

Product Catalog For Space Experiment

Mitsubishi Heavy Industries, Ltd.

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Heritage of MHI's Space Experiment Products

Space Shuttle



Thermo Electric Incubator (TEI)



Aquatic Animal Experiment Unit (AAEU)



Bonner Ball Neutron Detector (BBND)



Vestibular Function Experiment Unit (VFEU)



Vestibular Function Experiment Unit (VFEU)

International Space Station



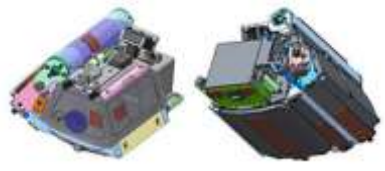
Cell Biology Experiment Facility (CBEF)



Robot Experiment on JEM (REX-J)



Aquatic Habitat (AQH)



Mouse Habitat Unit (MHU)



Cell Biology Experiment Facility (CBEF-L)

MHI's Space Experiment Mission History

- 1992 TEI, FFEU and VFEU were flown by Space Shuttle Mission STS-47.
TEI: Thermo Electric Incubator, FFEU: Free Flow Electrophoresis Unit, VFEU: Vestibular Function Experiment Unit
These units were developed for a joint mission by NASA and National Space Development Agency of Japan (NASDA, currently JAXA) utilizing a manned Spacelab module conducted microgravity investigations in materials and life sciences.
- 1994 Aquatic Animal Experiment Unit (AAEU) was flown by Space Shuttle Mission STS-65.
AAEU was designed to provide an environment supporting studies of live fish and small amphibians under microgravity conditions. It permits observations of spawning, fertilization, embryonic stages, vestibular functioning and behavior in microgravity.
- 1998 Vestibular Function Experiment Unit (VFEU) was flown by Space Shuttle Mission STS-90 and 95.
VEFU was designed to breed marine fish in microgravity environment for experiment on the nervous system.
- 2001 Bonner Ball Neutron Detector (BBND) was flown by Space Shuttle Mission STS-102 and returned to ground by STS-108.
It was installed in US Lab Module as one of the experiment units for Human Research Project. BBMD is designed to detect and record neutron inside the ISS.
- 2008 Cell Biology Experiment Facility (CBEF) was flown by Space Shuttle Mission STS-123. It has been installed in the Pressurized Module of Japanese Experiment Module (Kibo). CBEF consists of an incubator and a centrifuge unit to provide controlled environments, temperature, humidity, concentration of CO₂ and gravity (0 to 2G) for experiment.
- 2012 Robot Experiment on JEM (REX-J) was flown by H-IIB and installed on the Exposed Facility of Japanese Experiment Module (Kibo). REX-J has an extendable and retractable robot arm for developing the robotic system which is capable to support extravehicular activities by astronauts.
- 2012 Aquatic Habitat (AQH) was flown by H-IIB. AQH is capable to accommodate small freshwater fish, such as medaka or zebrafish for experiment in the Pressurized Module of Japanese Experiment Module (Kibo).
- 2016 Mouse Habitat Unit (MHU) was flown by H-IIB and has been used several times for mouse experiment in the Pressurized Module of Japanese Experiment Module (Kibo). MHU consists of Habitat Unit, Transportation Cage Unit (TCU), Glove Box etc., and can support mice transportation and return to ground alive for science research in microgravity environment.
- 2019 Cell Biology Experiment Facility Left (CBEF-L) was flown by H-IIB. CBEF-L is an upgraded unit of CBEF which was launched in 2008, and installed on left side of it. CBEF-L has a larger diameter centrifuge and can provide Ethernet and HDTV interface for payloads.

Components for Experiment

- Sense and control environment
- Experiment apparatus
- Animal breeding

Temperature/Humidity Sensor

Description

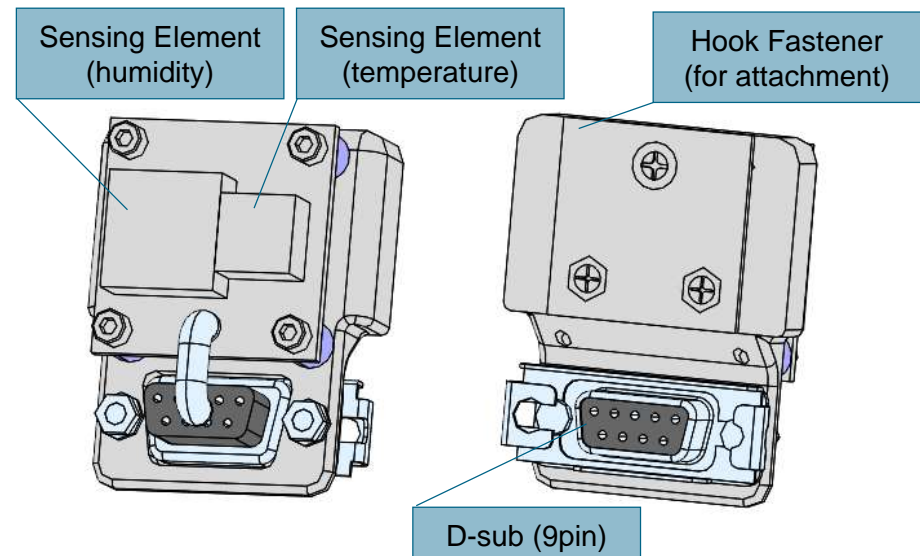
- Designed for temperature and humidity measurement of environmental air.
- Compact size and easy to mount onto flat surface (e.g. incubator).



Temperature/Humidity Sensor

Specifications

Size	47 x 38 x 15 [mm]
Mass	0.15 [kg]
Input Voltage	Temperature: (PT100/3-wire) Humidity: 3.135 to 5.5 [VDC]
Range	Temperature: 0 to 60 [degC] Humidity: 20 to 95 [%RH]
Resolution	Temperature: 0.01 [degC] Humidity: 0.1 [%RH]
Accuracy	Temperature: $\pm(0.15+0.002t)$ [degC] Humidity: ± 5 [%RH]



O2/CO2 Sensor

Description

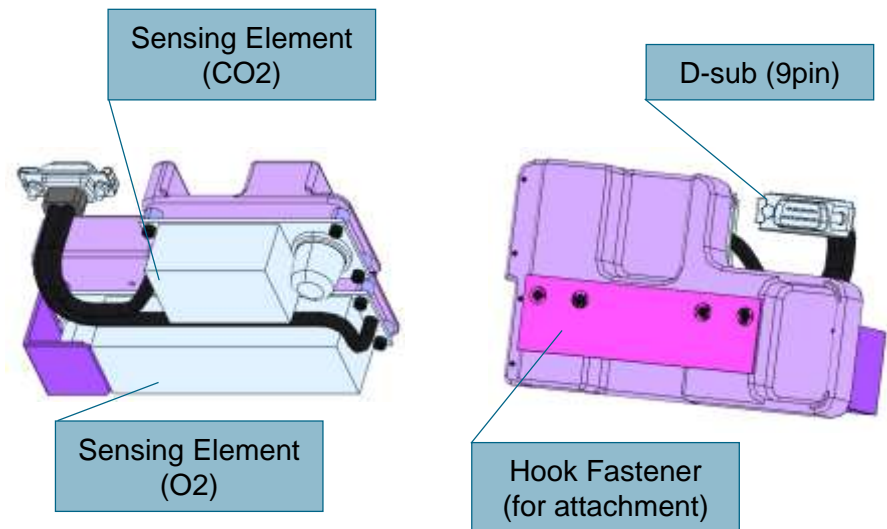
- Designed for O2 and CO2 concentration measurement.
- Compact size and easy to mount onto flat surface (e.g. incubator).

Specifications

Size	129 x 76 x 48 [mm]
Mass	0.37 [kg]
Input Voltage	12 [VDC]
Range	O2: Max. 24.5 [vol%] CO2: Max. 20 [vol%]
Resolution	O2: 0.01 [vol%] CO2: 0.01 [vol%]
Accuracy	O2: ± 0.25 [%] CO2: ± 0.3 [vol%] (@37 \pm 1 [degC])



O2/CO2 Sensor



Humidifier

Description

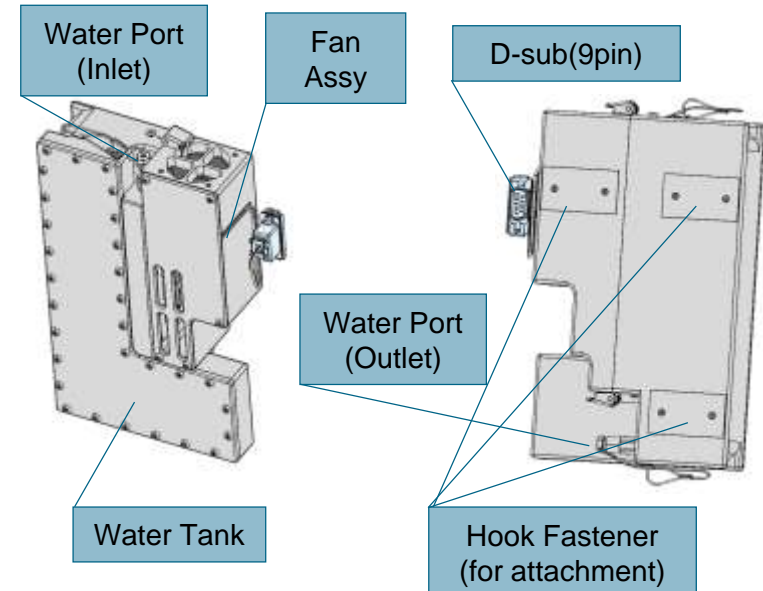
- Humidify environmental air in encloser (e.g. incubator) .
- Consists of a water tank and a fan assy.
- While the fan is powered on, water in the tank evaporates through permeable membrane.
- No spilled water in microgravity environment.
- Water can be refilled from inlet port, and also water tank is replaceable (separate from the fan assy).



Humidifier

Specifications

Size	209 x 122 x 47 [mm]
Mass	1.45 [kg] (WET)
Input Voltage	24 [VDC]
Water Volume	363 [cc]



Odor Removal Filter Unit

Description

- Made from activated carbon that can remove ammonia, tri-methylamine, and other odorous component.
- Odor removal filter in the case is exchangeable.
- Low pressure drop.

Specifications

Size (Filter Case)	305 x 170 x 140 [mm]
Mass	4 [kg]
Diameter of Inlet / Outlet	Φ36 [mm] / Φ43 [mm]
Objective Fluid	Air
Major Target Odorous Component	Ammonia Tri-methylamine
Deodorizing Capability	Ammonia: 5 ppm to less than 1 ppm Tri-methylamine: 50 ppb to less than 5ppb Duration: 30 days at air flow rate 34 L/min



Odor Removal Filter Unit



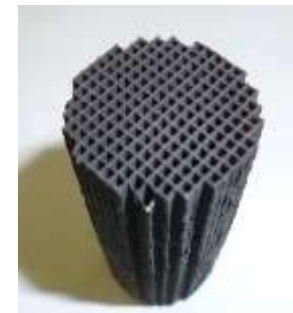
Filter

Low Temperature Oxidation Catalyst

Description

- Detoxify the contaminant gases in the cabin air of manned vehicle/module by chemical combustion.
- Combustion temperature is lower (<math><200^{\circ}\text{C}</math>) than the standard catalyst.
- Various shapes of the catalysts can be provided according to **the** customer's design requirements.(See below for example.)

Examples of Manufactured Shape	Size / Specifications
Granulated	3mm in diameter
Granulated	5mm in diameter
Honeycomb	400 cell per square inch (CPSI)
Ceramic Form	#06(6 cell per inch)



Honeycomb



Granulated



Ceramic Form

Components for Experiment

- Sense and control environment
- Experiment apparatus
- Animal breeding

Glove Box

Description

- Designed for various crew tasks to prevent particles from scattering in the cabin of ISS.
- Working area of glove box is made of flexible resin and foldable.
- Ventilation fan, odor filter, and particle filter are installed.
- Back panel can be fastened to the sheet track*1.
- Glove Box can supply CO2 gas from CGSE *2 to the working area.



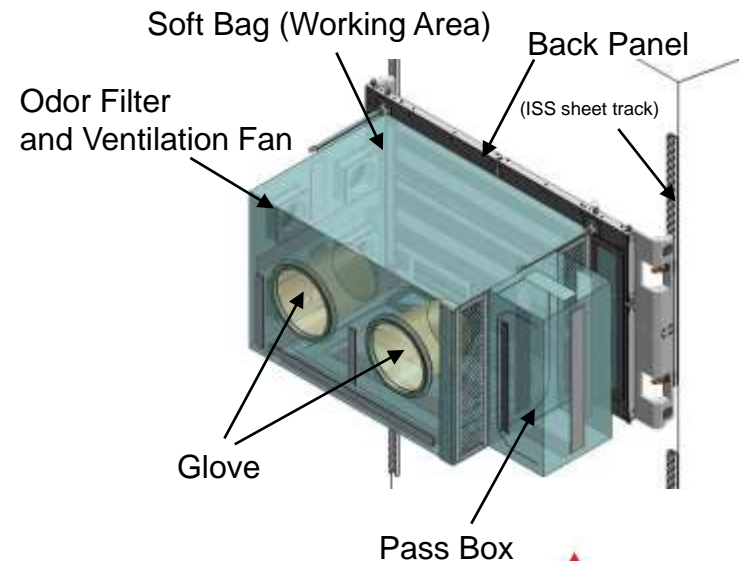
Glove Box

*1: Sheet tack is mechanical interface used in the ISS, and located both ends on the rack.

*2: Common Gas Supply Equipment equipped on JEM.

Specifications

Size (Work Area)	750 x 500 x 500 [mm]
Size (Pass Box)	200 x 500 x 250 [mm]
Total Mass	25 [kg]
Input Voltage	16- 28 [VDC]
User Interface (Inside of Work Area)	Power Supply: 5 [VDC] x 6ch Gas Interface: CO2 x 1

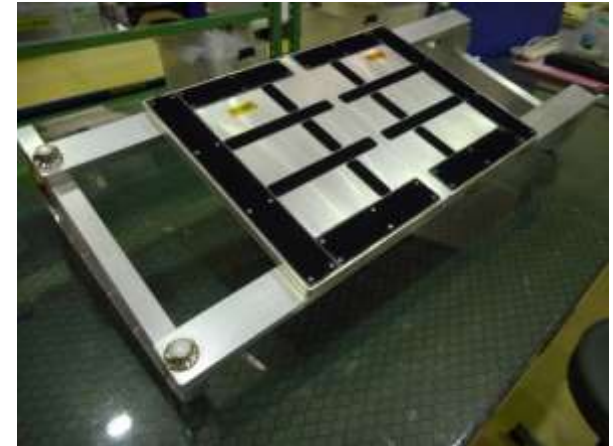


Working Table

Description

- Designed for accurate task conducted in the glove box (see other page).
- Located under the glove box and can be fastened to the sheet track*.

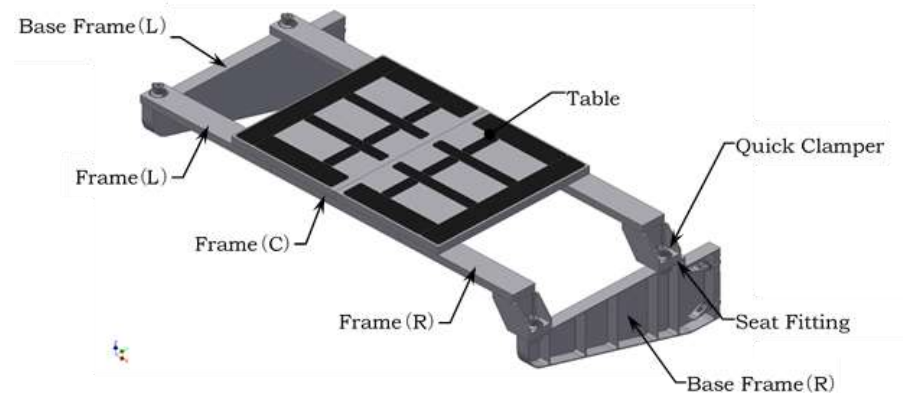
*: Sheet tack is mechanical interface used in the ISS, and located both ends on the rack.



Working Table

Specifications

Size	1050 x 530 x 320 [mm]
Table Size	410 x 450 [mm]
Mass	17 [kg]



Centrifuge Rotor

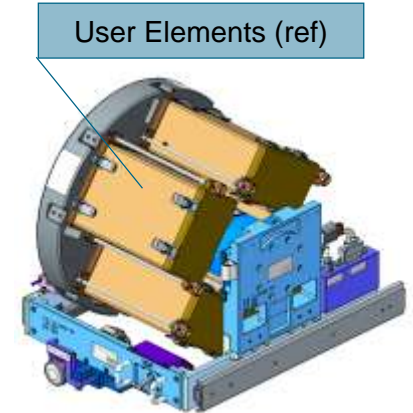
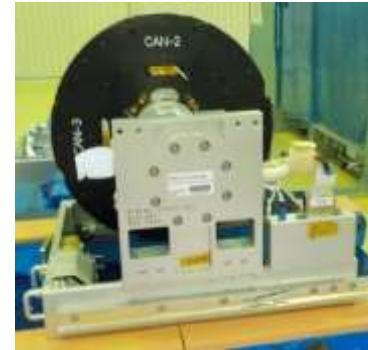
Description

- Can accelerate artificial gravity from 0.1 to 2.0 G.
- Rotor diameter can be enlarged by use of attachment.
- Provides utilities to user elements, power supply and data interface.

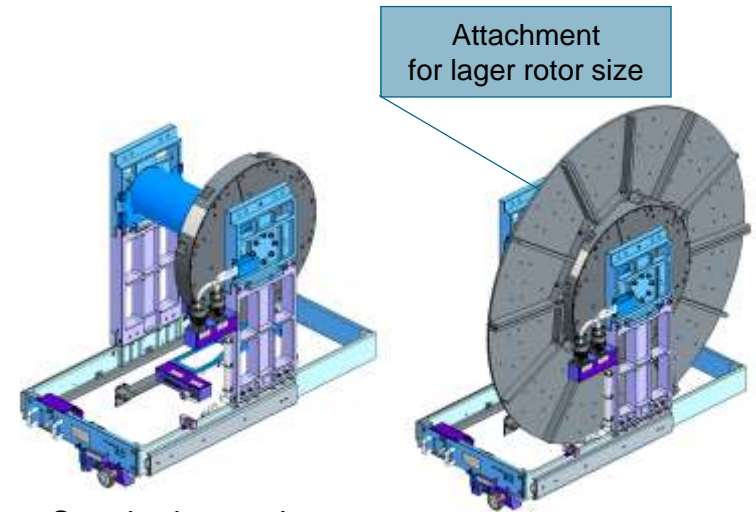
Specifications

Size	438 x 352 x 396 [mm] Φ350 [mm] (table)	683 x 352 x 601 [mm] Φ760 [mm] (table)
Mass	17 [kg]	20 [kg]
Input Voltage	24 [VDC] (motor) ±15, 5, 3.3 [VDC] (sensor)	
Rotor Speed	15-140 [rpm]	15-82 [rpm]
Accuracy	±2 [rpm]	±1 [rpm]
User I/F	Electrical: D-sub (25pin) x 4 (total) Mechanical: #6-40 UNF x 12 (total) for user elements M6 threaded hole 16 (total) for enlarge attachment	
User utilities	Power: 5,12, +/-15, 24 [VDC] Sensor output : 0 to 5 [VDC] NTSC and HD video interface RS-485 interface	

Note: Requires motor driver and controller



Centrifuge Rotor



Standard rotor size
Φ350 mm

Lager rotor size
Φ760 mm

Components for Experiment

- Sense and control environment
- Experiment apparatus
- Animal breeding

Waterer

Description

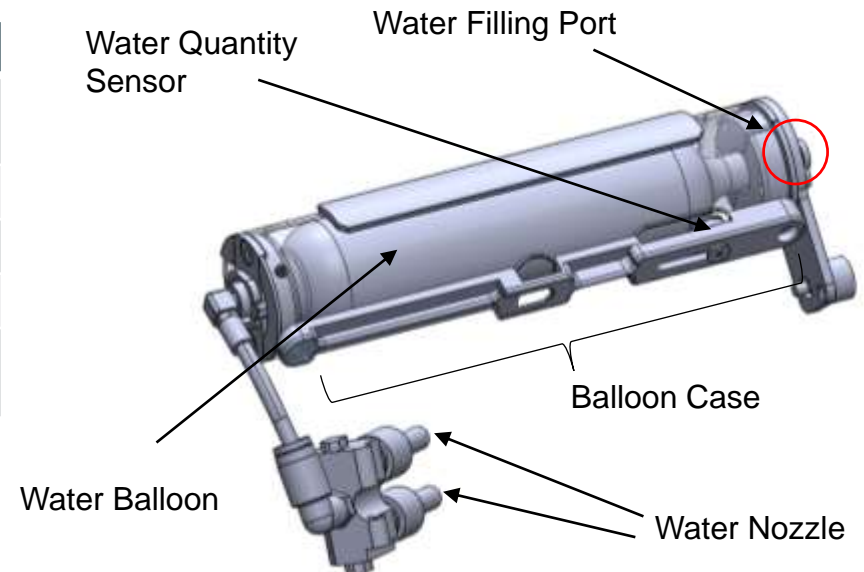
- Designed to supply potable water to rodents in cage (see other page).
- Elastic balloon presses water which filled in the balloon. No electrical and mechanical component is used for supplying water.
- Compact Size
- Redundancy for drinking nozzle



Waterer

Specifications

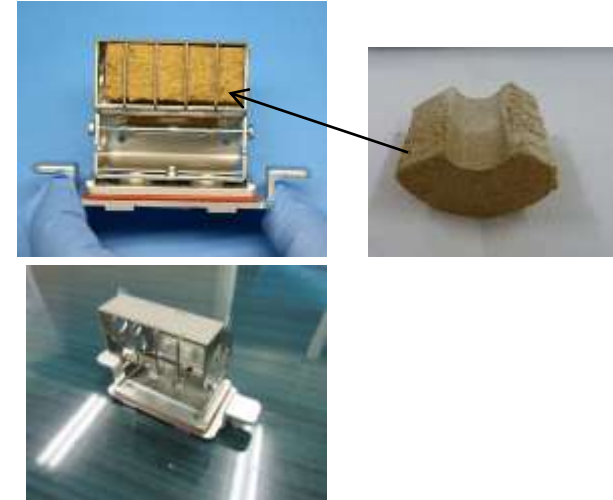
Size	Φ32 x L160 [mm] (Balloon Case)
Max Volume of Water Balloon	70 [ml]
Objective Animal	Rodent (Mouse)
Water Filling Port	Luer Fitting (Female)
Option	Pressure sensitive sensor for detecting full or empty of water



Feeder

Description

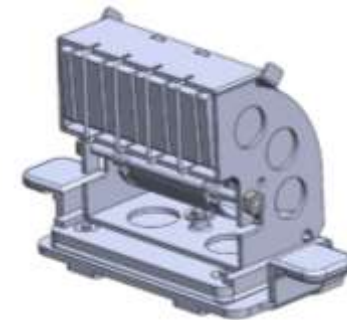
- Designed for mouse rearing in microgravity environment
- Torsion springs push the dedicated molded feed (exchangeable) to feeding area.
- Compact size



Feed Cartridge(left) and Feed (right)

Specifications	
Size (Cartridge)	100 x 40 x 60 [mm]
Total Mass	0.13 [kg]
Objective Animal	Rodent (Mouse)
Mass of Feed	35 [g]
Duration of use (One mouse)	7days (5g/day)
Component of feed	CRF-1 * or equivalent

*: Product of Charles River Laboratories



Note: Feeder can be set outside of the mouse cage . This makes feed keeping clean.

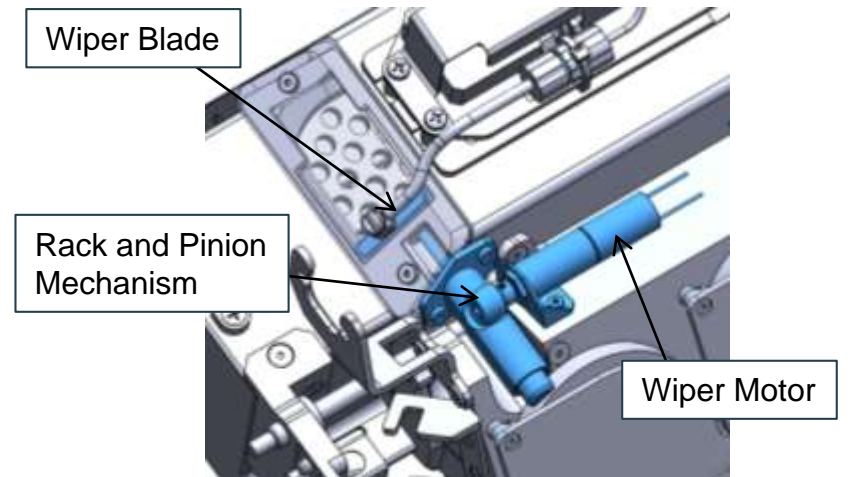
Wiper System

Description

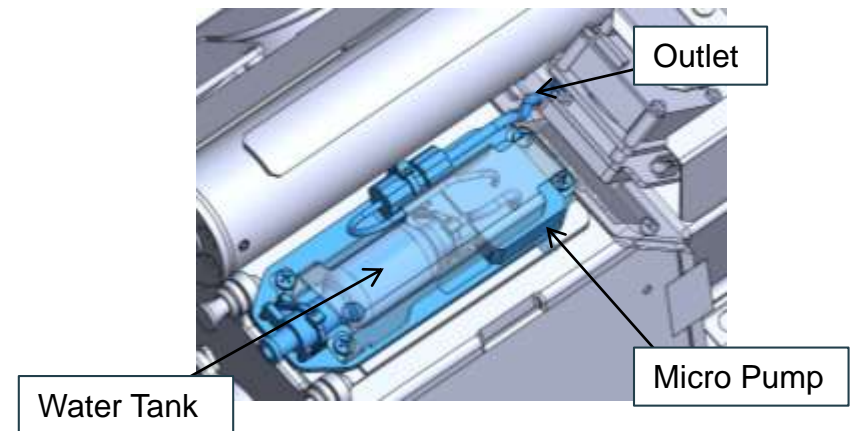
- Designed to wipe visual window for mouse cage (see other page).
- A small DC motor drives wiper.
- Water tank stores washer fluid, and micro pump supplies washer fluid to the window.
- Miniature Size System

Specifications

Main Components	<p><Wiper Mechanism> Wiper Blade DC motor (to drive wiper) Rack and Pinion</p> <p><Washer Fluid Supply System> Water tank Micro Pump (to supply washer fluid)</p>
Volume of Water Tank	Over 5 [ml]
Input Voltage	DC motor: DC+4.5 [V] Micro Pump: DC+5 [V]
Water Filling Port	Luer Fitting (Female)



Wiper Mechanism



Washer Fluid Supply System

Zebrafish Experiment Unit (ZEU)

Description

- Designed for fish experiment for short duration for space experiment.
- No water spillage in microgravity environment.

Specifications

Size	171 x 111 x 62 [mm]
Mass	1.2 [kg]
Fish Quantity	3 fishes (zebrafish juvenile)
Water volume	270 [ml] Replaceable by syringe
LED	50-100 [lux] x 10 days On/Off by slide switch AA battery x 2
Fish Habitat Duration	7 days



ZEU

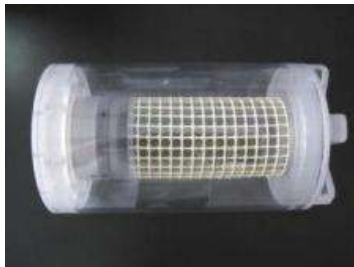


Fish Container

Fish Transportation Container

Description

- Transport living fishes from Ground to Space
- LED light is attachable, and both are installed in Soft Bag.



Specifications	
Size	Φ150 x 265[mm] (not including LED)
Mass	2.1 [kg] (dry)
Water volume	0.52 [L]
Fish Quantity	3 fishes (adult)
Fish Habitat Duration	Over 5 [day]
LED	Over 5 [day] On/Off by slide switch AA battery x 2

Fish Retriever

Description

- Transport living fishes from Space to Ground
- LED lights is installed in Soft Bag.



Specifications	
Size	137 x 117 x 105[mm]
Mass	1.1 [kg] (dry)
Water Volume	0.65 [mL]
Fish Quantity	3 fishes (adult)
Fish Habitat Duration	5 [day]
LED	Over 3 [day] On/Off by slide switch AA battery x 2

Fish Catcher

Description

- Catch living fish from aquarium (port) by pushing button (spring-driven)



Specifications

Size	Φ80 x 269 [mm]
Mass	0.6 [kg]

Bubble Remover

Description

- Remove bubbles in aquarium by pump with supplying water.
- Inlet and outlet bags are necessary



Specifications

Size*	177x 80 x 250 [mm]
Mass*	1.0 [kg]
Water Volume (Inlet Bag)	0.2 [L] (MAX 0.6 [L])
Flow rate	High: 100 [mL/min] Low: 50 [mL/min]
Battery	006P battery x 2

*): Not including inlet and outlet bags.

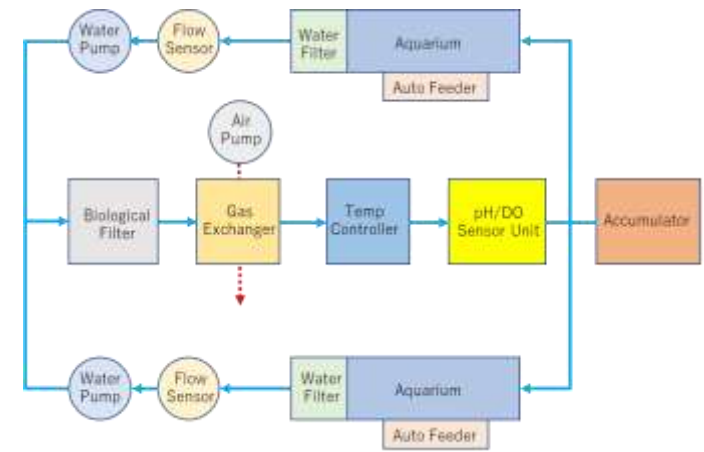
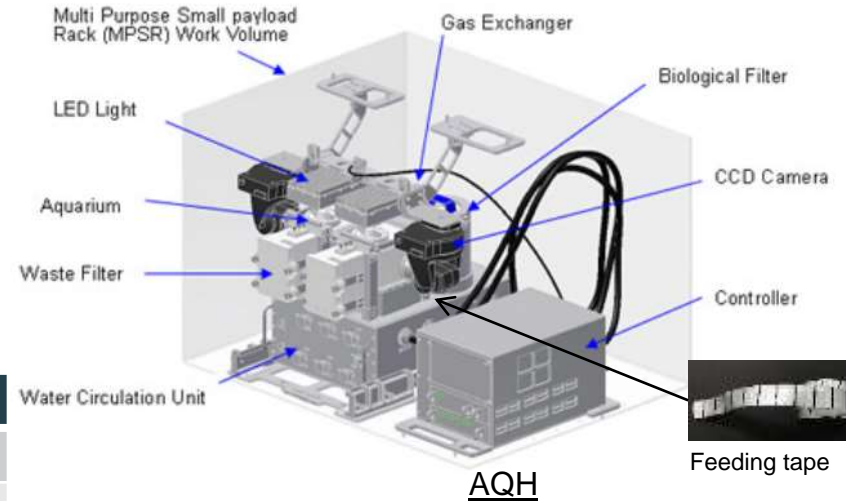
Experiment Units

Aquatic Habitat (AQH)

AQH is composed of one closed water circulation system with two aquariums. The aquarium has automatic feeding system, LED light for day/night cycle and CCD camera for observation. The aquarium environment will be maintained by water flow rate control, water temperature control, dissolved gas exchange with air, and biological/physical filtrations. Also, the AQH will have on-orbit maintenance capabilities, such as water quality check, water exchange, waste filter replacement and so on, to achieve long-term experiments up to 90days.

Specifications

Experiment Duration	Up to 90 days
Water Circulation System	Closed water loop with two aquariums Total water volume 3.2 Liter
Aquarium	150 x 70 x 70 [mm] (Inner) 0.7 Liter per aquarium (inner)
Water temperature control	Range: 25 to 30 [degC]
Water flow rate control	Range: 0 to 0.4 [L/min]
Day/night cycle	LED light for each aquarium Light/ dark cycle selectable
Observation	CCD camera for each aquarium Infrared camera observation is available
O2 supply/CO2 removal	Gas exchange with air by artificial lung



System schematic

Mouse Habitat Unit (MHU)

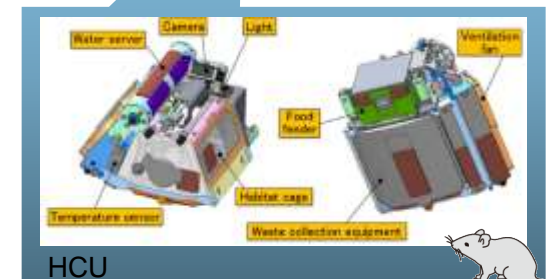
MHU is a system that makes space mouse experiments possible, supporting launch, rearing on orbit and return alive for mouse research. It consists of Transportation Cage Unit (TCU), Glove Box and Habitat Cage Unit (HCU) and control unit. HCU can be installed in the CBEF (see next page) and rearing mice in microgravity and artificial gravity environments at the same time for comparison.

HCU is equipped with the followings for mouse rearing.

- ✓ Feeder
- ✓ Water supply apparatus
- ✓ Excrement collection equipment (excrement is collected by air flow in the cage)
- ✓ Deodorant filter
- ✓ Ventilation fans
- ✓ LED illumination (Visible and infrared)
- ✓ Video camera with night vision technology and window wiper
- ✓ Temperature sensor
- ✓ Gas monitoring sensors (CO2 and NH3) in controller unit

Specifications

	HCU	TCU
Size	162 X 180 X 117 [mm]	150 X 70 X 70 [mm]
Mass	1.3 [kg]	13 [kg]
Input Voltage	5,12,15 [VDC]	28 [VDC]
Number of Mouse	1	12
Mission duration	30 days	10 days



One mouse per one cage

Mission outline

Cell Biology Experiment Facility (CBEF and CBEF-L)

CBEF is designed for various life science experiments such as cultivating cells, plants, and so on in the Pressurized Module .

CBEF consists of an incubator and control equipment for control and communication.

The incubator unit consists of a microgravity compartment and an artificial gravity compartment which a centrifuge that can control gravity from 0.1 to 2.0 G for gravity.

Incubator can provide the following environments.

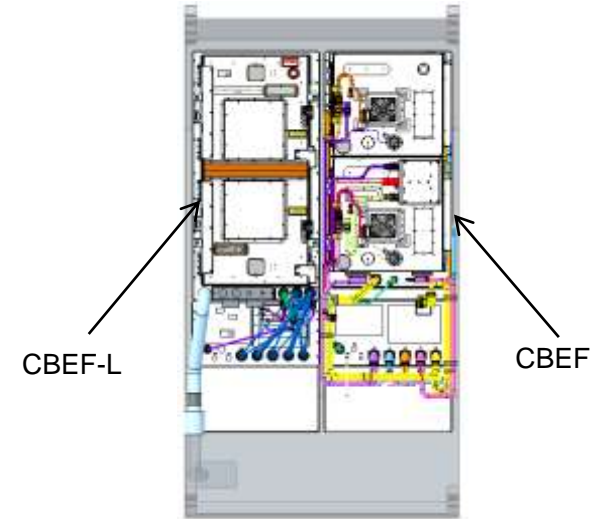
- ✓ Temperature control : 15 deg. C to 40 deg. C
- ✓ Humidity control : 20 % RH to 80 % RH
- ✓ CO2 concentration : 0 vol % to 10 vol
- ✓ Centrifugal acceleration: 0.2 to 2G

Control Equipment can provide the following utilities for users.

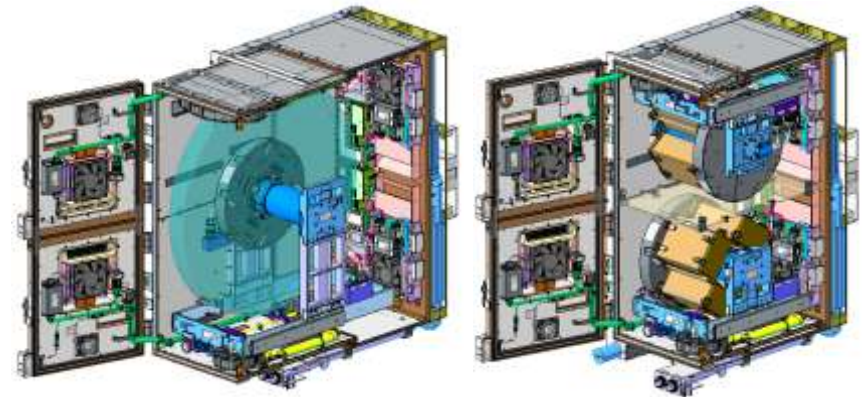
- ✓ Power: 5 V,12 V +/-15 V (DC)
- ✓ Sensor output :0 to 5 V
- ✓ NTSC video interface
- ✓ RS-485 interface

In addition to above, CBEF-L has advanced features shown below.

- ✓ Power: 24V
- ✓ HD(High Definition) vide interface
- ✓ Ethernet
- ✓ Various Centrifuge experiment (larger diameter than CBEF and tandem operation)



SAIBO Rack in ISS Kibo



Single rotor with larger rotor diameter.

Dual rotor with standard rotor diameter.

MHI's Space Experiment Unit and Mission to be continued for the future (MIRAI)...

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