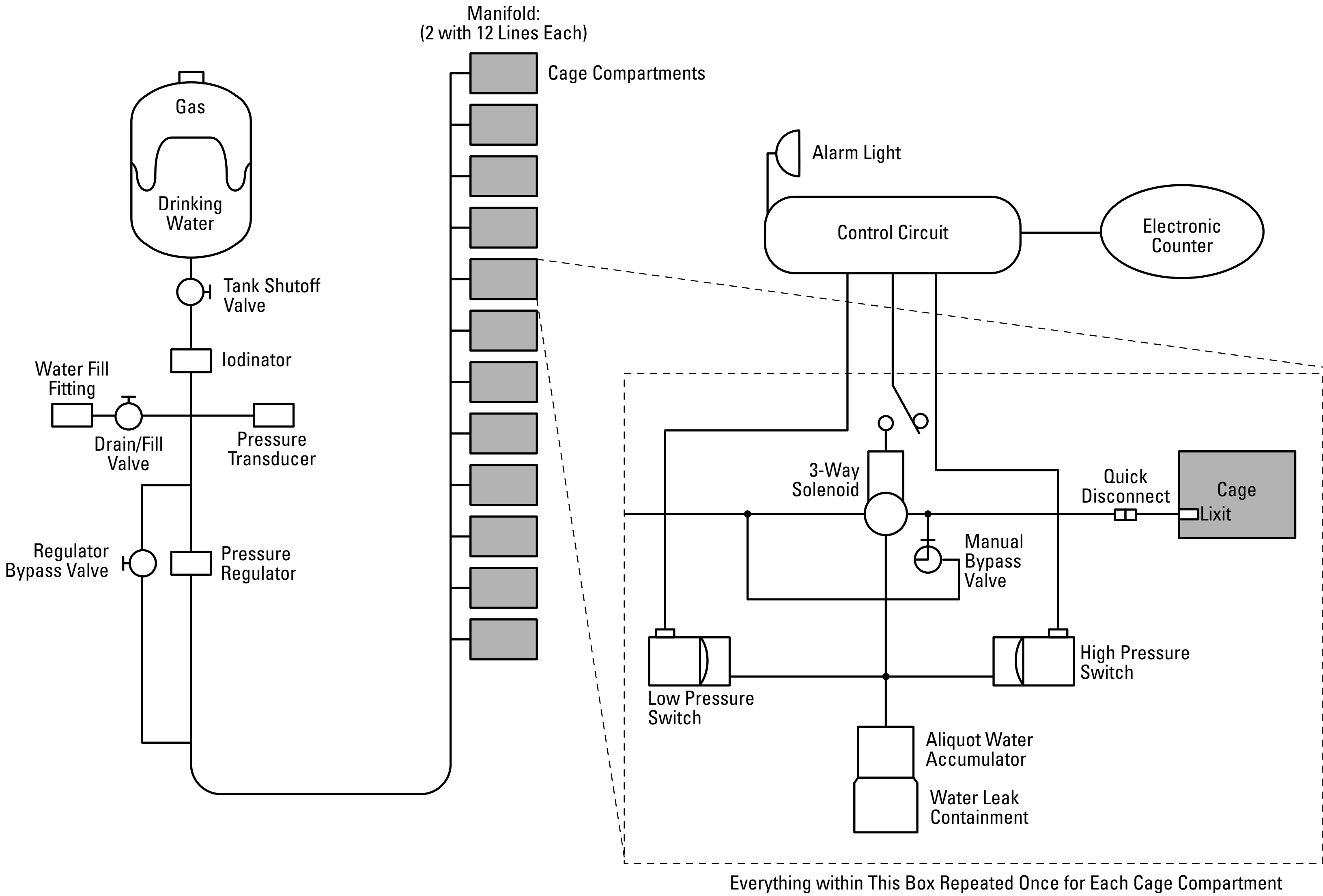
Fill and Bleed Cart: The cart is used to fill, drain, and dry, and bleed air from the RAHF drinking water system on the ground prior to use of the system.

Hardware Publications

- Dalton, B.P., G. Jahns, J. Meylor, N. Hawes, T.N. Fast, and G. Zarow: *Spacelab Life Sciences-1 Final Report.* NASA TM-4706, August 1995.

Missions Flown 1991-1995

SLS-1/STS-40, SLS-2/STS-58


Manifold:
(2 with 12 Lines Each)
Cage Compartments
Gas
Drinking Water
Tank Shutoff Valve
Iodinator
Water Fill Fitting
Drain/Fill Valve
Pressure Transducer
Regulator Bypass Valve
Pressure Regulator
Alarm Light
Control Circuit
Electronic Counter
3-Way Solenoid
Quick Disconnect
Cage
Lixit
Manual Bypass Valve
Low Pressure Switch
High Pressure Switch
Aliquot Water Accumulator
Water Leak Containment
Everything within This Box Repeated Once for Each Cage Compartment

Hardware Description

The Small Mass Measurement Instrument (SMMI) is designed to measure the weight of biological samples and small specimens from 1 to 10000 g in a microgravity environment. It can be integrated into a standard Spacelab single rack or on one side of a double rack. The SMMI determines the weight of a specimen through the use of its mass properties, thereby minimizing the influence of any gravity field.

Mass measurements can be obtained when the specimen is placed on the tray assembly and restrained with the perforated rubber cover to minimize relative motion. The measurement process begins with the semi-automatic release of the specimen and tray assembly from an offset position, so that they oscillate mechanically. A set of plate fulcra springs support the tray assembly and provide the oscillatory forces for motion. The zero crossover detection assembly precisely measures the period of oscillation, which is a function of the mass of the tray assembly, specimen, and part of the plate fulcra springs. The measurement process ends with the semi-automatic recapture of the specimen and tray assembly and return to its original offset position. The SMMI controller then calculates and displays a mass value for the specimen. A set of 12 stackable calibration weights are provided with each instrument.

In addition to the calibration and measurement modes, multiple non-standard diagnostic functions are available, such as inspection of calibration values stored in memory, inspection of equations used to calculate the specimen weight, testing of the oscillation function of the tray assembly, and an option to display period-of-oscillation measurements in seconds.

Specifications

Dimensions: 31 x 48 x 46 cm
Weight: 17 kg
Calibration Masses: 1.3 kg
Power: 15 W
Range/Accuracy: 25 g – 2 kg ± 0.5 g
2–10 kg ± 5 g

Data Acquisition

Mass of Specimen

Related Ground-Based Hardware

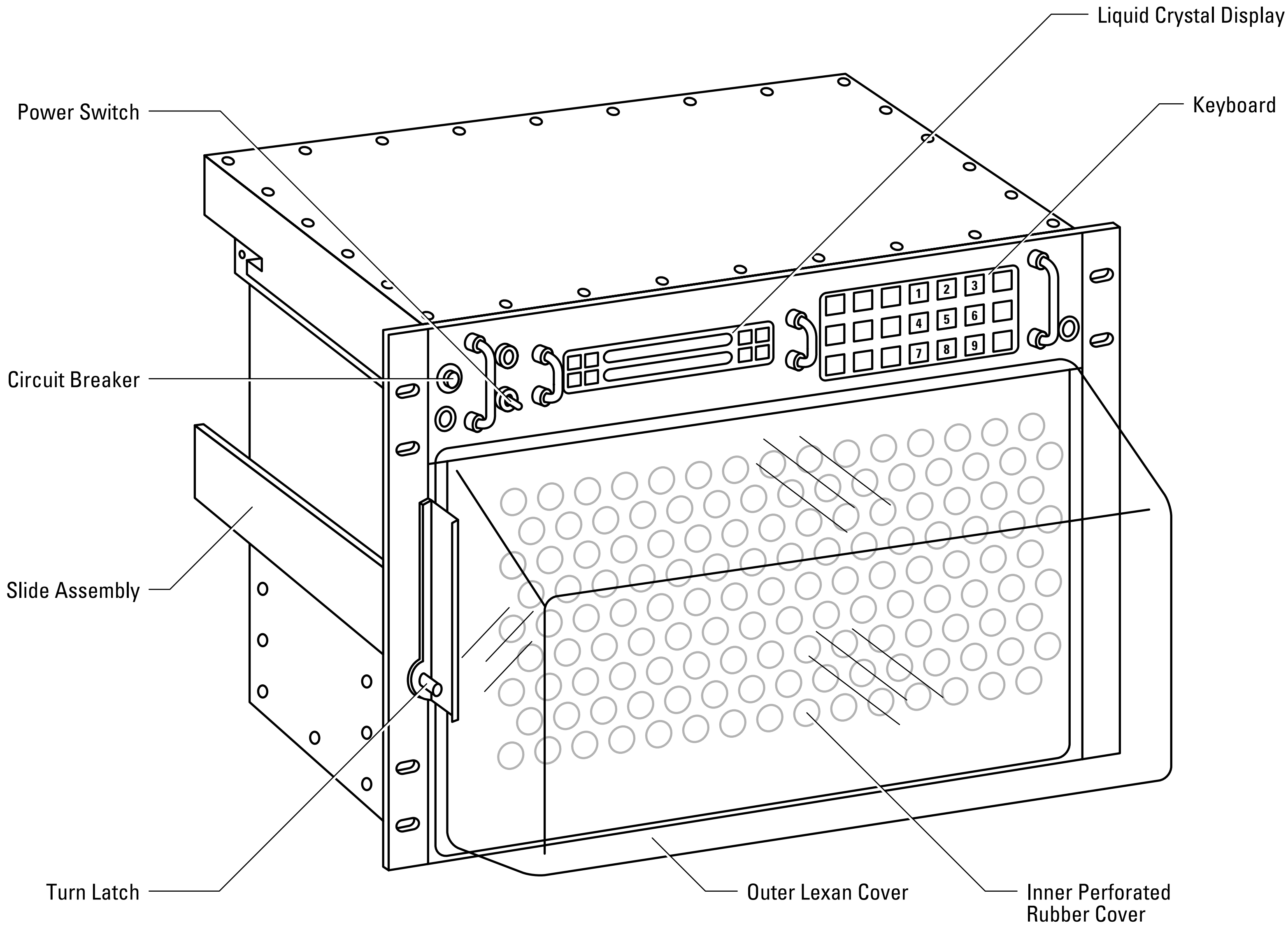
None

Hardware Publications

- Dalton, B.P., G. Jahns, J. Meylor, N. Hawes, T.N. Fast, and G. Zarow: *Spacelab Life Sciences-1 Final Report.* NASA TM-4706, August 1995.
- *Life Sciences Laboratory Equipment (LSLE) On-line Catalog.* NASA, 1998. http://lifesci.arc.nasa.gov:100/lsle/.

Missions Flown 1991-1995

SLS-1/STS-40, SLS-2/STS-58


Liquid Crystal Display
Keyboard
Power Switch
Circuit Breaker
Slide Assembly
Turn Latch
Outer Lexan Cover
Inner Perforated Rubber Cover
1
2
3
4
5
6
7
8
9

Hardware Description

The Space Tissue Loss-A (STL-A) Module, currently renamed the Cell Culture Module (CCM), is a completely automated cell culture facility designed specifically to aid in the study of microgravity effects at the cellular and embryonic levels. The entire hardware unit fits inside a Shuttle middeck locker. The system offers a variety of biological sample maintenance systems, variable temperature settings, options for media delivery and collection of conditioned media samples, and programmed additions of drugs, hormones, radioactive labels, and other experiment requirements.

Subsystems

Biological Samples: The STL-A has space for four separate experiments, each housed in a separate module, or Bioreactor Rail Assembly. The rails hold a variable number of bioreactor cartridges, which are inlaid with hollow fibers to provide an exchange surface for nutrient media, gas, and the removal of waste products. Hollow fiber bioreactors allow for culture growth in three dimensions. Fiberless cartridges are also available for culturing larger pieces of tissue.

Incubation/Refrigeration: The unit can be programmed to maintain a constant temperature or be adjusted during orbit. Temperature regulation from 10 to 40 °C is available.

Media Delivery: Nutrients and gas are provided to the growing cells via a closed-loop flowpath. The one-way flow of liquid has two different nutrient delivery options. The recirculating flow path option directs media flow through the media bag, oxygenator, pump, biochamber, and back to the media bag, allowing growth factors and other products to accumulate. An intermittent feed option periodically pumps fresh media into a short-flow path that recirculates in the same manner as the first option, but the media is eventually diverted to a sump and replaced with fresh media.

Injections: The injection system can be used to add drugs, hormones, fixatives, and chemical labels to the media.

Sampling: The STL-A allows for automated collection of media samples, which can be paired with the injection system.

Specifications

Dimensions: Occupies 1 middeck locker
Weight: 57 lbs control
Power: 100 W
Temperature: standard 37 °C and a separate 4 °C reagent or sample cooling chamber
Cartridge Capacity: 24 Bioreactor cartridges (standard)

Data Acquisition

Event execution log, pressure, temperature, and acceleration

Related Ground-Based Hardware

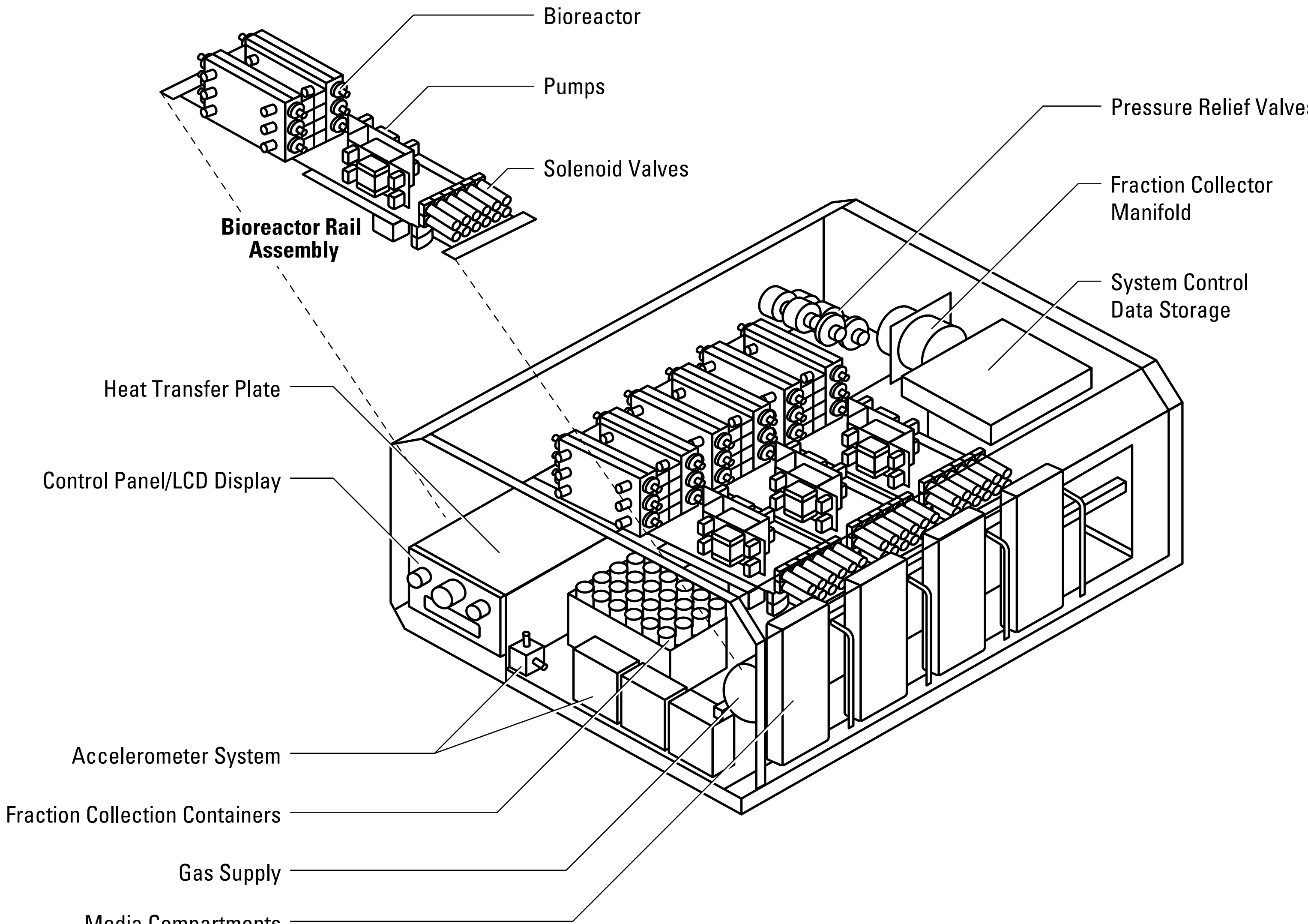
PI Laboratory Trainer: The trainer is a fully functional nonflight version of the STL-A, used as a training and demonstration unit.

Hardware Publications

- *Life Sciences Laboratory Equipment (LSLE) On-line Catalog.* NASA, 1998. http://lifesci.arc.nasa.gov:100/lsle/.

Missions Flown 1991-1995

NIH.C1/STS-59, NIH.C2/STS-66, NIH.C3/STS-63, NIH.C4/STS-69


Bioreactor
Pumps
Solenoid Valves
Bioreactor Rail Assembly
Pressure Relief Valves
Fraction Collector Manifold
System Control Data Storage
Heat Transfer Plate
Control Panel/LCD Display
Accelerometer System
Fraction Collection Containers
Gas Supply
Media Compartments