

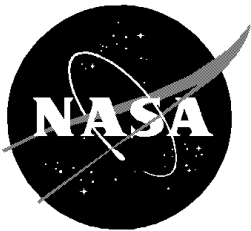
Crew Systems Reference Manual

Volume 1 – Crew Escape

Mission Operations Directorate

EVA, Robotics, and Crew Systems
Operations Division

Revision A
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National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

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**Crew Systems Reference Manual
Volume 1 – Crew Escape**

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PREFACE

The Crew Systems Reference Manual, Volume 1, has been prepared by the Extravehicular Activity (EVA), Robotics, and Crew Systems Operations Division of the Mission Operations Directorate (MOD), National Aeronautics and Space Administration (NASA), Lyndon B. Johnson Space Center (JSC), Houston, Texas.

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1.0 INTRODUCTION

1.1 PURPOSE

The Crew Systems Reference Manual (CSRM) provides a single-source reference document that addresses the various pieces of crew systems hardware and crew escape systems hardware. In-Flight Maintenance (IFM) hardware and photo/Television (TV) hardware are not covered in this document. This CSRM should be used with other crew systems documents when forming an operational database for Space Shuttle Program (SSP) crew systems, as applied to console reference, flight design and planning, simulations, and Flight Data File (FDF) development. The Shuttle Operational Data Book (SODB) references this document.

1.2 SCOPE

This manual provides data on space shuttle crew systems and crew escape systems equipment and is specifically intended for reference by flight crews and flight operations personnel.

This document is organized to allow quick reference to specific types of hardware, based on their operational use. Sections 2.0 through 5.0 provide descriptions, operations, failures, etc. for specific crew escape items.

1.3 AUTHORITY

The Extravehicular Activity (EVA), Robotics, and Crew Systems Operations Division within the Mission Operation Directorate (MOD) has the responsibility of providing documentation necessary to support SSP flight operations, as defined in the Flight Operations Directorate Program Support and Management Plan (JSC-10750). This document partially fulfills that responsibility as it relates to the crew systems area.

1.4 CONTROL

The general content (i.e., subjects covered, level of detail, and format) is under the control of the EVA, Robotics, and Crew Systems Operations Division.

2.0 EMERGENCY SYSTEMS – CREW WORN

2.1 ADVANCED CREW ESCAPE SUIT

References: Space Shuttle Systems Handbook (SSSH) drawing 18.5 (sheet 3 of 3),
ACES Components and Seat Interface
SSSH drawing 18.8, ACES/TELCU/QDM

The Advanced Crew Escape Suit (ACES) (Figure 2-1) is designed to provide protection to each crewmember for the following conditions:

- a. Loss of cabin pressure at altitudes up to 100,000 feet
- b. Cold atmospheric and/or water temperatures after bailout
- c. Pooling of the blood in the lower body after prolonged exposure to microgravity
- d. Contaminated atmosphere during flight or postlanding egress
- e. Fire



Figure 2-1. Advanced Crew Escape Suit

The ACES delivers oxygen to the crewmember for breathing, suit pressurization, and anti-g suit inflation.

The ACES is a full pressure suit that applies static pressure evenly to the entire body surface. This pressure is maintained by a dual suit controller and, at full inflation, provides an absolute pressure of 3.24 to 3.67 psia to a crewmember's body. A positive pressure regulator (Figure 2-2) located at the rear of the neck ring delivers positive pressure inside the helmet to protect the crewmember up to an altitude of 100,000 feet.

The ACES has an inner pressure bladder that encompasses the crewmember's body and an outer covering. The pressure bladder is constructed of Gore-Tex material that wicks body moisture and vapor away from the crewmember when unpressurized, yet holds pressure when inflated. The outer covering is made of orange Nomex material that is heat/flame resistant and provides a highly visible target for Search and Rescue (SAR).



Figure 2-2. ACES positive pressure breathing regulator

The ACES incorporates a pressure-sealing zipper (Figure 2-3) at the back for donning and doffing, a neck ring to attach the helmet, and wrist rings to attach the pressurized gloves.



Figure 2-3. ACES zipper

A neoprene neck dam at the neck ring (Figure 2-4) separates the helmet cavity from the suit cavity. This neck dam has two exhalation valves to allow pressurization gasses to flow from the helmet to the suit. The neck dam also prevents water from entering the ACES in the event of a water landing after bailout. For comfort, two elastic neck dam tabs allow the neck dam to be held away from the crewmember's neck. These tabs must be released prior to closing the helmet visor to allow the helmet and suit to be pressurized.



Figure 2-4. ACES neck dam

2.1.1 Helmet

The helmet (Figure 2-5) attaches to the ACES via a locking neck ring and provides a pressurized breathing volume and head protection to the crewmember. The helmet is also the interface for communications between the Communications Carrier Assembly (CCA) and the orbiter.



Figure 2-5. Helmet

The helmet neck ring on the ACES has a three-position latch (Figure 2-6) to secure the helmet to the suit:

- Open – Allows the helmet to be removed from the neck ring
- Engage – Allows the helmet to be attached to the neck ring
- Locked – Locks the helmet onto the neck ring

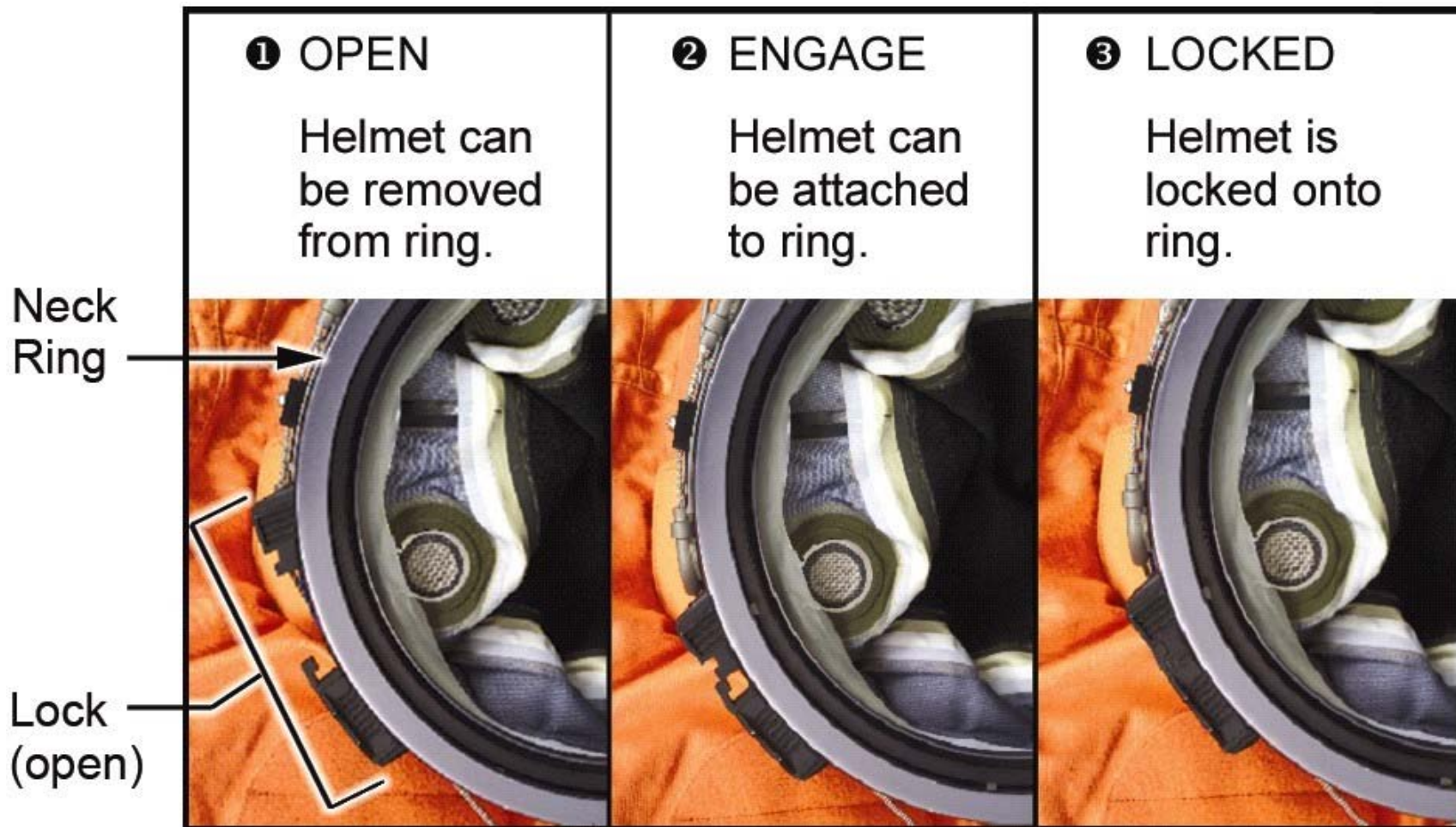


Figure 2-6. Helmet latch

To close the visor, the crewmember grasps the white tab on the clear visor and pulls it down. To lock the visor, he/she pulls the bailer bar down into the bailer bar latch (Figure 2-7) and snaps it into place. To unlock the visor, first the ribbed locking lever is pushed down and then the two buttons on either side of the lock are squeezed together. The visor can now be raised manually to the open position.



Figure 2-7. Bailer bar latch

CAUTION

The visor should not be closed by pulling down on the bailer bar; this will damage the visor mechanism.

A rotating, tinted sunshade is mounted to the outside of the helmet with a continuous friction hinge and can be manually raised or lowered independently of the clear visor.

The helmet also contains an anti-suffocation valve that is located at the lower right rear of the helmet (Figure 2-8). It permits ambient air from outside the helmet to enter when the visor is closed and breathing O_2 is not available. The valve opens when the pressure inside the helmet is 1.5 inches H_2O (0.054 psi) less than ambient, which occurs whenever the crewmember inhales with the visor closed and there is no O_2 supply.



Figure 2-8. Anti-suffocation valve

The communications cable has a Quick Disconnect (QD) pigtail that connects to an orbiter Headset Interface Unit (HIU). The QD is used for rapid seat egress. Note that there are dual (redundant) microswitches in the helmet that deactivate the microphones in the comm cap during O₂ flow to the helmet (inhalation, open visor, or leaking neck dam seal). See Figure 2-9, Figure 2-10, Figure 2-11, and Figure 2-12.

Reflective tape has been added to the helmet to increase visibility at night. Comfort pads are velcroed in place inside the helmet for crew comfort.



Figure 2-9. Helmet interior features



Figure 2-10. CCA connector

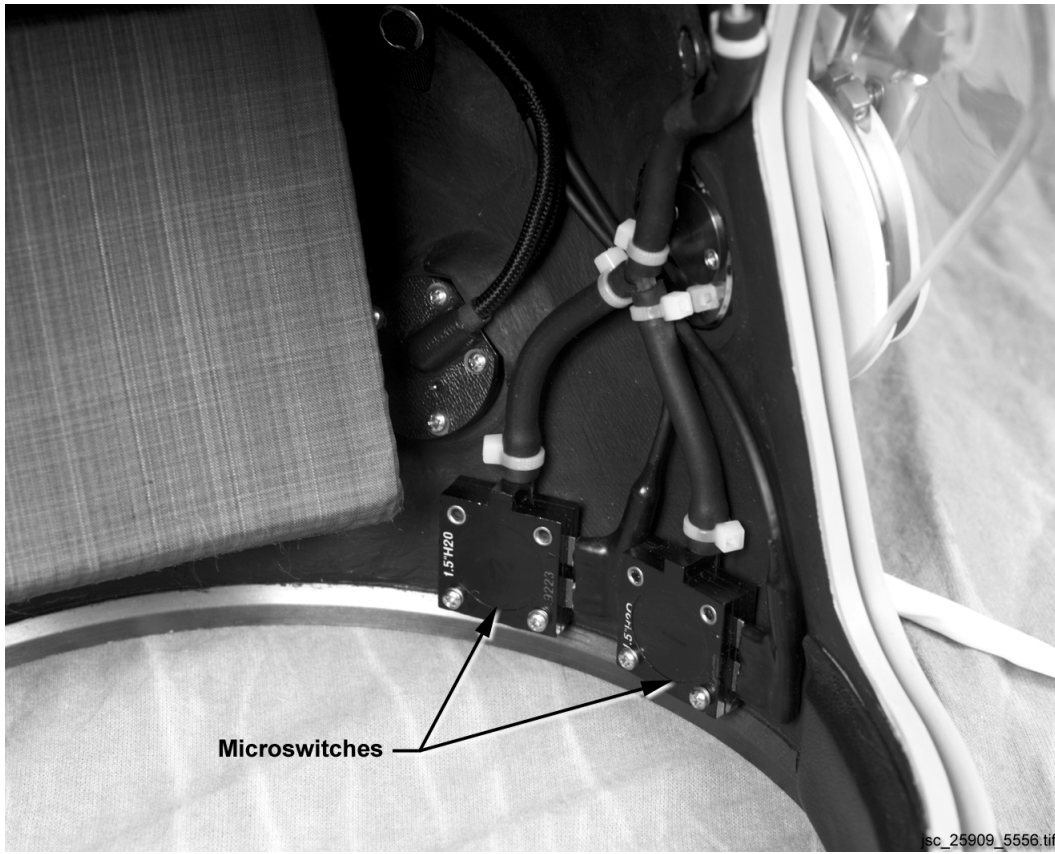


Figure 2-11. Helmet microswitches



Figure 2-12. Comm quick disconnect

2.1.2 Communications Carrier Assembly

The CCA, or comm cap, contains equipment necessary for voice communications. The microphones and earphones are contained in the comm cap, rather than being part of the helmet itself. The ear cushions in the comm cap provide noise attenuation, and that attenuation is enhanced when the helmet is closed. The comm cap includes dual (redundant) microphones and dual (redundant) earphones. There is a pigtail on the back of the comm cap that is attached to the inside of the helmet by a connector. From there, the comm cable passes through the helmet and connects to a standard HIU, which, in turn, connects to the orbiter comm system via comm cable. See Figure 2-13 and Figure 2-14.



Figure 2-13. Communications carrier assembly



Figure 2-14. CCA to helmet comm connection

2.1.3 Gloves

Detachable gloves are required for ACES use (Figure 2-15). The gloves attach to the ACES sleeves via mating rings on each glove and each sleeve. The gloves must be worn to allow the ACES to pressurize. The rings provide an airtight seal and allow the gloves to swivel for improved mobility (Figure 2-16). The gloves have adjustable straps around the lower wrist and around the palm (Figure 2-15). These straps prevent “ballooning” of the glove during pressurization and allow the glove to be flexed at the palm.



Figure 2-15. ACES gloves



Figure 2-16. Glove-wrist connection

NOTE

The gloves must be worn to allow the ACES to pressurize.

NOTE

The gloves must be worn during water operations.
Removing the gloves will allow water to enter the suit.

2.1.4 ACES Full Pressurization System

The pressurization components of the ACES consist of an O₂ distribution manifold on the upper left leg of the suit, a positive pressure breathing regulator just below the neck ring, a dual suit controller on the right side of the chest, and a relief valve.

The dual suit controller (Figure 2-17) consists of redundant aneroid and valve assemblies that determine the degree of suit pressurization. The primary aneroid begins to close the primary valve assembly when the ambient pressure decreases to between 3.67 to 3.24 psia (equivalent to 34,000 to 36,500-foot altitude). The secondary aneroid will back up the primary aneroid at a pressure of 3.48 to 3.05 psia (35,000 to 38,000 feet altitude).



Figure 2-17. ACES dual suit controller

Normally, the ACES is unpressurized and does not retain pressure unless the valve assembly in the dual suit controller is closed. During normal unpressurized use, pressurized O₂ from the orbiter supply enters the helmet by way of a positive pressure breathing regulator to a pressure of 0.8 to 1.4 in. H₂O above suit pressure. Two exhalation valves between the helmet cavity and suit bladder will open when the pressure inside the helmet is 1.5 to 1.8 in. H₂O above suit pressure. This happens during exhalation. Exhaled air passes into the suit bladder and out the dual suit controller. As long as the valve assembly in the suit controller is open, exhaled gas exits the bladder through the suit controller. When the valve assembly in the suit controller closes, the bladder is inflated by crewmember respiration until the total of suit pressure and cabin pressure equals 3.67 to 3.24 psia (primary) or 3.48 to 3.05 psia (secondary). The suit controller will open and close as necessary to maintain the correct suit pressure.

The suit controller also allows the ACES to be manually pressurized when the helmet visor is closed and locked and a supply of breathing O₂ is available. Manual pressurization may be performed during prelaunch suit checkout to ensure all suit components are working properly. A dial-to-test knob on the suit controller manually closes the primary valve assembly and pressurizes the ACES up to 3.5 psi when fully closed. Suit pressure will be maintained until the dial-to-test knob is turned fully counterclockwise. A press-to-test button is located next to the dial-to-test knob on the suit controller. When depressed, the press-to-test button partially closes the secondary valve assembly and allows the ACES to inflate to 2.3 psi for as long as the button is held down.

The ACES relief valve is located under the outer coverall in the right hip area. The relief valve opens when the ACES suit pressure reaches 5.5 ± 0.2 psi. Once open, the relief valve will remain open until suit pressure drops to 3.5 psi.

2.1.5 Neck Ring Tiedown Strap

The position of the neck ring can be adjusted using the neck ring tiedown strap (Figure 2-18). Adjusting the neck ring may be desired to improve visibility or comfort while seated or during suit inflation. When a crewmember sits, the ACES torso tends not to foreshorten with the crewmember's body torso, thus the neck ring may rise to be level with the crewmember's chin or mouth area. Also, if the ACES should inflate for any reason, the suit will elongate and raise the neck ring in the same manner.

The neck ring has two pulley arrangements to allow for adjustment. The lower adjustment is a coarse adjustment used first to take up slack in the tiedown strap and provide some adjustment to the neck ring. The upper adjustment strap provides finer adjustment to bring the neck ring to the desired level.

The neck ring tiedown strap connects to cables mounted to the neck ring and the neck ring counterbalance.



Figure 2-18. Neck ring tiedown strap

2.1.6 Chemlight Pockets

Each ACES has a pocket sewn on the upper arm of each sleeve for placement of a red chemical light (Figure 2-19). The pocket has a clear window sewn into it to allow the Chemlight to be visible to search and rescue personnel. The Chemlight is activated prelaunch by insertion technicians and is also activated during deorbit activities by the crew. The red Chemlight was chosen because it is highly visible to night vision equipment used by SAR personnel.



Figure 2-19. Chemlight pocket

2.1.7 Bioinstrumentation Passthrough Plug

A Bioinstrumentation Passthrough (BIP) plug (Figure 2-20) is incorporated into each suit to allow external hardware cables and hoses to pass through the pressure bladder of the suit without compromising suit pressure integrity. The BIP is located on the upper right leg of the ACES and provides an airtight and watertight passthrough interface. Although initially intended to accommodate physiological instrumentation, the crewmember liquid cooling hoses currently use the BIP plug.

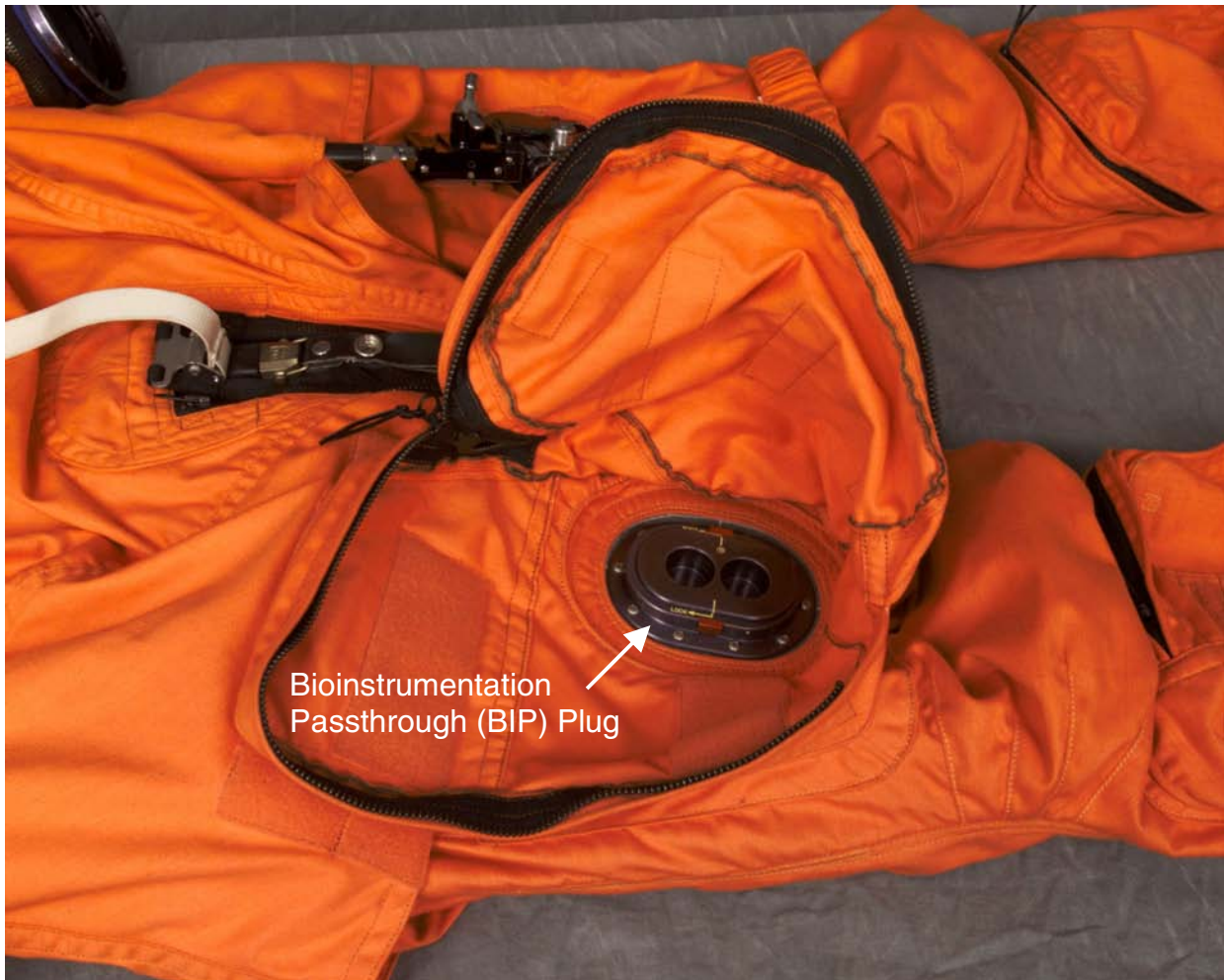


Figure 2-20. Bioinstrumentation Passthrough (BIP) plug

2.1.8 Underwear

Long thermal underwear is available to the crew to wear underneath the ACES. The underwear provides comfort and thermal protection to the crew and is worn beneath the liquid-cooled garment (see Section 2.3.3). Expedition and lightweight thickness underwear is available to the crew. The underwear is off-the-shelf hardware manufactured of Capiline polyester fabric (Figure 2-21).



Figure 2-21. Underwear

2.1.9 Boots

Crewmembers wear lightweight boots for foot protection (Figure 2-22). They are Rocky 911 off-the-shelf, military type, fabric and leather boots with rubber soles. The boots are secured with laces.



Figure 2-22. Boots

2.1.10 Cooling Vent

A cooling vent inlet is located on the lower left chest of the ACES (Figure 2-23). The vent was initially used as an inlet for the crewmember ventilation fan but, because the crew now uses liquid cooling, the vent is not used. The vent still utilizes the suit ventilation fan elbow that connects to the vent ring. The elbow has a spring-loaded flapper valve that seals the vent from water entry (Figure 2-24).



Figure 2-23. Cooling vent



Figure 2-24. Vent elbow

2.1.11 ACES Technical Data

Table 2-1 lists ACES components and specs concerning them.

Table 2-1. ACES technical data

ACES component	Technical data
ACES Weight Material Outer layer (coveralls) Inner liner Bladder Neck dam Gloves Relief valve Opens Closes	16.5 lb Nomex Gore-Tex Single layer of nylon laminated to Gore-Tex Neoprene Nomex 5.5 ± 0.2 psig 3.5 psig
Dual Suit Controller Primary valve assembly Closes Opens Dial-to-test Secondary valve assembly Closes Opens Press-to-test	3.24 to 3.67 psia Above 3.67 psia Inflates to 3.5 psig 3.05 to 3.48 psia Above 3.48 psia Inflates to 2.3 psig
Anti-g Suit Weight Material Inflation Range Increments Relief valve Opens Closes	2.0 lb Nomex/Nylon 0 to 2.5 psi 0.5 psi 3.0 psig 2.5 psig
Helmet Weight Anti-Suffocation Valve Microswitches	7.4 lb Opens when internal helmet pressure is 1.5 in/H ₂ O (0.054 psi) less than ambient Mute microphones during O ₂ flow
CCA Weight Microphones Headphones	~1.0 lb Dual Redundant. Automute during O ₂ flow into helmet Dual Redundant

2.2 O₂ MANIFOLD AND ANTI-G SUIT SYSTEM

Each crewmember is issued an anti-g suit (Figure 2-25) to be worn during shuttle reentry and landing. The anti-g suits are designed to counteract the effects of orthostatic intolerance due to body fluid loss by applying mechanical pressure to the crewmember's lower abdomen and legs. The anti-g suits are worn under the ACES and connect to the O₂ manifold via a QD hose.



Figure 2-25. Anti-g suit

Inflation of the g-suit is controlled at the O₂ manifold/g-suit controller (one piece), located on the crewmember's upper left leg. This assembly consists of the following components (Figure 2-26):

- a. A male, swivel O₂ hose fitting that connects to the orbiter O₂ supply hose – The supply hose has a breakaway QD fitting to facilitate rapid egress. The fitting has a check valve that prevents O₂ from flowing out of the manifold.
- b. An emergency O₂ hose fitting that connects the manifold with the emergency O₂ system in the crewmember's parachute harness – The harness hose has a QD for

normal use; it is locked in place with a locking clip to prevent accidental disconnection. A check valve prevents the emergency O₂ from being used for anti-g suit inflation.

- c. A threaded male O₂ hose fitting that connects the manifold with the oxygen regulator for crewmember respiration.
- d. The g-suit dial – When the manifold is connected to orbiter O₂, rotating the g-suit dial (knurled knob) clockwise, inflates the g-suit bladders 0.5 psi per complete turn, to a maximum pressure of 2.5 psi. A one-way valve inside the manifold prevents the g-suit from inflating with emergency O₂, which is reserved for breathing. Rotation of the knob counterclockwise will deflate the g-suit bladders 0.5 psi per complete turn. Each complete revolution of the knob is indicated by a slight detent. The recommended setting for inflation is 1.5 psia, which is obtained by rotating the red knurled knob three complete turns clockwise.
- e. The g-suit controller including a removable clip – When the g-suit controller clip is pulled free, the current volume of O₂ will be trapped maintaining g-suit pressure. Reinstallation of the clip will allow a normal deflation of the g-suit bladders.

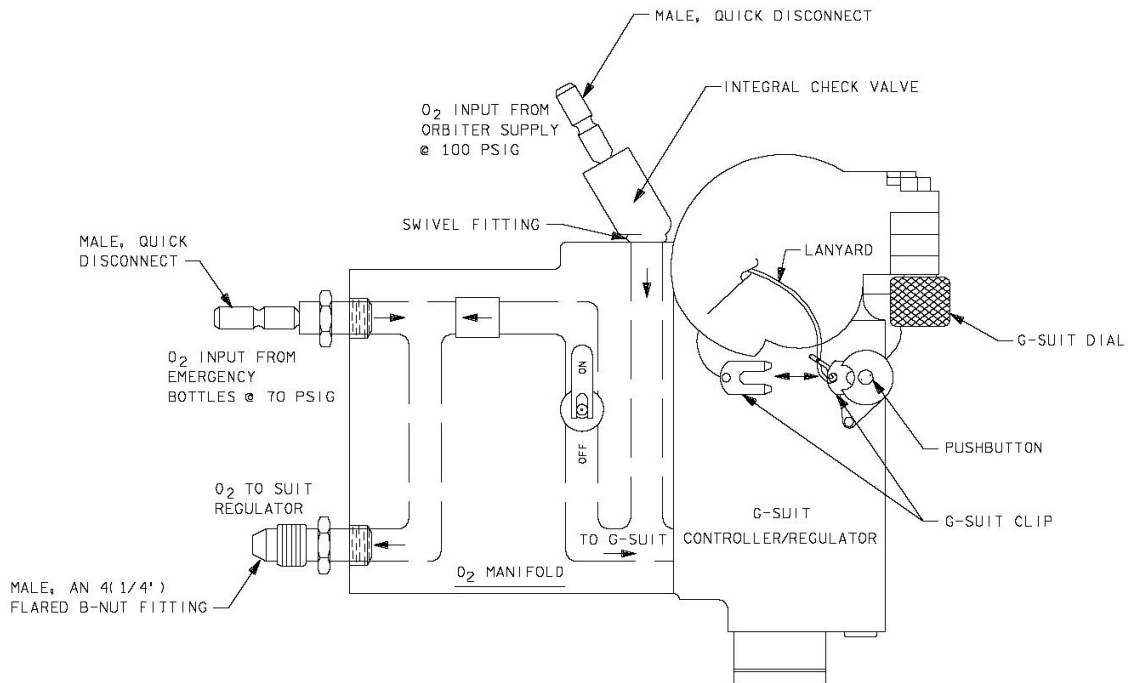


Figure 2-26. O₂ manifold/g-suit controller

A relief valve on the abdomen bladder of the anti-g suit vents pressures in excess of 3.0 psi (Figure 2-25). Once open, the valve remains open until the anti-g suit bladder pressure has been reduced to 2.5 psi. Figure 2-27 shows the internal g-suit connection.



Figure 2-27. Internal g-suit connection

2.3 COOLING

2.3.1 Individual Cooling Unit

Flight crewmembers require cooling for personal comfort while wearing the ACES. The Individual Cooling Unit (ICU) (Figure 2-28) provides cooling by circulating cooled water through a Liquid Cooling Garment (LCG) worn under the ACES.



Figure 2-28. Individual Cooling Unit

The ICUs are mounted on the crewmember seats using the same type of brackets used for FDF bags.

The ICU operates on the following thermoelectric principle; i.e., when two dissimilar conductors are connected and a direct current is passed throughout the circuit, the temperature of one of those conductors decreases, while the temperature of the other increases.

The cold conductor can absorb heat from its environment, and the hot conductor can reject heat to its environment. In the ICU, thermocouples are used to accomplish this heat transfer process. A cooling fan helps increase the effectiveness of the thermocouples enclosed in the cooling core.

Warm water returning from the crewmember's LCG enters the cooling side of the ICU cooling core where the heat exchange process occurs. The cooled water leaves the ICU via the cooling hose. The ICU hose is insulated and taped to prevent tangling during egress. The ICU system is shown in Figure 2-29.

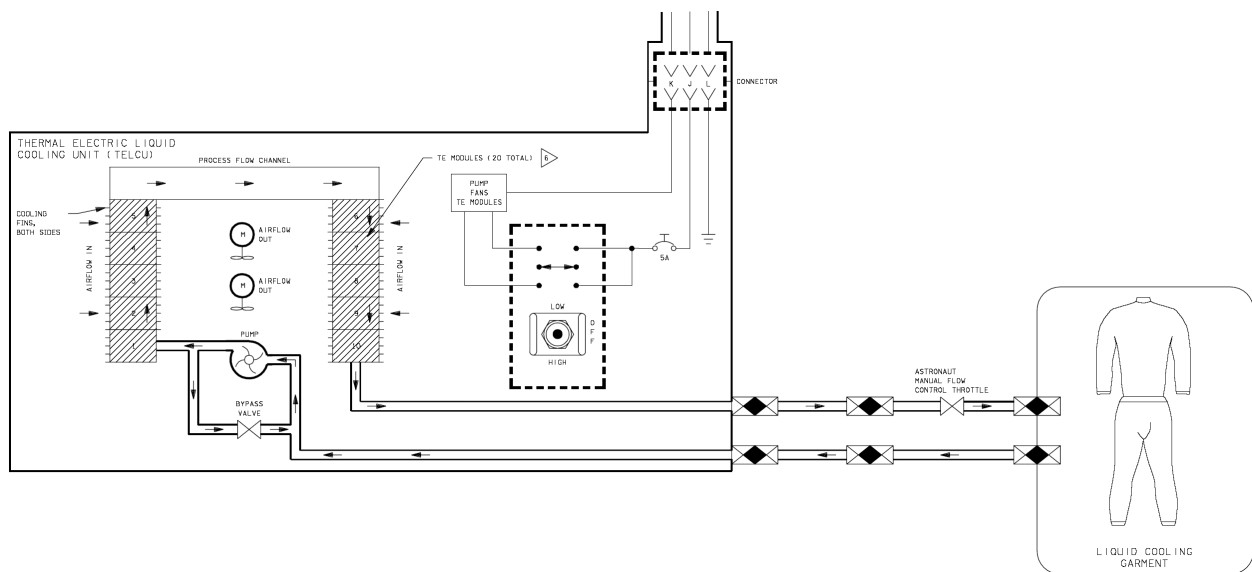


Figure 2-29. ICU system

A remote rotary switch turns the ICU on and off and controls the amount of cooling by varying the voltage across the thermocouples (Figure 2-30). The lowest setting delivers water cooled to approximately 70° F to the crewmember; the highest setting delivers water cooled to approximately 59° F. Cooling can also be controlled via a hose clamp that regulates the flow rate of the cooled water to the crewmember.



Figure 2-30. ICU switch

For circuit protection, each ICU has a 3-amp circuit breaker (cb) and additional circuit breakers at the power bus for further protection.

2.3.2 ICU Technical Information

Table 2-2 shows ICU technical information.

Table 2-2. ICU technical data

Description	Technical data
ICU P/N Weight Size Total water weight Total water volume BIP plug weight Cable routing	SDD33109966-001 ~11.5 lb 12 in. x 8 in. x 5 in. 1.3 lb; silver nitrate added for fungal protection (1 part/million, nontoxic) 600 cc (20.28 oz) 0.41 lb Refer to flight-specific Reference Data List
Operations Circuit protection Current draw Water flow Heat rejection Noise level	3 amp cb (resettable) 2.375 amps TBD TBD 61 dBa

2.3.3 Liquid Cooling Garment

The Liquid Cooling Garment (LCG) is a set of Patagonia thermal underwear that has tygon tubes sewn into the fabric (Figure 2-31). The LCG has a separate top and bottom that are connected to each other through QDs for the water supply and return lines. The supply and return lines are fed through the BIP plug in the pocket located on the crewmember's right thigh. The plug has QD fittings that attach to the cooling lines from the ICU (Figure 2-32). The LCG weighs 3.5 lbs. without water.



Figure 2-31. Liquid cooling garment



Figure 2-32. Liquid cooling BIP plug

Figure 2-33 shows the liquid cooling BIP plug installed in suit.



Figure 2-33. Liquid cooling BIP plug installed in suit

2.4 PARACHUTE HARNESS

The parachute harness (Figure 2-34) is a system of interwoven nylon straps that attach the Personal Parachute Assembly (PPA) to the crewmember. These straps provide complete body support for crewmembers during bailout, emergency egress, and rescue operations. In addition to the nylon straps, the harness has a wide Nomex vest panel that zips together for additional support and comfort.

The harness also includes the Emergency Oxygen System (EOS), Life Preserver Unit (LPU), emergency drinking water, and a carabiner.

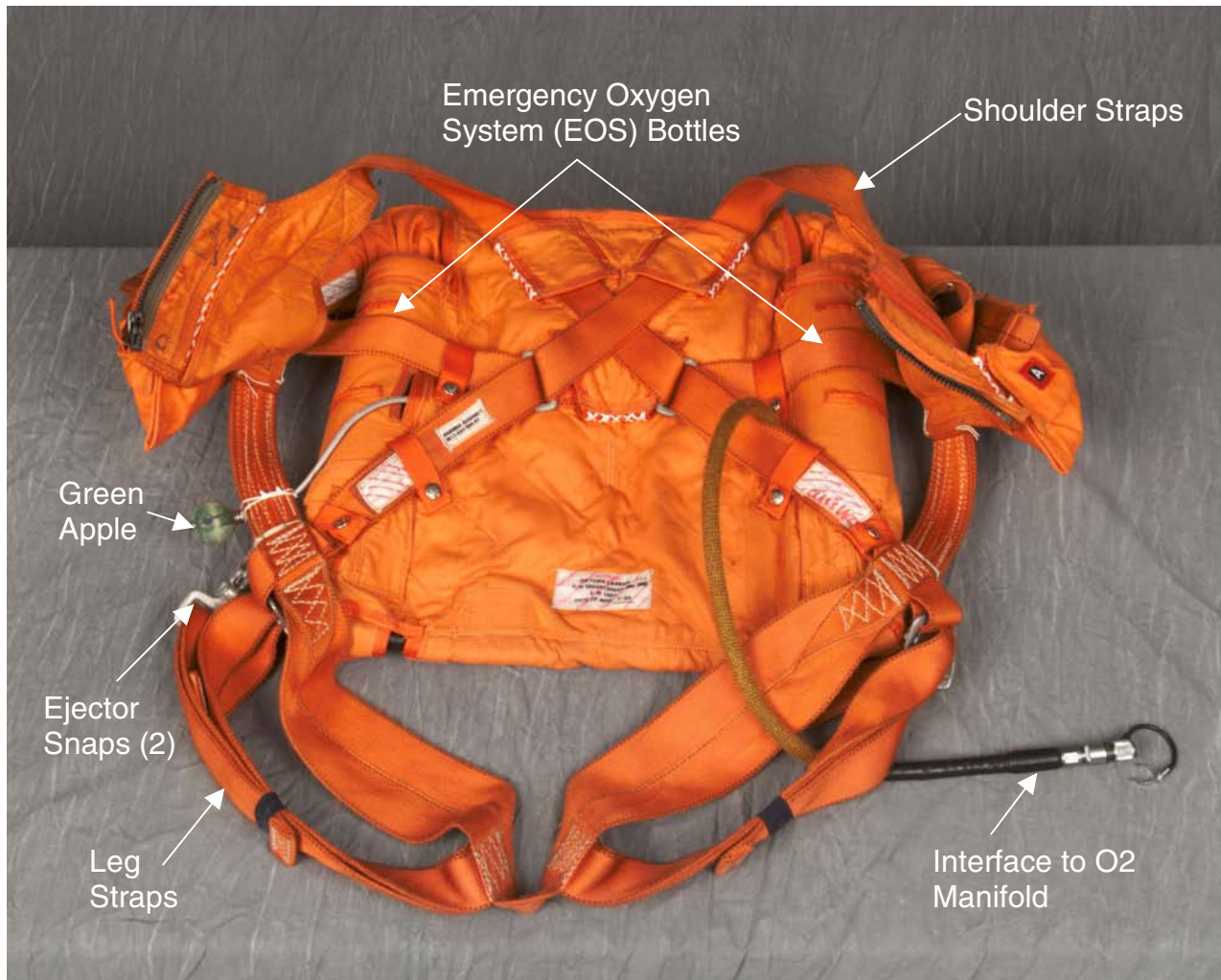


Figure 2-34. Parachute harness

2.4.1 Emergency Oxygen System

The EOS consists of two high-pressure cylinders containing breathing oxygen. Regulators reduce the 3000-psi pressure of the bottles to a working pressure of 70 psi. A common manifold delivers oxygen from both bottles to the O₂ manifold/g-suit controller on the left leg of the ACES. The system is activated by pulling the “green apple” activation knob on the right side of the harness below the LPU. See Figure 2-35, Figure 2-36, and Figure 2-37.

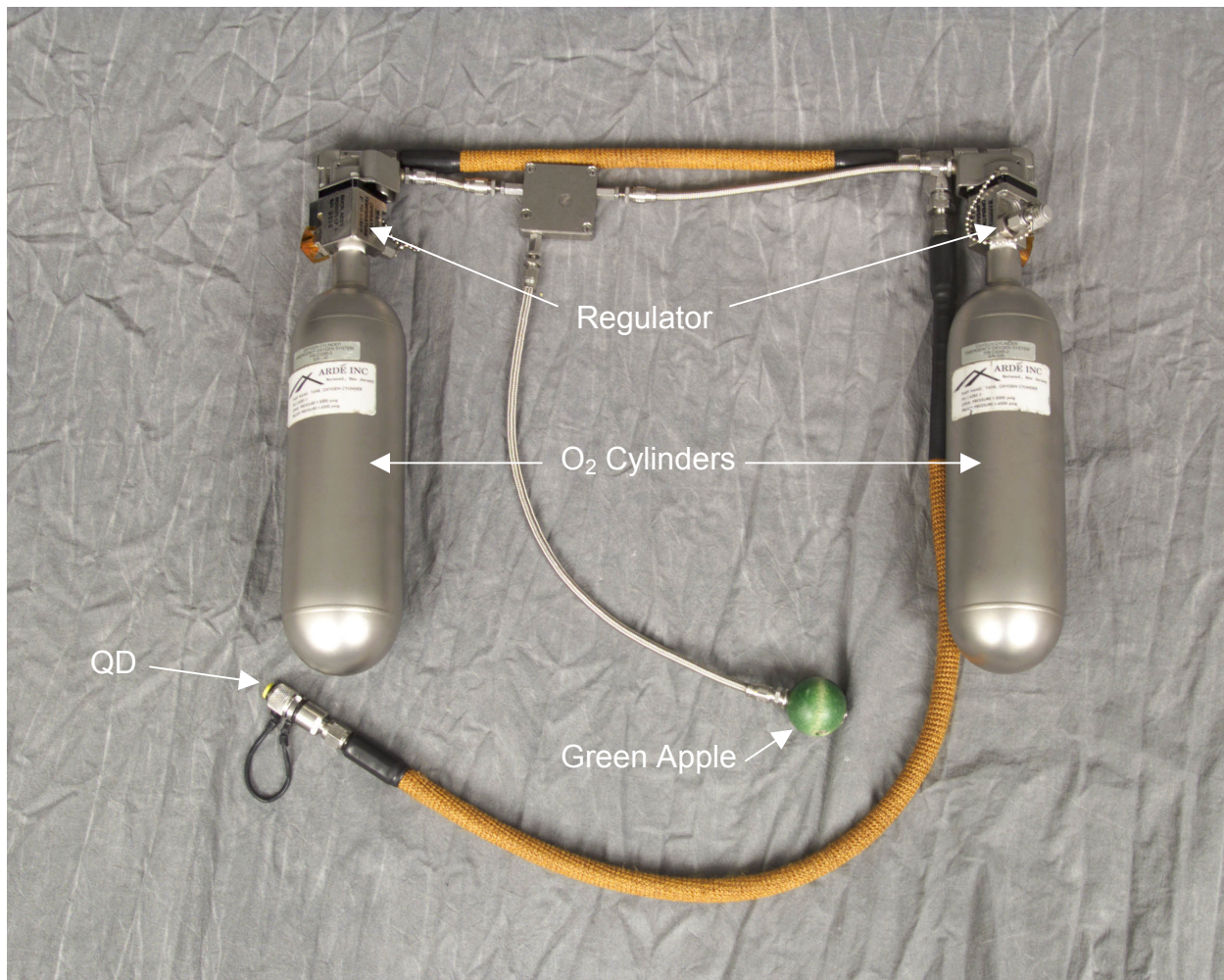


Figure 2-35. Emergency Oxygen System



Figure 2-36. EOS pressure gauge

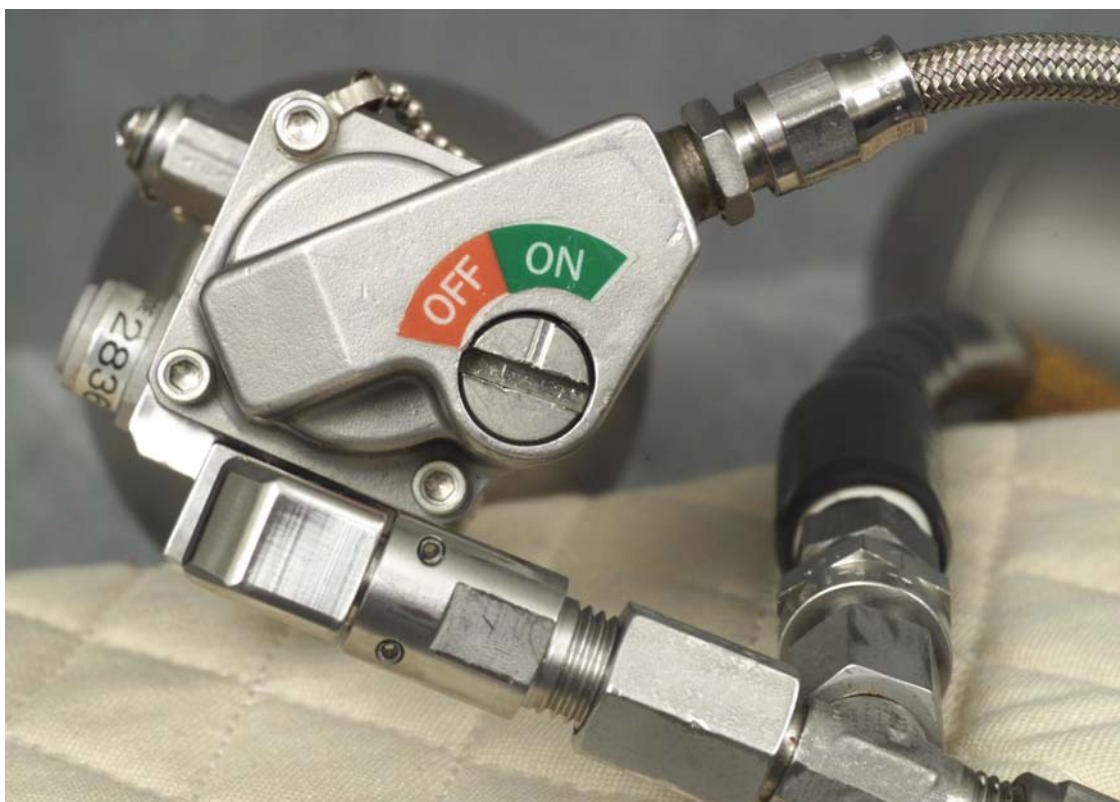


Figure 2-37. EOS valve reset

2.4.2 Drinking Water

Two liters of emergency drinking water are stored in a pack that is attached by Velcro to the rear of the harness. The drinking water consists of 16 individual 0.125-liter foil packets inside a Nomex pack that is tethered to the harness by a 2-foot-long Kevlar cord. The water and pack are shown in Figure 2-38.



Figure 2-38. Drinking water and pack

2.4.3 Life Preserver Unit

The LPU (Figure 2-39) is incorporated onto the parachute harness to provide crewmember buoyancy. The LPU is shaped to provide maximum floatation of the crewmember and is sized to keep the anti-suffocation valve above the water for a 95th percentile American male. The LPU is shown in use in Figure 2-40.



Figure 2-39. Life Preserver Unit

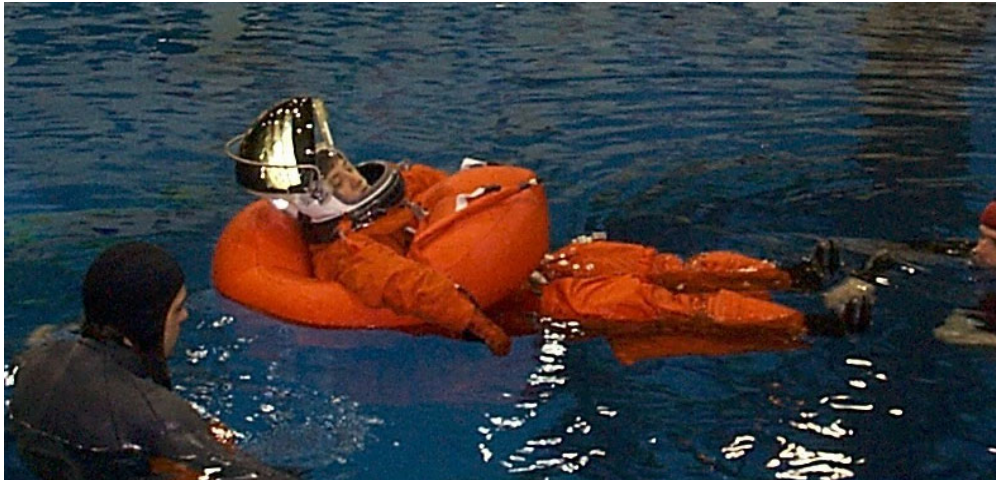


Figure 2-40. LPU in use

The LPU incorporates two FLU-8 CO₂ inflation devices that automatically inflate the LPU upon immersion in water. The LPU can also be manually inflated by pulling inflation lanyards attached to the FLU-8 devices. An oral inflation tube is included to allow the LPU to be inflated or deflated as needed. Twist the knurled collar to the open position and depress the tip valve to operate the oral inflation tube.

2.4.4 Carabiner

A locking carabiner is attached to the left side of the harness above the LPU (Figure 2-41). To unlock/open the carabiner, twist the locking collar counterclockwise and push inward.



Figure 2-41. Carabiner

2.4.5 Frost Fittings and Ejector Snaps

The parachute risers attach to the harness via Frost fittings (Figure 2-42) located on the upper shoulder area. To release the parachute risers, squeeze the Frost fitting latches together and the risers will eject from the Frost fitting.



Figure 2-42. Frost fittings

Ejector snaps on the lower harness leg straps connect to rings on the parachute pack. The ejector snaps are designed to push the parachute rings out of the snaps when disconnecting. See Figure 2-43 and Figure 2-44.



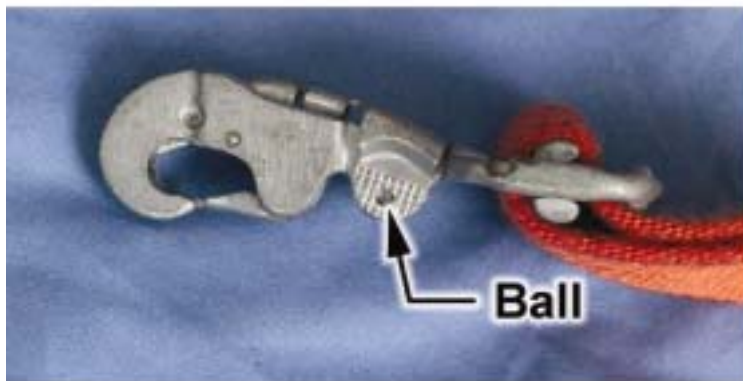
Figure 2-43. Ejector snaps



OPENED



SOFT DOCK



LOCKED

Figure 2-44. Ejector Snap positions

2.4.6 Parachute Harness Technical Information

Technical information about the parachute harness is shown in Table 2-3.

Table 2-3. Parachute harness technical information

Harness information	Technical data
Total weight	20.5 lb
Material	
Webbing	Nylon webbing, MIL-W-4088, type XIII
Vest panels	Nomex fabric with nylon duck between layers
Webbing strength	7000-lb max.
EOS	
Bottle pressure	3000 psi
Delivery pressure	70 psi
Bottle volume	120 in ³
Breathing Time	~10 minutes at sea level (~17 minutes at 25,000 feet)
LPU	
Material	Urethane bladder, nylon restraint layer
Volume	2.2 ft ³ (62.7 liter)
Inflation gas	CO ₂ , 68 g bottles (2 each)
FLU-8	
Buoyancy	138 lb
Drinking water	
Quantity	125 ml packets (16 ea); 2.0 liters total
Manufacturer	DATREX, Inc. Kinder, LA 70648
Carabiner	
Rated strength	2500 lb
Manufacturer	Clogwyn
Material	Aluminum

2.5 PERSONAL PARACHUTE ASSEMBLY

Reference: SSSH drawing 18.6, Personal Parachute Assembly

The PPA (Figure 2-45) is an integrated pack assembly containing the parachutes, risers, and actuation devices required for automatic and manual deployment of the parachutes. The PPA also contains survival equipment in the form of a personal life raft and personal locating beacon. The PPA serves as a seat back cushion during shuttle launch and entry and is placed on the crewmembers' seat prior to ingressing the seat.

The PPA attaches to the parachute harness at four locations, two Frost fittings at the risers and two ejector snaps at the lower pack. To attach the risers, squeeze the Frost fitting tabs together and insert the riser fitting. Release the tabs and ensure proper attachment by verifying that no red can be seen on the tab reflector. Pulling on the risers also verifies proper attachment. For lower PPA attachment, open the harness ejector snaps, insert the PPA rings, and lock the ejector snap latches. To remove the PPA, reverse the attachment procedures.



Figure 2-45. Personal Parachute Assembly

2.5.1 Parachute Components

The following items are contained in the parachute pack:

a. Right riser (Figure 2-46)

D-ring bridle – Connects to the lanyards on the Pole Crew Escape System (PCES). The attach ring and bridle activate the parachute automatic deployment sequence.



Figure 2-46. Right riser components

b. Left riser (Figure 2-47)

1. Ripcord handle – Allows for manual activation of the automatic deployment sequence.
2. Drogue chute release knob (red knob) – Used to manually deploy the main canopy if the automatic actuation device fails.

c. Pyrotechnic Deployment System – A system of manual and automatic pyrotechnic devices used to deploy the parachute and survival equipment. Heavy-duty cutters are used to sever the D-ring bridle/lanyard following pole descent. Light duty cutters are used for deploying the pilot chute. An Automatic Actuation Device (AAD) initiates main canopy deployment at a preset altitude of $14,000 \pm 1,000$ feet. Light duty cutters are also used in the main canopy reefing system and life raft

deployment. Finally, the LPU and the life raft use water-activated pyrotechnics for automatic inflation.



Figure 2-47. Left riser components

- d. Pilot chute – An 18-inch-diameter, spring loaded canopy used to pull the drogue chute from the PPA. During pilot chute deployment, this spring is uncompressed and the pilot chute is launched into the airstream.
- e. Drogue chute – A 4.5-foot-diameter canopy deployed by the pilot chute to stabilize the crewmembers' descent and to arm the AAD.
- f. Main parachute canopy – A Navy 26-foot-diameter modified circular canopy. The main canopy has four anti-oscillation windows and is fitted with a pyrotechnic reefing system to reduce opening shock on the crewmember and the canopy.
- g. Search and Rescue Satellite Aided Tracking (SARSAT) beacon – An emergency radio beacon activated by main canopy deployment.
- h. Life Raft – A modified military LRU-18 one-person life raft with sea anchor, sea dye, bailing cup, and bailing pump. Located in the lower compartment of the PPA, the life raft automatically partially inflates and deploys upon immersion in water. A manual deploy/inflation lanyard is also incorporated into the PPA. The life raft is attached to the PPA with a 12-foot tether to keep the raft within reach of the crewmember.

- i. SEAWARS – Sea Water Activated Release System (SEAWARS) located at the free end of both risers. SEAWARS is used to separate the parachute risers from the harness upon immersion in salt water (Figure 2-48).

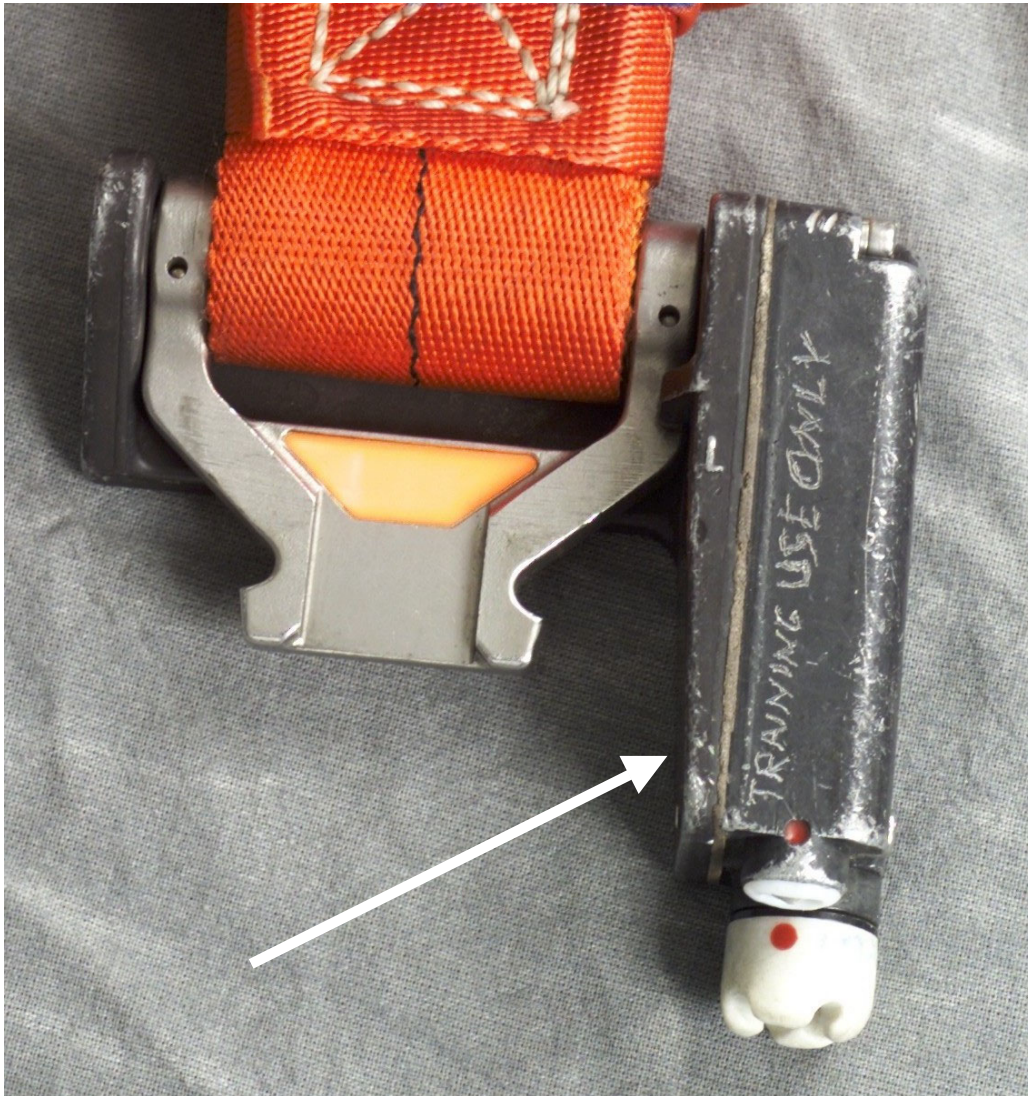


Figure 2-48. SEAWARS

2.5.2 Parachute Deploy Sequence

Applying a minimum force of 150 pounds to the bridle begins the automatic opening sequence for the parachute. This force is applied as the crewmember descends on the PCES during bailout, which fully extends the D-ring bridle. After a 1.5-second delay, the D-ring bridle/lanyard are separated from the PPA via heavy-duty pyrotechnic cutters. During bridle extension, light-duty pyrotechnic cutters are armed and after a 3.0-second delay the light-duty cutters fire. The pilot/drogue chute compartment opens and the pilot chute is launched via an internal, compressed spring. The pilot chute immediately pulls the drogue chute from the PPA, at which time the AAD is armed. The drogue chute acts to stabilize the crewmembers' descent to an altitude of $14,000 \pm 1,000$ feet.

The AAD is a pressure-activated pyrotechnic device with an internal aneroid that is sensitive to atmospheric pressure. When the AAD senses a pressure altitude of $14,000 \pm 1,000$ feet, the pyrotechnic charge fires and releases the drogue chute that pulls the main canopy out of the pack.

The main canopy is initially reefed at 70% to reduce opening shock. Descent velocity is reduced from ~120 ft/sec (free fall under drogue) to 80 ft/sec with the canopy reefed. Two seconds after the main canopy deploys, dual light-duty cutters sever the reefing line, allowing the canopy to open fully. The crewmember descends on the 26-foot-diameter main canopy at a 28-ft/sec descent rate (assuming a 200 lb crewmember).

Manual activation of the automatic deploy sequence can be accomplished by pulling the ripcord handle on the upper left riser. Pulling the ripcord handle performs the same function as the bridle activation by firing a single light-duty pyrotechnic cutter (2-second delay) to deploy the pilot chute. The ripcord handle would be used if the bridle activation failed or if the PCES is not used.

The drogue chute release knob is also located on the left parachute riser. The release knob is used if the AAD fails to deploy the main canopy. Pulling the drogue chute release knob disconnects the drogue chute riser from the parachute pack, allowing the drogue to deploy the main canopy. Figure 2-49, Figure 2-50, and Figure 2-51 show the parachute deployment sequences.

NOTE

The drogue chute release knob will not deploy the main canopy unless the drogue chute has been deployed via the bridle/lanyard or the ripcord handle.

WARNING

Do not pull the drogue chute release knob early or the following problems may occur:

- Opening shock will be more violent.
- Drogue chute will not have time to stabilize crewmember.
- Crewmember will be exposed to a higher altitude for a longer time.
- Crewmember will be blown farther by winds than other crewmembers.

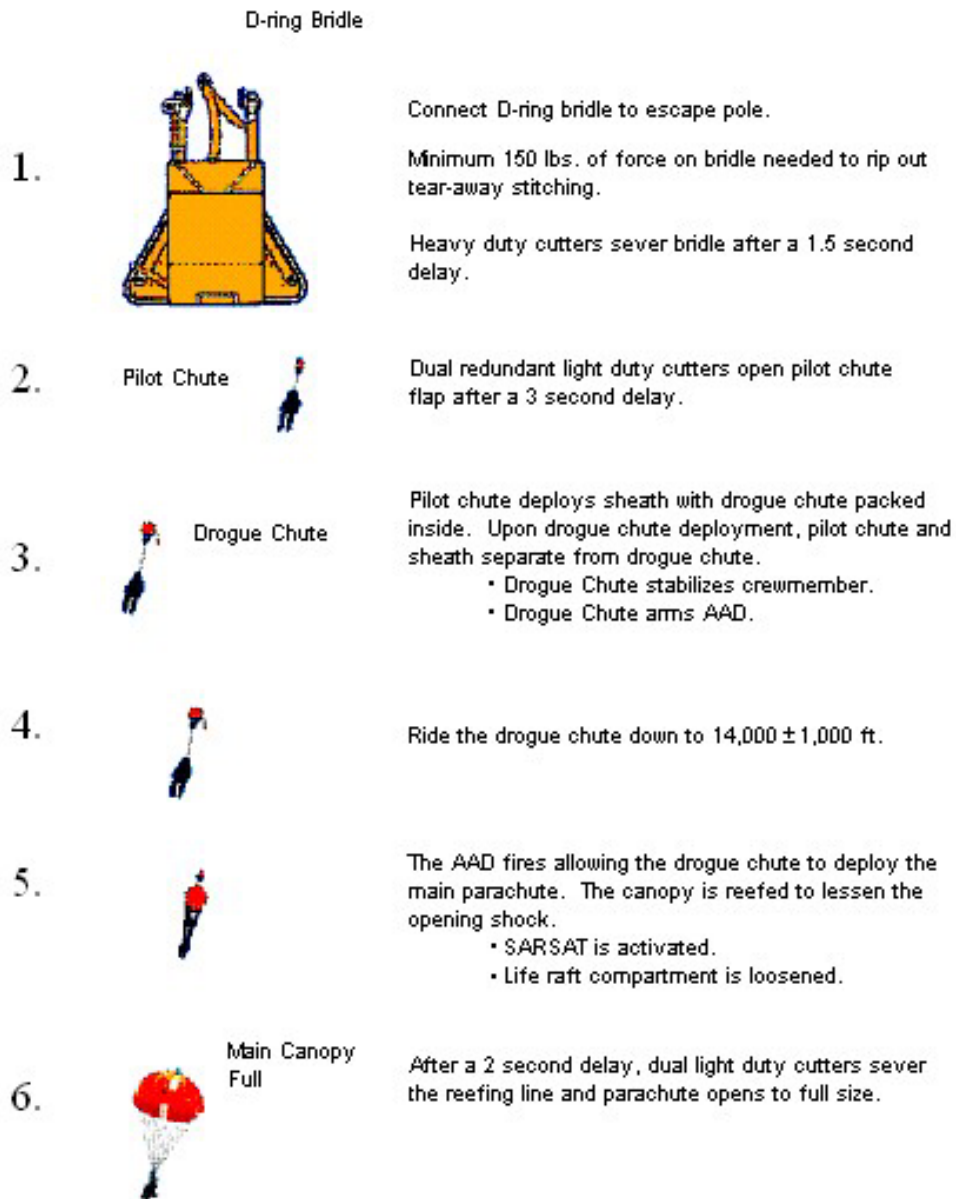


Figure 2-49. Automatic parachute deployment sequence

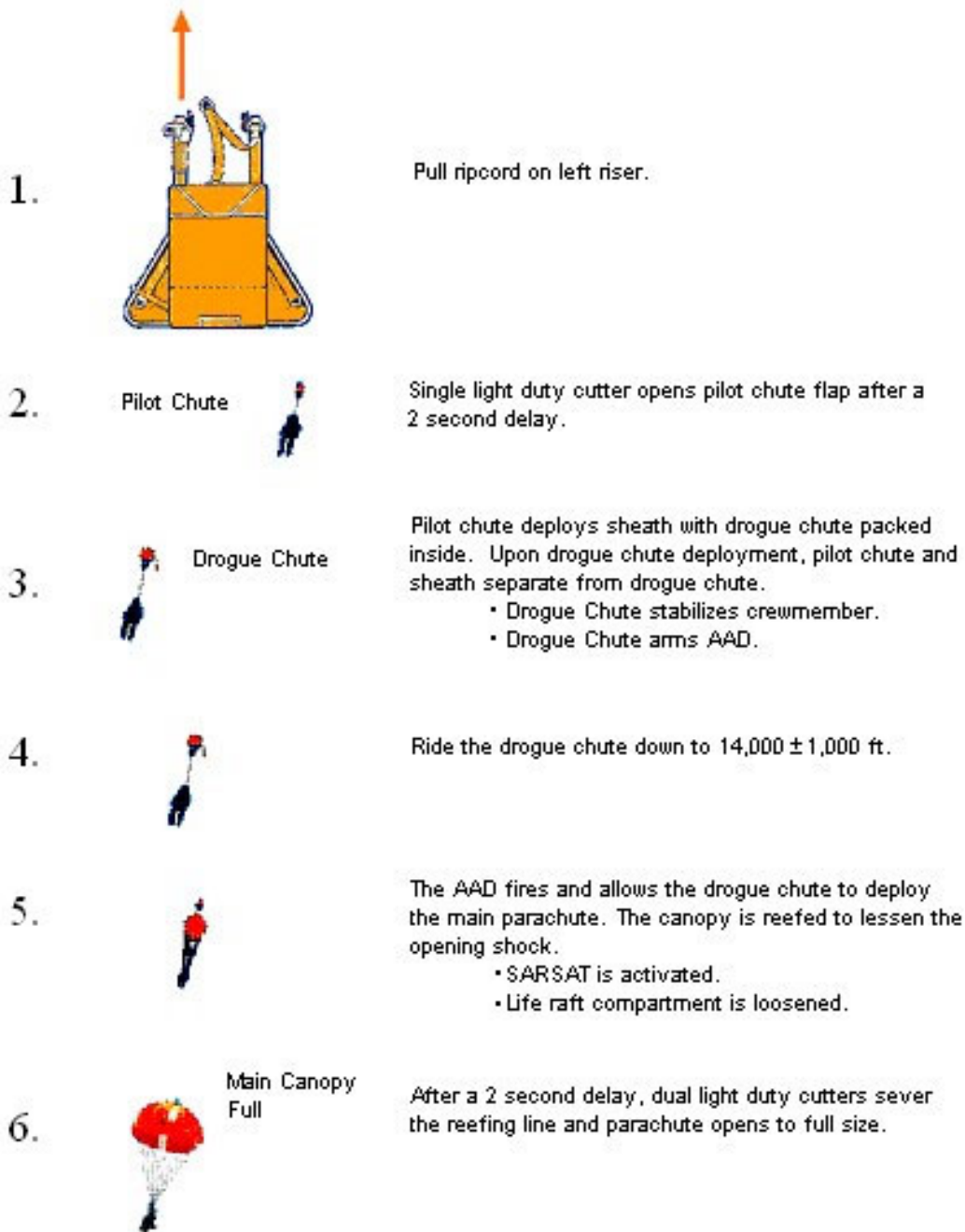
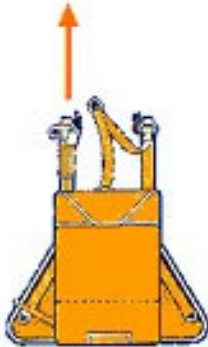




Figure 2-50. Manual parachute deployment sequence


1. 

Slide down the escape pole or pull the ripcord on left riser.


If the escape pole was used, heavy duty cutters sever bridle after a 1.5 second delay.
2.  Pilot Chute

Dual light duty cutters open pilot chute flap after a 3 second delay or a single light duty cutter opens pilot chute flap after a 2 second delay.
3.  Drogue Chute


Pilot chute deploys sheath with drogue chute packed inside. Upon drogue chute deployment, pilot chute and sheath separate from drogue chute.

 - Drogue Chute stabilizes crewmember.
 - Drogue Chute arms AAD.
4. 

Pull Drogue Chute Release Knob to deploy main parachute.

NOTE: Red Knob allows drogue chute to deploy parachute whether or not ripcord is pulled.
5. 

The main parachute is deployed. The canopy is reefed to lessen opening shock.

 - SARSAT is activated
 - Life raft compartment is loosened
6.  Main Canopy Full

After a 2 second delay, dual light duty cutters sever the reefing line and parachute opens to full size.

Figure 2-51. Parachute using the Red Knob

2.5.3 Operational Notes for Water Entry

Preparation for water entry after bailout entails manually inflating the LPU. After water entry, the SEAWARS will release the parachute risers from the crewmember's harness; if not, the risers can be released manually using the Frost fittings. The life raft should also deploy and partially inflate upon water entry. If it does not, the crewmember can

deploy and partially inflate the raft manually by pulling the life raft inflation lanyard located on the bottom left of the pack.

2.5.4 PPA Technical Information

Technical information about the PPA is shown in Table 2-4.

Table 2-4. PPA technical information

PPA information	Technical data
Weight (incl. all components)	26.2 lb
Pilot chute Size/type Descent rate	18-in. diameter, internally vaned and spring deployed N/A
Drogue chute Size/type Descent rate	4.5-ft diameter, ribless guide surface, 12 suspension lines with 400 lbf tensile strength each 120 ft/sec
Main canopy Size/type Descent rate	Navy 26-ft-diameter modified round Nylon with Kevlar reinforcement, bias gore conical construction, 22 suspension lines with a tensile strength of 400 lbf each, 4 anti-oscillation windows 80 ft/sec reefed* 28 ft/sec unreefed* (*at sea level with 200-lb crewmember)
Rip cord handle Activation force	17 ± 9 lb
Light-duty cutters Time delay Operating temps Operating pressure DOT Classification Cutting capacity	3.0 sec nominal 2.0 sec minimum 4.0 sec maximum -40° to 160° F 14.7 to 1.0 psia “C” explosive 2000-lb Kevlar line or 750-lb nylon line

Table 2-4. PPA technical information (concluded)

PPA information	Technical data
Automatic Actuation Device (AAD) Power Force at actuator cable Cable retract travel Operating temps Operating pressure	MK5 MOD 2 delay cartridge 80 lbf (min.) 2.25 in. min. 2.50 in. max. -40° to 160° F 14.7 to 1.0 psia
Bridle/lanyard deploy system Activation force	150 lb (force required to break tacking cords to allow bridal extension)
Heavy-duty pyrotechnic cutters Number Time delay Operating temps Operating pressure DOT classification Cutting capacity	2 each 1.5 sec nominal 1.0 sec minimum 2.5 sec maximum -40° to 160° F 14.7 to 1.0 psia "C" explosive 6000-lb Kevlar line
SEAWARS Number Weight (each) Power Initiating mechanism Time delay DOT classification	2 each 250 grams Two 24-volt alkaline (MnO ₂) batteries Sea water only 1.2 to 1.4 sec "C" explosive

2.6 SURVIVAL/SAR EQUIPMENT

Reference: SSSH drawing 18.5 (sheet 1 of 3), Survival Gear

Each crewmember carries survival equipment in pockets located on each leg (Figure 2-52 and Figure 2-53). This equipment is supplied to enhance survivability during water evacuation and to allow the crewmember to signal SAR forces. Survival/signaling equipment is also stowed in the PPA and the parachute harness.



Figure 2-52. Survival pack A



Figure 2-53. Survival pack B

2.6.1 Anti-Exposure Provisions

The ACES is designed to protect the crewmember from exposure to extreme atmospheric conditions. The outer orange covering is made of fire-resistant Nomex that protects against heat and flame. The ACES also insulates the crewmember from a cold environment caused by bailout at high altitude and immersion in cold water. The crewmembers wear two layers of undergarments: lightweight long underwear and a heavyweight LCG for further insulation. Heavy socks are worn inside the boots for foot protection.

When properly sealed, the neck dam, main sealing zipper, BIP plug, and gloves keep water from entering the ACES. The vent connector elbow has a water-sealing closure to prevent water from entering the cooling air inlet.

NOTE

The gloves must be worn during water operations. Removing the gloves will allow water to enter the suit.

Exposure mittens are included in each leg pocket with the survival gear for additional hand protection (Figure 2-54).



Figure 2-54. Exposure mittens

2.6.2 Signaling Devices

The following nonelectronic signaling devices are stowed in the lower leg pockets. Each piece is packed inside and tethered to a survival packet; the packets are tethered inside the ACES leg pockets. Technical data for the following hardware are found in Table 2-6.

- a. Strobe light – A high-intensity, battery-powered strobe light is stowed in the left leg pocket (Figure 2-55).



Figure 2-55. Strobe light

- b. Pen-gun Flares – A pen-gun firing device and seven flares are stowed in the left leg pocket (Figure 2-56 and Figure 2-57).



Figure 2-56. Pen-gun flare kit



Figure 2-57. Pen-gun with flare

- c. Signal mirror – One signal mirror is stowed in the right leg pocket. Instructions for use are located on the back (Figure 2-58).



Figure 2-58. Signal mirror

- d. Day/night signal flare – One signal flare is stowed in the left leg pocket. One end has a high intensity flare for night use; the other end has a smoke signal for day use (Figure 2-59).



Figure 2-59. Day/night signal flare

- e. Sea dye – Two packages of sea dye are carried (Figure 2-60). One is located with the sea anchor and automatically wicks dye when deployed. The other is stowed inside the life raft bailing cup and can be deployed at the crewmember’s discretion.



Figure 2-60. Sea dye packages

2.6.3 Knife

The knife has a hooked shroud line cutter for cutting the parachute suspension lines. The knife also has a switchblade that is taped shut (Figure 2-61).



Figure 2-61. Knife

2.6.4 High-Intensity Chemlight

Two high intensity chemlights are stowed in the lower left leg pocket. They are standard, off-the-shelf, 24-hour, green chemlights (Figure 2-62).



Figure 2-62. 24-hour high intensity green chemlight

2.6.5 Life Raft

The one-person modified military LRU-18 life raft (Figure 2-63) is stowed in the bottom portion of the PPA. A “daisy chain” holds the bottom portion of the pack closed until tension is applied to the left main parachute riser. This tension activates two redundant light-duty pyrotechnic cutters that cut through the daisy chain securing line and allows the pack to open. The raft remains in the pack until water entry. Upon water entry, a FLU-9 pyrotechnic device activates the lower of two CO₂ cartridges (Figure 2-64) and partially inflates the raft. Inflating the raft deploys it from the PPA. The raft can be inflated and deployed manually by pulling the life raft inflation lanyard on the lower left side of the PPA. This lanyard pulls a curved pin releasing the daisy chain and activates the FLU-9. The other CO₂ cartridge (FLU-1) is manually activated.

The raft consists of eight rows of tubes. Rows 2, 3, and 4 (from the top) are interconnected and inflated by the lower CO₂ cartridge (FLU-9) giving the raft shape and initial buoyancy. Row 1 and rows 5 through 8 are interconnected and manually inflated by the upper CO₂ cartridge (FLU-1). These five tubes provide additional flotation and stability for the raft.



Figure 2-63. Life raft

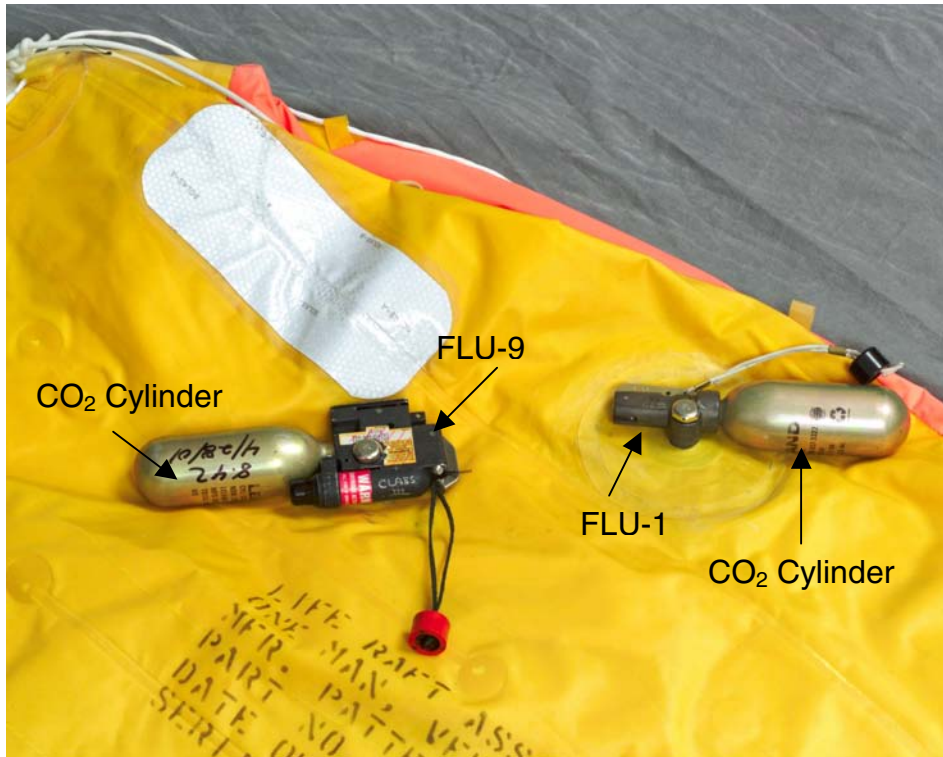


Figure 2-64. FLU-9 and FLU-1 inflation devices

Two oral inflation tubes (Figure 2-65) are provided to allow the crewmember to add buoyancy to the raft, if required.



Figure 2-65. Raft oral inflation tubes

A sea anchor and sea dye marker (Figure 2-66) are attached to the raft by a 64-in. (5 ft 4 in.) nylon cord. Deploying the sea anchor keeps the raft perpendicular to the waves and prevents the raft from drifting away from the predicted search area. Deploying the sea anchor also deploys a sea dye package that is designed to automatically wick dye when placed in the water. The sea dye produces a green fluorescent slick highly visible by SAR forces.



Figure 2-66. Sea anchor and sea dye marker

The raft package includes a bailing cup and bailing pump (Figure 2-67) for removing water from the raft. Both are tethered to the inside of the raft. Inside the raft is an additional sealed package of sea dye (Figure 2-68).



Figure 2-67. Raft bailing pump and bailing cup



Figure 2-68. Sea dye marker (sealed)

The raft may be closed and sealed by two spray shields (Figure 2-69). The left and right shields Velcro together down the middle to prevent additional water from entering the raft and to provide additional shelter to the crewmember. Reflective tape is attached to the spray shield surface to increase visibility in the dark, and a SARSAT radio beacon is stowed in a pocket on the outside of the left spray shield.



Figure 2-69. Life raft spray shield

2.6.6 AN/PRC-112 Survival Radio

The AN/PRC-112 survival radio provides voice and beacon capability between the crewmember and SAR forces. The radio also provides range and bearing information to aircraft supplied with interrogator-equipped avionics systems and provides for specific personnel identification. The radio is shown in Figure 2-70.



Figure 2-70. AN/PRC-112 survival radio

The AN/PRC-112 is stowed in the right lower leg pocket of the ACES.

All controls to operate the radio are easily accessible (Figure 2-71 and Figure 2-72). The transceiver is designed for rugged operational environments and is waterproof.

The AN/PRC-112 radio has five operator-selectable frequencies and two beacons (Figure 2-72).

- a. 282.2 MHz – (UHF) Allows for voice transceiver operation or interrogation by the Personal Locator System (PLS) avionics on 282.8 MHz. This is the NASA primary SAR operations frequency and the AN/PRC-112 will be packed in this position.
- b. 121.5 MHz – (VHF) Allows voice transceiver operation on the international aviation distress frequency on 121.5 MHz. Uses line-of-sight transmission.
- c. 243 MHz – (UHF) Allows for voice transceiver operation or interrogation by the PLS avionics on the military aviation distress (guard) frequency.

- d. A – Preprogrammed to the orbiter Air-to-Ground (A/G) frequency of 259.7 MHz. (UHF) Allows for voice transceiver operation or interrogation by the PLS avionics on the pre-programmed frequency. Used as the secondary SAR frequency.
- e. B – Preprogrammed to the orbiter frequency of 236.0 MHz. (UHF) Allows for voice transceiver operation or interrogation by the PLS avionics on the preprogrammed frequency. Used as the backup SAR operations frequency.
- f. 121.5 BCN – Transmits a swept tone beacon signal on the international aviation distress frequency. Channel/mode selector must be depressed to rotate to this position.
- g. 243 BCN – Transmits a swept tone beacon signal on the military aviation distress (guard) frequency. Channel/mode selector must be depressed to rotate to this position.



Figure 2-71. PRC-112 PTT switch



Figure 2-72. PRC-112 frequency select

The signals are radiated with a unique high-efficiency, mechanically-rigged whip antenna.

A 3-inch-long piece of Kapton tape is placed over the ON/VOL rotary switch to prevent inadvertent operation while stowing and unstowing the radio in the pouch. An earpiece and spare antenna (Figure 2-73) are stowed in a small pouch attached to the radio strap.



Figure 2-73. Earpiece and spare antenna

A lithium battery (Figure 2-74) attached to the bottom of the radio provides power for 24 hours. There is no spare for this battery.



Figure 2-74. PRC-112 lithium battery

2.6.7 Operational Comments for AN/PRC-112

- a. Antenna – Unsnap from retaining snap and rotate to vertical position.
- b. Channel/Mode Selector – Rotate to the desired channel frequency and mode as shown on the channel/mode indicator.
- c. VOL/OFF – Rotate clockwise to turn the radio ON and adjust the volume. Rotate counterclockwise to turn the radio OFF.
- d. PTT (Push-to-Talk) Switch – Press to transmit voice (not used in beacon or transponder modes) and release to listen.
- e. Distance Measuring Equipment (DME) – The self-contained transponder is activated by an interrogated Identification (ID) code sent by the SAR forces and responds by keying the transmitter in the same frequency. DME indicator is a flashing green Light-Emitting Diode (LED) used to indicate the interrogation of the radio by the PLS avionics system.

Table 2-5 lists the radio ID codes.

Table 2-5. AN/PRC-112 ID codes

Position	Color	Transponder ID
CDR	Red	000001
PLT	Yellow	000002
MS1	Blue	000003
MS2	Green	000004
MS3	Orange	000005
MS4/PS1	Brown	000006
MS5/PS2	Purple	000007
MS6/PS3	Beige	000008
MS7/PS4	Black	000009
MS8/PS5	Light gray	000010

2.6.8 SARSAT Beacon

The SARSAT radio beacon mounted on the left spray shield of the life raft provides position data and personnel information to SAR forces. The beacon is activated upon main parachute deployment and automatically transmits position/ID information to within 1 minute of accuracy during descent and water survival operations. See Figure 2-75 and Figure 2-76.



Figure 2-75. SARSAT beacon

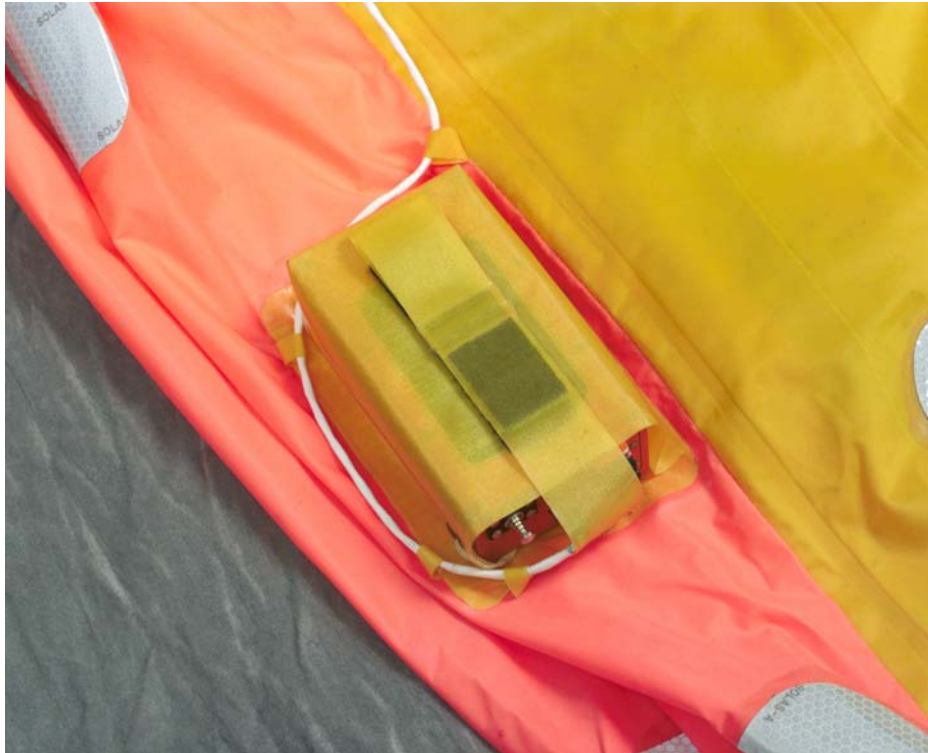


Figure 2-76. SARSAT beacon pouch

The beacon transmits on the following three frequencies:

- 121.5 MHz – International aviation distress frequency
- 243.0 MHz – Military aviation distress (guard) frequency
- 406.0 MHz – SARSAT distress frequency

Once the beacon is activated, each signal can be received by a constellation of satellites used in search and rescue and is transmitted back to receiving stations called Local User Terminals (LUTs). The receiving satellite can store the 406.0 signal and send it to the LUT when both are within line-of-sight of each other. The satellite cannot store the 121.5 and 243.0 frequencies; the beacon-to-satellite and satellite-to-LUT must each be within line-of-sight of each other.

The SARSAT beacon transmits a 15-digit, hexadecimal coded string. Each digit gives specific information regarding that specific SARSAT beacon. Personnel at the LUT receiving the coded string can determine to whom each beacon signal belongs by reading the beacon serial number. Coded within the string is the two-letter code AA that stands for American Astronaut. Upon receiving this code, the LUT sends faxes to the following three locations:

- Shuttle Operations Center (SOC) at Patrick Air Force Base, Florida (PAFB)

- Mission Control Center (MCC) at Lyndon B. Johnson Space Center (JSC)
- Ellington Field, Houston, Texas (sent in case a unit is malfunctioning/turned on by mistake)

The NASA SARSAT encoded message begins with bit 25 and goes through bit 85. All the NASA SARSAT beacons have the same values for all bits, with the exception of bits 52 to 63, which correspond to the unit serial number.

Bit number	Meaning
25	0 = short message (not part of the NASA 15-character hex code)
26	1 = no location provided in message (GPS use only)
27-36	Country code: USA = 366
37-39	Beacon type (ship, aircraft, personal): personal protocol = 3
40-43	12 = personal locator beacon
44-51	Manufacturer's number: Telonics = 1
52-63	Serial number (S/N): For this example S/N = 280
64-67	Beacon model number: NASA beacons = 3
68-75	Production run number: NASA beacons = 1
76-83	Normally blank: NASA's beacons use AA ("1010 1010" in binary) for American Astronaut
84-85	Homing beacon 121.5 MHz installed: Yes = 1

Bit no.	26	27-36	37-39	40-43	44-51	52-63	64-67	68-75	76-83	84-85
Decimal value	1	366	3	12	1	280	3	1	"AA"	1
Binary code	1	010 1101 110	0 11	11 00	00 0000 01	00 0100 0110 00	00 11	00 0000 01	10 1010 10	01

Binary code (4-bit groupings)	1010	1101	1100	1111	0000	0000	0100	0100	0110	0000	1100	0000	0110	1010	1001
Hexadecimal code	A	D	C	F	0	0	4	4	6	0	C	0	6	A	9

Therefore, the 15 hex message for the above beacon is ADCF004460C06A9.

Notes:

1. Bits 52-63 are the only ones that vary among the NASA beacons, so only the 7th, 8th, 9th, and 10th characters of the hex code vary.
2. Because the first two bits of the 7th character are fixed at "01," it will be either "4," "5," "6," or "7." However, as long as the serial numbers are less than 1023 (decimal), the 7th character will be a "4."
3. The 8th and 9th characters can be any hex code from "0" to "F."
4. Because the last two bits of the 10th character are fixed at "00," it will be either "0," "4," "8," or "C."

2.6.9 Motion Sickness Remedy

Two capsules of Scopdex anti-motion sickness medicine are stowed in survival pack B. The Scopdex consists of 5 mg Dexedrine, and 0.4 mg Scopolamine.

2.6.10 Drinking Water

Survival drinking water is provided as part of the parachute harness assembly. Specific information can be found in Section 2.4.2 and Figure 2-38.

2.6.11 Survival Equipment Technical Information

Table 2-6 contains technical information for the survival equipment.

Table 2-6. Survival equipment technical information

Component	Technical information	
Survival Pack A	Part number (P/N)	SED39119393-305
Day/Night Flare	P/N	1370-01-030-8330
	Manufacturer	TBD
	Model	MK 124 Mod O
	Flare Duration Visibility	20 sec 30 miles
	Smoke Duration Visibility	20 sec 7 miles
	Dimensions	1.64 in. dia./5.38 in. length
	Weight	8.3 oz
Pen-Gun Flare Kit	P/N	MK 79 MOD 2
	Manufacturer	TBD
	Launcher, one each	MK 80 Mod O
	Signal flares, seven each	MK 31 Mod O
	Duration	4.5 sec
	Visibility	50 miles
	Height achieved	Approx 200 ft
Chemical Light Stick, Green	P/N	5-45330201
	Manufacturer	American Cyanamid Co. Milton, FL 32570
	Type	Cyalume lightstick, high intensity, green
	Duration	12 hr
Strobe Light	P/N	034145
	Model	SDU-5/E
	Manufacturer	Fed of Handicapped
	Power	4.5-volt mercury battery
	Service life	6-9 hr continuous use 18 hr intermittent use
	Visibility	50 miles

Table 2-6. Survival equipment technical information (continued)

Component	Technical information	
Survival Pack B	P/N	SED39119382-705
AN/PRC-112 Radio Transmitter	P/N	AN/PRC-112
	Weight	28 oz with battery
	Manufacturer	Motorola
	Dimensions w/ battery	8 in. x 3 in. x 1.5 in.
	Power source	One BA-5112/U sealed lithium battery. 11.25 V
	Service life	24 hr (90 percent receive and 10 percent transmit use)
	Mean Time Between Failure (MTBF predicted)	3133 hr
	Waterproof	To 50 ft
	Operational temperatures	-40° to 55° C
	Storage temperatures	-60° to 95° C
	Frequency range	121.5 MHz, 225 – 299.975 MHz
	Transmit output avg power	1 W – UHF 100 mW – VHF
	Available channels	<ul style="list-style-type: none"> – 121.5 MHz voice/beacon – 243.0 MHz voice/beacon/transponder – 282.8 MHz voice/transponder – Channel A programmed to 259.7 MHz (ground and shuttle A/B freq) voice/ transponder – Channel B programmed to 236.0 MHz (SAR operations) voice/transponder
	Frequency stability	±5 ppm
Modulation modes	AM voice AM swept-tone beacon: 121.5 MHz Transponder mode: BPSK/OOK	
Operating modes	Voice – 121.5, 243.0, 282.8, 259.7, 236.0 Beacon – 121.5 and 243.0 MHz Swept-tone DME transponder – 243.0, 282.8, 259.7, 236.0	

Table 2-6. Survival equipment technical information (continued)

Component	Technical information	
Survival Pack B (continued)		
Signal Mirror	P/N	6350-00-105-1252
	Manufacturer	S. I. Howard Glass
	Model	Mirror, Emergency Signaling, Mark 3
	Visibility	40 miles
	Candlepower	8 million (sunny day)
Motion Sickness Medication	Purpose	Anti-nausea medication
	Ingredients	Scopolamine, 0.4 mg Dexedrine, 5 mg
	Quantity	2 capsules
SARSAT Radio Beacon	P/N	TBD
	Manufacturer	Telonics
	Model	TSUB-A
	Dimensions	5.25 in. x 2.825 in. x 1.5 in.
	Weight	19 oz.
	Power source	Four 2/3 A size lithium batteries (waiver required)
	Transmit output avg power	121.5/243.0 MHz – 15-20 Mw 406.0 MHz – 1 W
	Frequencies	406.0 MHz (satellite) 243.0 MHz 121.5 MHz
	Location	Tethered and contained in a pocket on the left-hand spray shield of the personal life raft
	Antennas	7.25 in. telescoping TBD in. flexible

Table 2-6. Survival equipment technical information (continued)

Component	Technical information	
Survival Pack B (continued)		
Life Preserver Unit (LPU)	P/N	TBD
	Manufacturer	Mustang Survival
	Model	TBD
	Description	Circular life preserver
	Size	TBD
	Weight	TBD
	Flotation	138 lb (63 L of H ₂ O)
	Inflation gas	Carbon dioxide (CO ₂)
	Power	12-V alkaline (MnO ₂) battery
	Activation forces (manual)	5 – 27 lbf
	DOT classification	Class “C” explosive
	Cylinder weight	68 grams
	Cylinder pressure	TBD
Time delay	<5 sec	
Exposure Mittens, one pair	P/N	16874G-02
	Material	Neoprene lined
Bailing Cup, one each	Part number	SED39119392-701
	Material	Urethane Coated Yellow Nylon
Bailing Pump	P/N	SED39120480-301
	Manufacturer	TBD
	Type	Fuel siphon
	Length	75 in.
	Tube diameter	1/2 in. outer diameter 1/4 in. inner diameter
Sea Anchor, one each	P/N	TBD
	Material	TBD
	Dimensions	TBD

Table 2-6. Survival equipment technical information (concluded)

Component	Technical information	
Survival Pack B (concluded)		
Sea Dye Marker	P/N	SED33104771-701 with wick SED33104771-703 with no wick
	Manufacturer	TBD
	Type	Fluorescent green
	Quantity	2
	Duration	20-30 min
	Visibility	10 miles at 3000-ft altitude
Life Raft	P/N	SDD40100198-703
	Manufacturer	TBD
	Type	One person
	Material	Polyurethane coated nylon
	Inflation source Cylinder pressure Cylinder weight Gas mass	CO ₂ gas cylinder, 2 each ~839 psia at 70°F 8.2 oz 2 oz
	Inflation device, manual	FLU-1
	Inflation device, automatic Type Power Weight Initiation source Manual activation force DOT classification Initiation delay	FLU-9 12-V alkaline (MnO ₂) battery 150 grams (without battery and cylinder) Fresh or saltwater 5-27 lbf Class "C" explosive <5 sec
	Knife	P/N
Manufacturer		Camillus, New York
Blade type		Hook blade Spear blade, pushbutton deploy
Weight		TBD
Chemical Light Stick, red	P/N	SED39119213

3.0 EMERGENCY PROVISIONS – ORBITER SYSTEMS

3.1 CABIN VENT/HATCH JETTISON

Reference: SSSH drawing 18.7, Side Hatch Jettison

3.1.1 Description

The cabin vent system and hatch jettison system allow the flight crew to quickly and safely egress the orbiter during emergency situations. The cabin vent system consists of pyrotechnics and valves that allow the crew to quickly depressurize the crew cabin to ambient pressure prior to hatch jettison during bailout. Depressurizing the cabin prevents structural buckling of the middeck floor during hatch jettison. The hatch jettison pyrotechnic system ejects the hatch from the orbiter, allowing the crew to bail out or rapidly egress the orbiter after landing. Both pyrotechnic systems use mechanical energy transfer systems that do not require orbiter electrical power.

3.1.2 Cabin Vent System

The purpose of the cabin vent system is to depressurize the cabin at a controlled rate prior to side hatch jettison. This is necessary to prevent severe buckling of the middeck floor that otherwise would occur if the side hatch were jettisoned without any attempt to equalize pressure inside and outside the cabin. If the cabin vent system was operated at an altitude of 40,000 feet, it would take approximately 75 seconds for the cabin pressure to equalize with ambient pressure. Equalization would occur at approximately 31,000 feet.

The cabin vent system pyrotechnics consist of redundant linear-shaped charges that blow out a plug in the $X_0=576$ bulkhead of the crew pressure cabin behind the Waste Collection System (WCS). Cabin pressure then vents through a 2.47-inch-diameter and a 3.47-inch-diameter hole (combined area $\sim 15 \text{ in}^2$) into the orbiter payload bay. A Kevlar debris net catches the panel to prevent flying debris damage in the payload bay. Because the cabin vent pyrotechnics introduce a flame source into the payload bay, the system is used only during in-flight bailout.

3.1.3 Hatch Jettison System

The hatch jettison system is designed to sever the side hatch hinges, separate the hatch adapter to which the hatch is latched, and eject the hatch away from the vehicle. Four linear-shaped charges (two per hinge) cut through the hinge arms near the hatch. Two Expanding Tube Assemblies (XTAs) are used to fracture the 70 frangible bolts that hold the hatch adapter to the vehicle. Three thruster assemblies mounted inside the hatch opening eject the hatch/adapter assembly from the vehicle at 45 ft/sec. The hatch jettison system could be used in a bailout or landing emergency.

3.1.4 Initiator T-Handles

Separate T-handle initiators located on the forward port middeck floor activate the cabin vent and hatch jettison systems. The T-handles are located inside a pyrotechnic initiator box that is accessible to the crewmember seated in seat 5 (Figure 3-1). Squeezing together two latches on the top opens the pyro box. A safing pin (Figure 3-2) is used to secure the box during on-orbit operations. The safing pin is removed prelaunch by crew insertion personnel and given to the occupant of seat 5. During postinsertion activities, the pin is reinserted into the box. The pin is again removed prior to deorbit and reinserted soon after wheel stop. The convoy crew will not approach the orbiter vehicle unless the crew has reported “pyro box secure” or “side hatch safed.”



Figure 3-1. Hatch jettison pyrotechnic initiator box



Figure 3-2. Pyro box safing pin

The T-handle initiators are connected to their respective systems via redundant lengths of shielded detonating cord.

The aft T-handle activates the cabin vent system. Removing a red safing pin, squeezing the handle, and pulling the handle free initiates the pyrotechnic sequence. A pull force of 20-50 pounds is required to activate the pyro system.

The hatch jettison T-handle is located immediately forward of the vent handle. The hatch jettison handle has a cloth covering and a heavier, ribbed handle than the vent handle. Hatch pyrotechnic initiation is the same as for the cabin vent system. See Figure 3-3 and Figure 3-4.

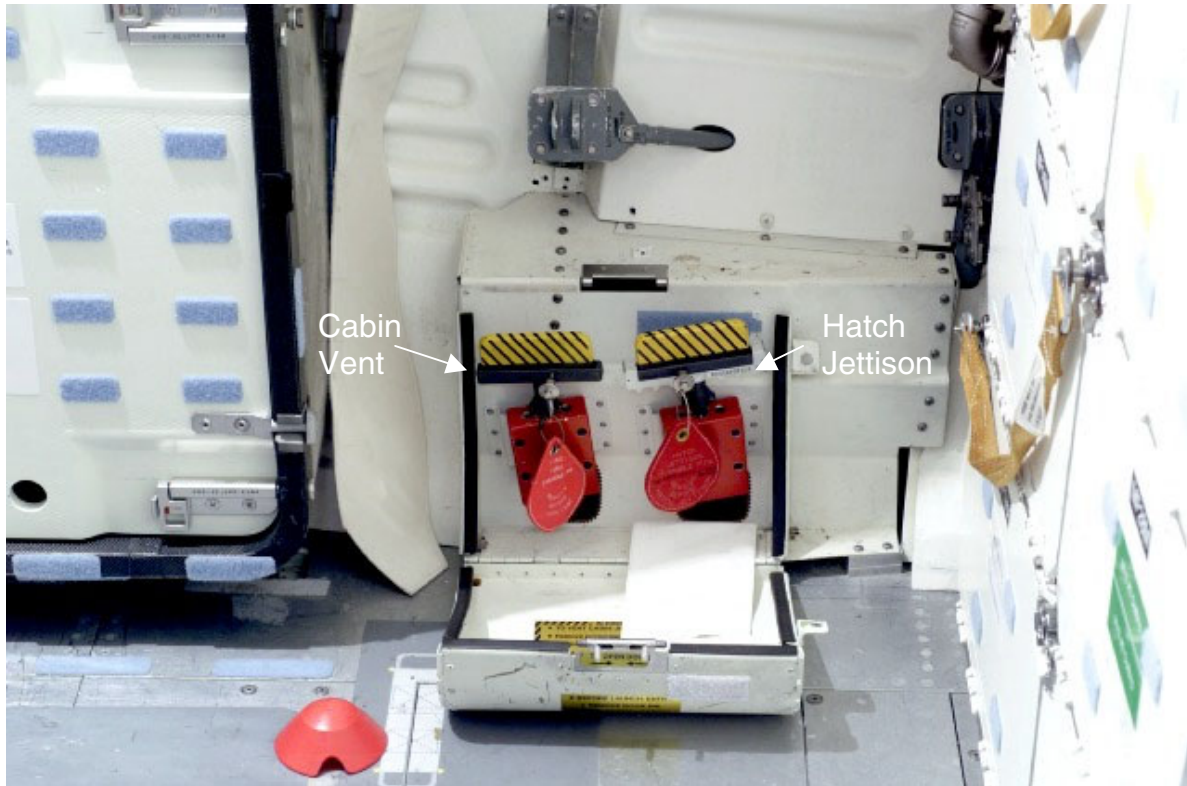


Figure 3-3. Cabin vent and hatch jettison T-handles



Figure 3-4. Pyro handle pip pins

Pyrotechnic system technical information is listed in Table 3-1.

Table 3-1. Cabin vent pyrotechnic system technical information

Cabin vent system item	Technical information
T-handle Pull force Location	20-50 lbf Port forward middeck floor (below galley)
Vent size	2.47-in. diameter 3.47-in. diameter ~15 in ² total area
Depress time (14.7 to 4.2 psi)	Approx. 75 sec

3.2 CREW ESCAPE POLE

3.2.1 Crew Escape Pole Description

The purpose of the crew escape pole is to guide the crewmember under the left wing when bailing out of the orbiter.

The escape pole consists primarily of a curved, spring-loaded, telescoping steel and aluminum cylinder. The pole is contained in an aluminum housing that attaches to the orbiter middeck ceiling and hatch tunnel area.

A magazine containing eight crew lanyards is attached to the port end of the pole housing near the side hatch tunnel (Figure 3-5). In the event of bailout, the crewmember extends the D-ring bridle from his/her parachute pack and attaches it to a snap hook on the outermost lanyard. As the crewmember egresses the orbiter, the pole directs him/her beneath and away from the vehicle. Upon bailout, the forces on the lanyard and bridle initiate automatic parachute deployment.

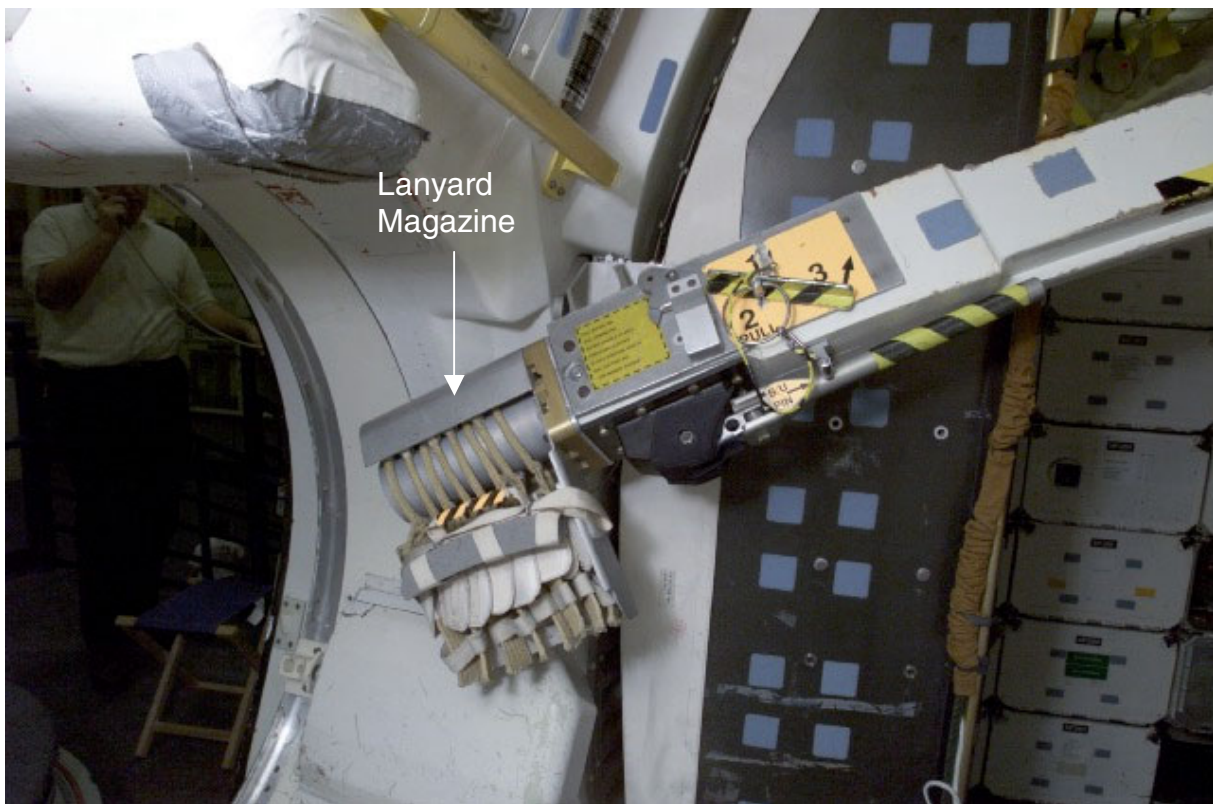


Figure 3-5. Escape pole lanyard magazine

3.2.2 Crew Escape Pole Operational Comments

For launch and entry, the port end of the pole is mounted to the port bracket assembly by a nonrotating pin. The nonrotating pin is installed from the bottom of the port bracket and is secured by a spring-loaded side pin and a latch that slides over the end of the nonrotating pin at the top of the bracket (Figure 3-6). The starboard end of the pole is secured to the middeck ceiling via a pip pin secured with a hitch pin (Figure 3-7). Both the nonrotating pin and the pip pin are tethered to the pole near their respective mounting brackets. In case of loss, a spare starboard pip pin is stowed in the postinsertion locker. No spare is flown for the nonrotating pin.



Figure 3-6. Escape pole port mounting bracket



Figure 3-7. Escape pole starboard mounting bracket

Pole deployment is purely mechanical; i.e., no orbiter electrical power is required and no pyrotechnics are used. The pole is deployed by removing a safing pin and an arming pin, then rotating the deployment handle counterclockwise. A wide green stripe appears around the pole near the magazine if it has deployed sufficiently. If the pole does not deploy fully and the green stripe is not visible, the pole may be manually extended. To manually extend the pole, remove the ratchet handle pip pin and cycle the ratchet handle up and down until the green strip is seen. The ratchet handle hinges down 100° and is spring-hinged away from the egress path. Each upward stroke of the ratchet handle extends the pole 4 inches taking approximately 25 strokes to fully deploy the pole. The time to fully extend the pole using the manual ratchet is about 30 seconds, depending on operator speed. See Figure 3-8.

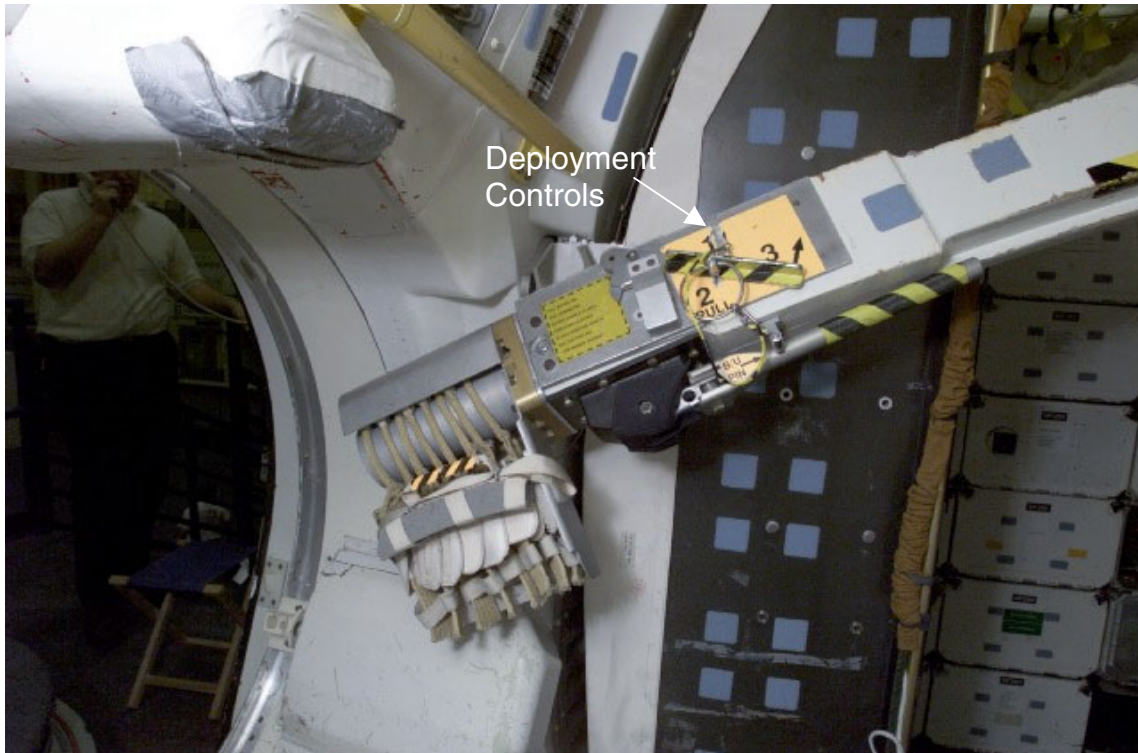


Figure 3-8. Escape pole deployment controls

During post insertion activities, the pole is stowed on the ceiling of the middeck. There are three positions in which to stow the pole and each is determined by the configuration of the middeck. Two or three straps attach the pole to the middeck ceiling; two foam pads are placed between the pole and the ceiling for standoffs.

The lanyard magazine contains a total of eight lanyards, regardless of crew size. A spring-loaded retention clip at the top of the magazine prevents the lanyards from accidentally falling out. Each lanyard has a small fabric hook cover sewn onto it that hides the hook of the lanyard behind it. The hook cover ensures that the crewmember attaches to the outermost lanyard in the magazine.

Once the pole is deployed, the first crewmember to bail out must remove the lanyard retainer strap from the magazine. The retainer strap is held in place with Velcro and is removed by pulling the cloth loop handle. Next, the crewmember must expose and extend the D-ring bridle on his right parachute riser, connect the D-ring to the pole lanyard snap hook, and release the lanyard from the magazine. The crewmember should perform these tasks before entering the hatch tunnel for bailout. This is to ensure that the crewmember does not fall out of the hatch tunnel before attaching to a pole lanyard.

3.2.3 Crew Escape Pole Contingencies

Inadvertent pole deployment is prevented by the arming pin that passes through the deployment handle, the pole housing, and the main and extension poles.

It is unknown what would happen if the pole were to deploy inadvertently. The Failure Mode and Effects Analysis (FMEA)/Critical Items List (CIL) for the pole assumes loss of vehicle and crew, but that is probably an unrealistic worst case. The best case would be loss of bailout capability, but damage of some sort to the interior of the vehicle seems likely.

Corrective actions for pole failures or contingencies can be obtained from the DX33 Crew Systems group.

3.2.4 Crew Escape Pole Technical Information

Technical data for the crew escape pole is shown in Table 3-2.

Table 3-2. Crew escape pole technical information

Escape pole component	Technical data
Weight	267 lbm
Spring force	
Main pole	375 lbf
Extension pole	42 lbf
Rate of extension	17 ft/sec
Pole deployment energies	
Main pole	3800 in-lb
Extension pole	900 in-lb
Length	
Extension pole	32 in.
Main pole	103 in.
Overall (extended)	135 in. (~11 ft 3 in.)
Housing length	126 in.
Magazine	9 in.
Pole diameter (outside)	
Extension pole	2.25 in.
Main pole	3.0 in.
Housing dimensions	126 in. x 9 in. x 9 in.
Stow/install time	10 min (2 crewmembers)

3.3 EMERGENCY EGRESS SLIDE SYSTEM

Reference: SSSH drawing 18.3, Emergency Egress Slide/Sky Genie

3.3.1 Description

The Emergency Egress Slide System (EESS) provides a means of postlanding emergency and contingency egress from the orbiter. The EESS consists of the inflatable slide, argon inflation cylinder, support assembly, slide storage cover, and valise. See Figure 3-9. The slide can be deployed with the side hatch either opened manually or jettisoned. The preferable practice is to manually open the side hatch for EESS deploy rather than jettison the side hatch because of the resulting damage to the orbiter and the potential for hazards from ignition sources or contact from the hatch.

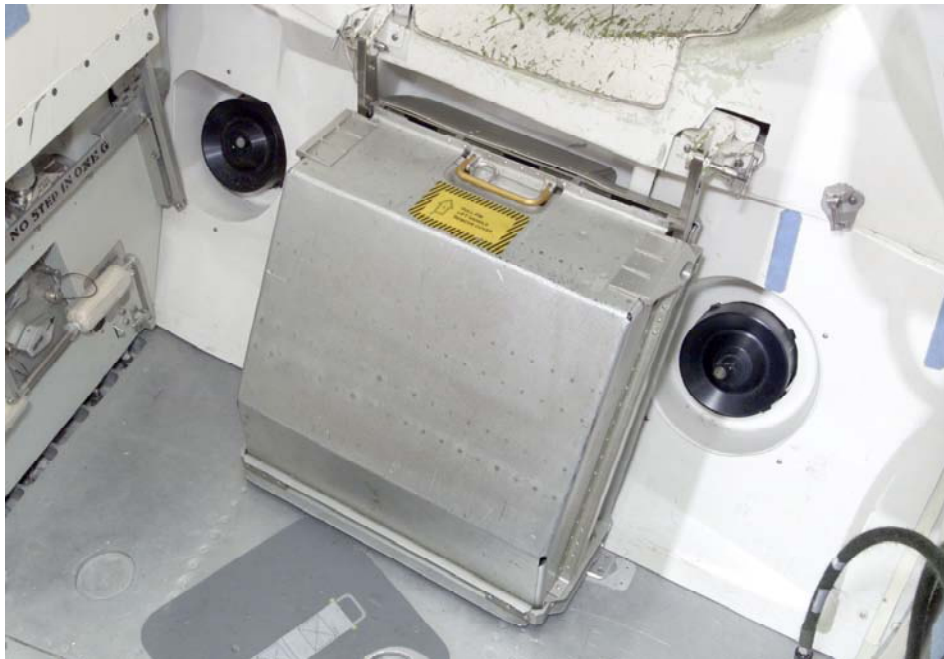


Figure 3-9. Egress slide stowage

3.3.2 Slide Assembly

The slide assembly consists of an inflatable tube assembly constructed of neoprene-coated nylon fabric. The sliding surface consists of a conductive urethane-coated nylon fabric. The tube assembly is attached to the slide support assembly with a fabric girt that loops around the girt bar. When deployed, the slide inflates to its full length (190 in.) to reach ground level from the side hatch opening. The slide assembly may be detached from the orbiter by pulling a detach line located on the aft tube.

A pressure relief valve is installed in each slide assembly to prevent overinflation. The pressure relief valve contains a poppet valve that vents excess slide pressure to the

atmosphere. The valve is set to open at 3.00 ± 0.25 psig; it is set by means of an adjusting screw.

3.3.3 Charged Cylinder Assembly

A charged cylinder assembly, consisting of a stored gas pressure vessel and regulator, inflates the tube. When actuated by pulling the inflation lanyard, 400-psia argon gas flows through a hose to an aspirator that entrains approximately four times the stored gas with air.

The pressure bottle contains 155 in^3 of argon gas at 3000 psia, which is approximately 18 ft^3 at standard temperature and pressure or about 1 percent of the total crew compartment volume. If the entire contents of the pressure bottle leaked out slowly, it would not be detectable by the crew or the orbiter instrumentation. Argon is a nontoxic, inert gas, approximately 1 percent of standard Earth atmosphere.

3.3.4 Slide Support Assembly

The slide support assembly consists of two aluminum plates and brackets that are attached to the port wall of the orbiter below the side hatch. This assembly can be easily removed from the vehicle and attached to the hatch via two pip pins. The inflatable portion of the EESS is attached to the slide support assembly with a fabric girt that loops around the removable girt bar portion of the slide support assembly.

3.3.5 Valise

The EESS is packed into a valise that is made of an aluminum packboard and Nomex covers. The slide is packed so that the charged cylinder pressure gauge is visible through a window in the side. The Nomex covers can be tightened to compress the pack as small as possible. The valise is released by pulling the inflation lanyard, which is attached to the pack-opening cable assembly.

3.3.6 Stowage Cover

The stowage cover protects the packed valise and is secured to the valise by a bracket mechanism and to the orbiter floor by stainless steel floor pins. The cover and brackets are made from aluminum. The packed valise, with the attached stowage cover, is attached to the port wall of the orbiter just below the side hatch. The cover has a recessed handle for easy removal. When removed, the stowage cover can be set aside or tossed out of the side hatch if the area is clear.

3.3.7 Emergency Egress Slide System Operations

The crew may utilize the EESS by either mounting it to the side hatch for deployment or, if rapid egress is required, deploying the slide following side hatch jettison. The decision to jettison the side hatch rests with the crew and should be based on the severity and nature of the emergency.

3.3.7.1 Hatch Jettisoned Operations

Following side hatch jettison, pulling the safing pin from the cover handle and then lifting the cover handle releases the cover from the packed valise and slide support assembly. The cover should be placed in an area that does not impede egress, or it may be tossed overboard. The next step for slide deployment is to rotate the lower slide support assembly until it locks into the extended position. The entire slide support assembly is then rotated into the hatch tunnel, and the valise is pushed off the lower slide support assembly and allowed to dangle out the side hatch tunnel. The escape slide is inflated by pulling the inflation lanyard completely free from the valise.

3.3.7.2 Hatch Mounted Operations

In the event that egress from the orbiter vehicle does not require hatch jettison, the side hatch handle should be unlocked and rotated to the VENT position. This allows any differential pressure between the orbiter cabin and the ambient to be relieved and places the hatch handle in a position to be opened with the egress slide in place. Following hatch handle placement, pulling the safing pin from the cover handle and then lifting the cover handle releases the cover from the packed valise and slide support assembly. The cover should be placed in an area that does not impede egress. The next step for slide deployment is to rotate the lower slide support assembly until it locks into the extended position. The entire slide support assembly is then rotated into the hatch tunnel against the side hatch. The slide assembly is removed from the vehicle by releasing the two pip pins that secure it to the orbiter. The entire slide assembly is picked up and the slide bracket bayonets are inserted into side hatch receptacles. The hatch handle is rotated to the OPEN position, and the hatch is pushed open. The slide is pushed over the outboard end of the hatch and inflated by pulling the inflation lanyard fully free from the valise.

3.3.7.3 Egress

Crewmembers are cautioned against jumping onto the inflated emergency egress slide during egress. Jumping on the slide can cause a rebound that may cause the crewmember to bounce outward off the slide. Proper alignment and positioning include sitting at the top of the slide and in the middle of the slide prior to descent. Once at the bottom of the slide, crewmembers should assist the next crewmember to ensure everyone egresses safely.

There is a reentry line on the aft portion of the inflated tube. This reentry line may be used to climb up the slide if needed.

3.3.8 Emergency Egress Slide Technical Information

Technical data for the EESS is shown in Table 3-3.

Table 3-3. Emergency egress slide technical information

Slide component	Technical data
Part number	D102900-1
Manufacturer	OEA Inflatable Systems
Weight	51.0 lbm
Operating temperature range	-23° to +150° F
Cylinder pressure	3000 ±100 psig at 73° F (minimum pressure on gauge is 2750 psig)
Charging gas	100 percent argon (carrier grade 99.999 percent argon)
Pressure relief valve	
Open	3.00 ± 0.25 psig
Closed	3.00 ± 0.25 psig
Operating pressure	2.00 to 3.00 psig
Length (inflated)	190 in.
Inflated volume	~49.5 ft ³
DOT ID no.	DOT-E-8162
Technical manual/Intermediate and Depot Maintenance Manual	K-066V-01201 (OEA Inflatable Systems)
Inflation time	~3 sec at inflation lanyard pull

3.4 OVERHEAD ESCAPE PANEL

Reference: SSSH drawing 18.1, Escape Panel

The overhead escape panel is an alternate path for postlanding egress in the event that egress through the side hatch is impossible. The escape panel is located on the port side of the aft flight deck at Window 8 (W8).

The overhead escape panel consists of an outer panel and an inner panel. These panels contain the W8 pressure and thermal panes, hinges, no-back device, seals, and associated pyrotechnic hardware. The escape panel is ejected by either a jettison handle initiator on panel C1 on the orbiter flight deck or by a T-handle initiator located externally on the starboard forward orbiter fuselage. The pyrotechnic system is a mechanical system requiring no orbiter electrical power for operation. The panel jettison system consists of XTAs, Mild Detonating Fuses (MDFs), frangible bolts, and associated initiators.

3.4.1 Escape Panel Operational Comments

The escape panel jettison handle (Figure 3-10) is located on panel C1 of the orbiter forward flight deck. The jettison handle is a flexible “ring-handle” secured beneath a rigid yellow and black striped cover. The cover is safed by a pip-pin that must be removed to access the jettison handle. Gripping and pulling the jettison handle activates the pyrotechnic system to jettison the escape panel.



Figure 3-10. Escape panel jettison handle

Ground rescue personnel use the external T-handle initiator for emergency access to the crew compartment (Figure 3-11). Ground rescue crews access the T-handle through an access door on the orbiter forward fuselage. Once exposed, the T-handle is squeezed and pulled to initiate the jettison sequence.

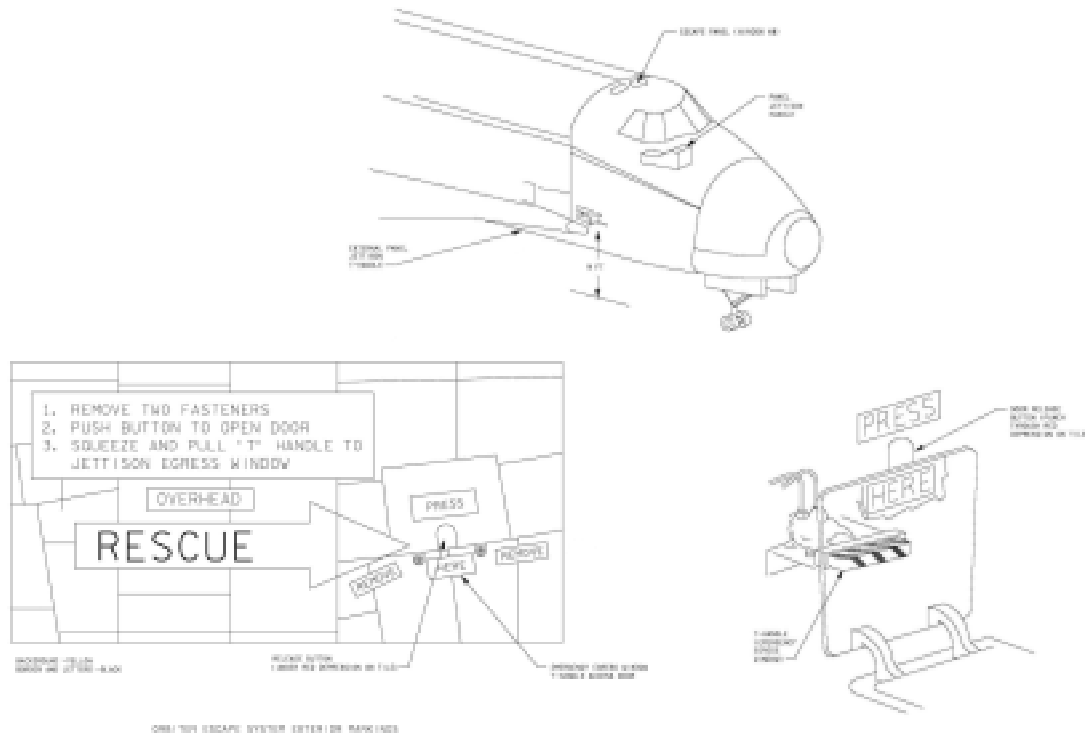


Figure 3-11. Escape panel external initiator location

A time delay in the pyrotechnic circuit delays firing of the inner panel 0.3 seconds after the outer panel. When jettisoned, the outer panel will travel upward approximately 40 feet (12 meters).

WARNING
Window glass will shatter. Beware of flying glass around entire window area.

The inner panel rotates downward and aft into the crew module on hinges at the aft side of the window frame. A capture device attenuates the opening rate and holds the window in the open position. The inner panel should miss the head of the crewmember seated in seat 4; however, this crewmember should egress the seat prior to window jettison if possible.

If the inner panel fails to rotate inward because of a pressure differential or window shift, a pry bar located in A17 can be used at two locations to pry the panel open. See Figure 3-12, Figure 3-13, and Figure 3-14.

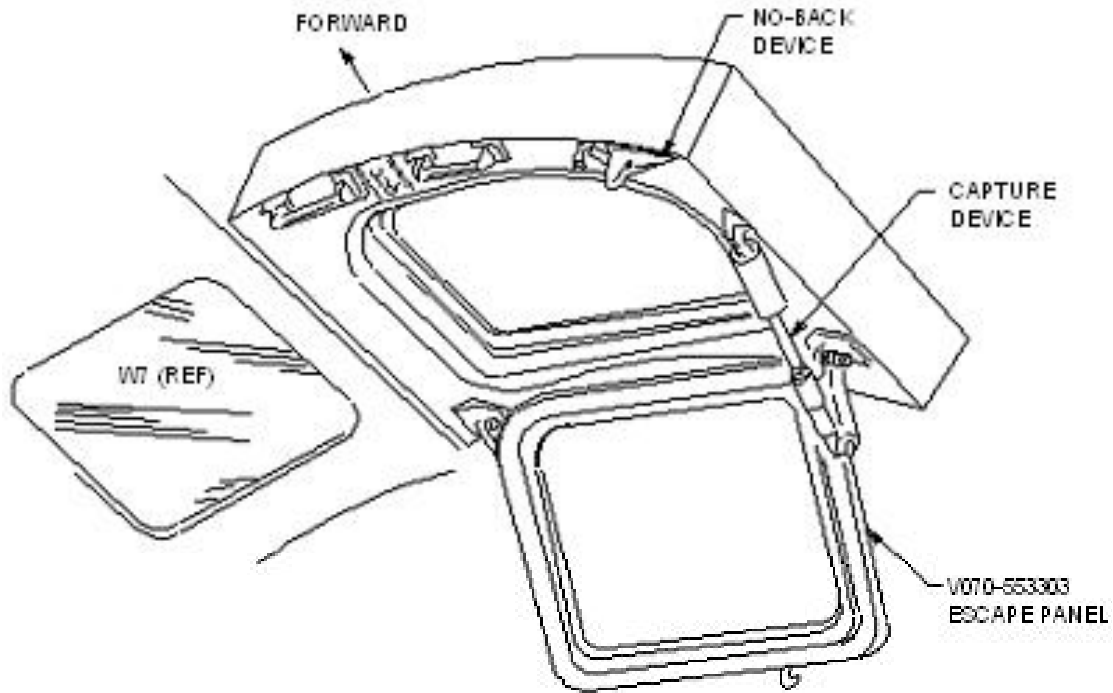


Figure 3-12. Escape panel



Figure 3-13. Pry bar stowage



Figure 3-14. Pry bar location

3.4.2 Escape Panel Technical Information

Technical data for the escape panel is shown in Table 3-4.

Table 3-4. Escape panel technical information

Escape panel item	Technical information
Weight	Inner panel: 150 lb Outer panel: TBD
Initiator pull force	Ring handle: 30 lbf Exterior T-handle: 30 lbf
Time delay (outer panel vs. inner panel)	0.3 sec
Operating temperature range	-40° to 160° F
DOT classification	
SMDC (rigid)	“C”
CDC (flexible)	“C”
XTA	TBD

3.5 DESCENT DEVICES (SKY GENIE)

Seven descent devices, called Sky Genies, are individually stowed in numbered bags on the flight deck overhead panels outboard of windows 7 and 8. These devices are used primarily for egress through the escape panel to allow crewmembers to lower themselves safely to the ground.

Sky Genies consist of a descent device, 40 feet of nylon rope, a crewmember hand loop, and a swivel snap shackle with a quick-release tab. The rope attaches to the support bracket forward of the W8 escape panel by a steel cable. The rope feeds through an opening at the top of the device and is wrapped 3-1/2 times around the central shaft, providing the friction required to slow the crewmember’s descent. The rope exits the device on the same side as the crewmember’s hand loop. A round metal cover over the end of the device prevents debris from the orbiter tiles and thermal blankets from fouling the rope inside the device and also provides a smooth surface to slide down the side of the orbiter. See Figure 3-15, Figure 3-16, and Figure 3-17.



Figure 3-15. Sky Genie

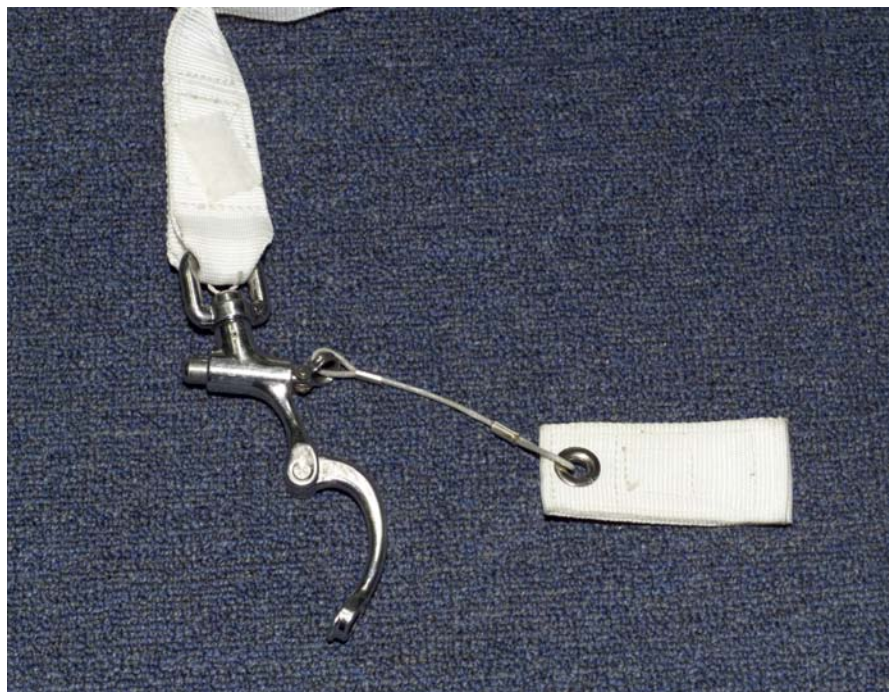


Figure 3-16. Sky Genie snap shackle (open)



Figure 3-17. Sky Genie stowage

3.5.1 Sky Genie Operational Comments

The loose end of the descent rope is stowed in a bag that is Velcroed to the device during stowage. The bag and rope are thrown out W8 over the starboard side of the orbiter. The rope uncoils from the bag as it passes over the orbiter.

NOTE

Ensure that the rope does not uncoil from the bag prior to throwing through W8. The rope may tangle and be difficult to deploy.

Once the Sky Genie is attached to the crewmember's carabiner and the rope is deployed, the crewmember uses seat 4 to climb through the W8 opening. Seat 4 has a footstep installed on its left side to aid the crewmember in climbing (Figure 3-18).

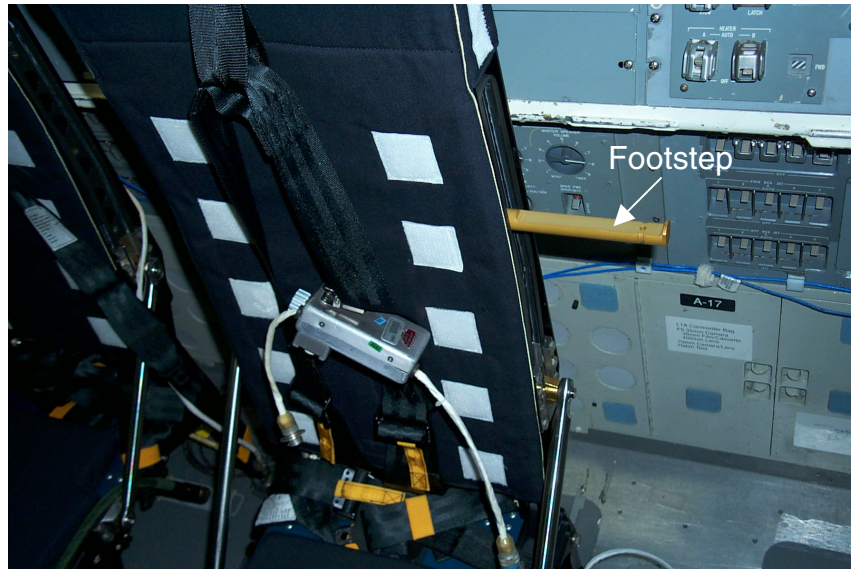


Figure 3-18. Seat 4 with footstep

Crewmembers descend on the vehicle's starboard side (Figure 3-19). Descending the starboard side provides the optimum crew body position for descent and minimizes Sky Genie contact with the vehicle to prevent jamming. Descent velocity and control is afforded by providing tension on the loose end of the rope held in the crewmember's right hand. Once safely on the ground, the crewmember disconnects from the Sky Genie using the snap shackle release tab and then assists other crewmembers.



Figure 3-19. Descent

3.5.2 Sky Genie Technical Information

Sky Genie technical data is shown in Table 3-5.

Table 3-5. Sky Genie technical information

Sky Genie item	Technical information
Weight Dimensions Overall Shaft Cover Material	4.1 lb (includes descent device, rope, deployment bag) TBD 9 in. x 0.75 in. diameter 6 in. x 1.75 in. diameter 6061-T6 aluminum
Rope Material Length Tensile strength Diameter	Type 2 nylon 40 ft 2500 lb 3/8 in.
Steel cable Length Diameter Tensile strength	Location dependent: No. 1 = 42 in. No. 4 = 50 in. No. 2 = 37 in. No. 5 = 48 in. No. 3 = 32 in. No. 6 = 52 in. No. 7 = 57 in. 5/32 in. 2,400 lb
Cable "D" shackle Manufacturer P/N Rated Strength	Ronstan RF 617 3080-lb point load rating
Snap shackle Manufacturer Load rating	TBD 7000 lb

3.6 ALTIMETER

An altimeter is mounted to middeck locker MF28H (Figure 3-20). The altimeter is used by the middeck crew to monitor cabin depressurization in the event of bailout. Nominal bailout procedures require the crew to vent the orbiter cabin prior to side hatch jettison (see Section 3.1). As cabin pressure decreases, the altimeter needle will indicate an increase in altitude. The altimeter allows the middeck crew to track the cabin vent process and prepare for the hatch jettison.



Figure 3-20. Middeck altimeter

3.7 EMERGENCY EGRESS NET (TRAMPOLINE)

The Emergency Egress Net (EEN), commonly referred to as the trampoline, serves as a platform for crew emergency egress when the orbiter is oriented vertically on the launch pad. With the removal of the internal airlock a large volume was created behind seats 6 and 7 on the middeck. To allow quick and safe crew egress during an emergency, the trampoline is installed prelaunch by ground crews (Figure 3-21).



Figure 3-21. Emergency egress net (trampoline)

3.7.1 Trampoline Attachment

The trampoline is installed in the middeck, parallel to the aft bulkhead. Its span is from the floor to the ceiling and from the interdeck access ladder to the aft modular lockers. On orbit, the crew stows the trampoline on the middeck ceiling for the duration of the flight (Figure 3-22).



Figure 3-22. Trampoline – stowed

The trampoline attaches to both the ceiling and the floor via six double-acting pins through six fittings. The ceiling and floor fittings are offset slightly, angling the EEN 3.7° aft from floor to ceiling. See Figure 3-23 and Figure 3-24.



Figure 3-23. Trampoline ceiling attachment



Figure 3-24. Trampoline floor attachment

Three straps are used to secure the port side of the trampoline across the edge of the egress platform, which is attached to the interdeck access ladder. The straps are wrapped across the front of the egress platform and attach to the inside of the ladder's forward post via "pull-the-dot" snaps. Two ratchet assemblies at the port and starboard ceiling edges are rotated clockwise to loosen the trampoline fabric (Figure 3-25).



Figure 3-25. Trampoline tension ratchets

3.7.2 Closeout Nets

Three closeout nets are installed around the trampoline to keep items from falling to the aft bulkhead. The closeouts are located at the ceiling, floor, and port sides of the trampoline and are held in place using Velcro. The starboard side of the trampoline has a white Nomex extension that also acts as a closeout. This extension is attached to the aft middeck lockers with six snap hooks (Figure 3-26). These closeouts are removed and rolled up inside of the trampoline during stowage.

Installation of the nets is facilitated with orientation labels on the edges of each closeout assembly. By design, the end of the ceiling and floor closeouts overlap the ends of the port and starboard closeouts. Therefore, to ensure a proper fit, the port and starboard closeouts should be installed prior to the ceiling and floor closeouts.



Figure 3-26. Trampoline locker snap hooks

3.7.3 Trampoline Stowage

During the postinsertion mission phase, the crew will perform the following procedures to stow the trampoline:

1. Remove the port, ceiling, and floor closeout net and disconnect the starboard trampoline extension.
2. Unlock the ratchet mechanism at the ceiling by rotating both release knobs in the clockwise direction. This action will loosen the trampoline fabric.
3. Disengage the three stowage straps from the three D-rings, located on the top of the trampoline assembly.
4. Remove the three straps from the interdeck access ladder via the “pull-the-dot” snaps.
5. Pull the six double-acting pins from the floor fittings.
6. Roll the trampoline from the floor to the ceiling with the webbing on the inside. Roll the trampoline with the closeout nets inside the assembly.
7. Wrap the stowage straps around the trampoline and retain with D-rings.
8. Unfurl the two retention straps and secure the trampoline to the ceiling with the two retention straps.

3.7.4 Trampoline Technical Information

Table 3-6 provides the trampoline technical data.

Table 3-6. Trampoline technical information

Trampoline item	Technical information
Emergency Escape Net P/N	V828-660101-001
Weight	TBD
EEN cover Material Dimensions Composition	Kevlar-29 cloth 53.81 in. wide 75.63 in. high Two (50.0 x 56.0) overlapping sheets stitched together with white Nomex thread size E
Stowage straps Material Dimensions D-rings (9) Snap hook, 2 in. (3)	Nomex webbing natural Side straps (2): 17.00 by 1.00 in. Middle: 18.00 by 1.00 in. P/N: DR-20 P/N: 2-480
Velcro loop Material Dimensions	Nylon Velcro loop, white EEN perimeter: 52 @ 1.00 by 2.00 in. Retention pocket: 18 @ 1.00 by 2.00 in.
Velcro hook Material Dimensions	Nylon Velcro hook, white Retention pocket: 18 @ 1.00 by 2.00 in.
Buttons (for ladder attach)	Button/socket (3) P/N: MS27983-1N/2N
Closeout nets Material Port P/N Ceiling P/N Starboard P/N Floor P/N	PBI braided cord V828-660127-001 V828-660127-002 V828-660127-003 V828-660127-004

4.0 EMERGENCY BREATHING PROVISIONS

4.1 QUICK-DON MASK

4.1.1 Description

The Quick-Don Mask (QDM) assembly (Figure 4-1) consists of an integrated breathing mask as well as goggles, regulator, overpressure relief valve, harness activation lever, communications module, inflatable harness, and oxygen supply hose. The QDM is designed to protect the entire face if fire, smoke, toxic spill, or loss of cabin atmosphere in the orbiter cabin occurs. The QDM is not fire retardant, but can operate in temperatures up to 130° F. The QDM is also used to perform oxygen prebreathe operations prior to conducting an EVA.

The QDM has a pneumatically inflatable head harness that allows the mask to be donned with one hand in less than 5 seconds. The wide, clear lens is of high optical quality that allows crewmembers to wear glasses with the mask. The QDMs are packed in Nomex pouches and stowed for launch and entry in middeck stowage volume 3B (Figure 4-2). During on-orbit operations, the QDMs are unstowed and connected to orbiter oxygen hoses. The QDMs are placed on the middeck and flight deck for quick access.

An integral microphone and earphone allow the QDM to be connected to the orbiter communications system via a standard comm connector.



Figure 4-1. QDM assembly



Figure 4-2. QDM stowage

4.1.2 Operational Comments

During post-insertion operations, the QDMs are unstowed and connected to prerouted orbiter O₂ hoses. The Launch and Entry Helmet (LEH) O₂ valves must be set to ON to allow orbiter oxygen to the O₂ outlets. Removing the mask from the Nomex stowage pouch and squeezing the harness activation lever to inflate the head harness allow the QDM to be donned (Figure 4-3). The mask is positioned against the face, and the activation lever is released. The emergency pressure switch on the underside of the regulator should be rotated to the EMERGENCY position (Figure 4-4).



Figure 4-3. QDM donning procedure



Figure 4-4. QDM regulator knob

4.1.3 Quick-Don Mask Technical Information

Technical information for the QDM is shown in Table 4-1.

Table 4-1. QDM technical information

Item description	Technical information
Quick-Don Mask	
P/N	SED33104528-303 (includes stowage bag)
Operating pressure	100 psig
Maximum pressure	180 psig
Oxygen flowrate	
Norm	TBD
Emergency	TBD
Supply hose length	40 in.
Comm cable length	TBD
Stowage location	Refer to flight-specific reference manual
Oxygen panel locations	
Flight deck	C6 - LEH O ₂ supply nos. 1, 2, 3, 4
Middeck	MO32M - LEH O ₂ supply nos. 5, 6 MO69M - LEH O ₂ supply nos. 7, 8

4.2 SPACELAB EMERGENCY BREATHING SYSTEM

The Spacelab Emergency Breathing System (SEBS) (Figure 4-5) is used by crewmembers for contingency air while in the Spacehab modules. The SEBS is a portable unit containing breathing air at an operating pressure of 2100 psi. The SEBS provides 12 minutes of air at 30 L/min consumption rate via a QDM stowed in a Nomex pouch on the side of the SEBS case. A Nomex belt is also provided for the crewmember to use as a waist belt.

The SEBS is launched in soft stow and temporarily stowed in the Spacelab or Spacehab module while on orbit. To operate, the O₂ supply switch on the top of the SEBS is switched to ON (Figure 4-6), and the QDM is removed and donned. The SEBS can then be carried wherever needed. For emergencies, crewmembers are instructed to “On, Don, and Carry” the SEBS.



Figure 4-5. Spacelab Emergency Breathing System



Figure 4-6. SEBS regulator

4.3 ORBITER OXYGEN SYSTEM

All orbiter oxygen panels and oxygen hoses are fitted with female oxygen connectors that are compatible with the ACES and QDM hose connectors.

Each orbiter has eight LEH O₂ outlets on the flight deck and middeck. These outlets are supplied with regulated (100 ± 10 psi (690 ± 69 kN/m²)) oxygen. Breathing oxygen supplied from the orbiter cryo system is delivered to the LEH O₂ outlets via two crossover valves. These two crossover valves receive power from Main Bus A (MNA) and Main Bus B (MNB), respectively, and remain open (powered) throughout each mission. This configuration ensures that regulated oxygen is available at the LEH O₂ outlets for launch, orbit, and entry phases of flight. Delivery of breathing oxygen to the LEH O₂ panels will be lost upon loss of MNA and MNB buses, emergency powerdown, or certain Environmental Control and Life Support System (ECLSS) contingency procedures. See Figure 4-7, Figure 4-8, and Figure 4-9.

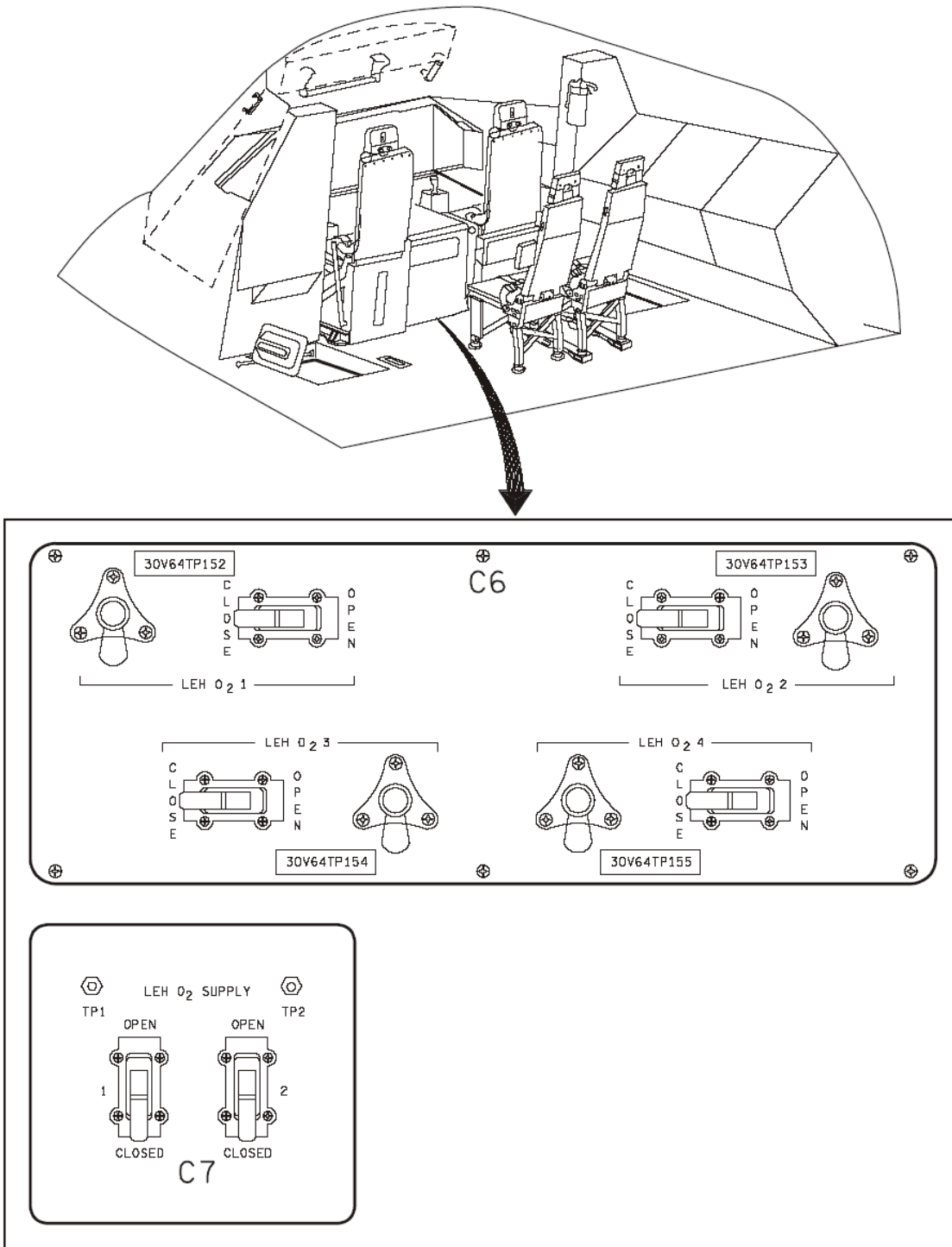


Figure 4-7. Flight deck LEH O₂ –Panel C6, Panel C7

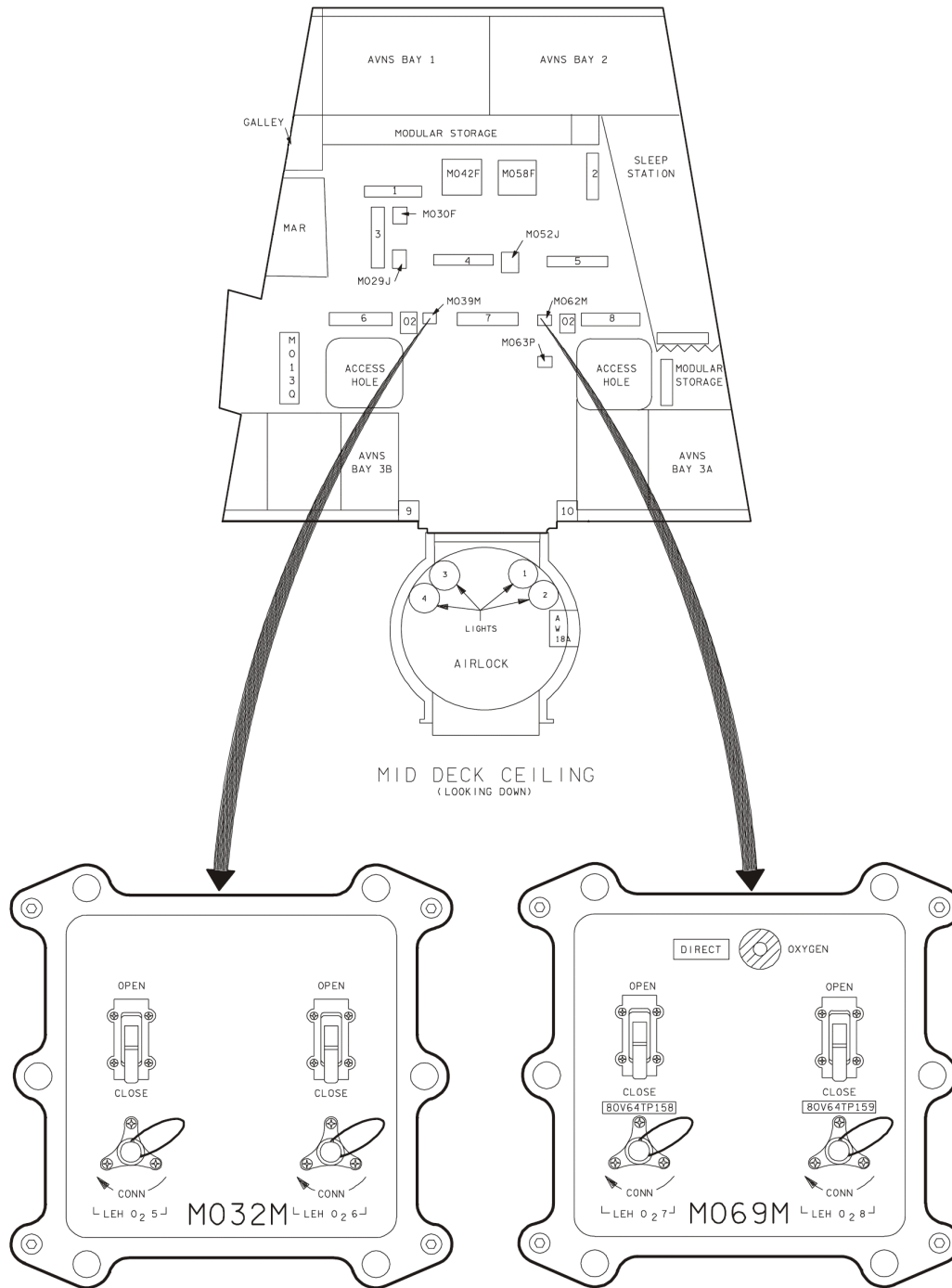


Figure 4-8. Middeck LEH O₂ –Panel M032M, Panel M069M

5.0 CREW SEATS

5.1 DESCRIPTION

Reference: SSSH, drawing 18.9 (sheets 1-3), Crew Seats

Two sets of seats are provided for crewmember positioning and restraint during launch, entry, and some on-orbit operations. Each seat accommodates a fully suited crewmember, cooling units, and FDF stowage bags. The seats are also used to secure oxygen hoses and communications and power cables during launch and entry. See Figure 5-1.



Figure 5-1. Crewmember seating

Crewmembers are secured into the seat by a five-point restraint (Figure 5-2) that restrains the upper torso (shoulder straps), and the lower body (lap and crotch straps). The shoulder straps and the lap straps connect to a rotary buckle permanently mounted to the crotch strap. The straps are released by rotating the buckle either clockwise or counterclockwise.

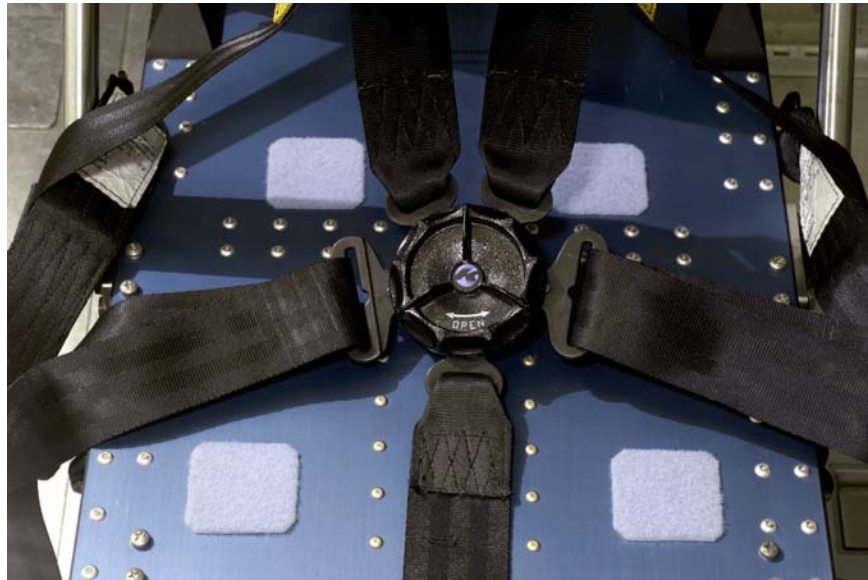


Figure 5-2. Five-point restraint

Seat 1 and Seat 2 (Commander (CDR) and Pilot (PLT)) are permanently installed in the orbiter forward flight deck (Figure 5-3). They are electrically powered for horizontal and vertical position adjustment, and equipped with mounting provisions for Rotational Hand Controllers (RHCs).



Figure 5-3. CDR and PLT seats

Mission Specialist (MS) and payload specialist seats (Figure 5-4) are equipped with QD fittings that interface with mounting studs on both the middeck and flight deck flooring. The specialist seats are disconnected, folded, and stowed during postinsertion activities. A maximum of five specialist seats can be installed for flight.

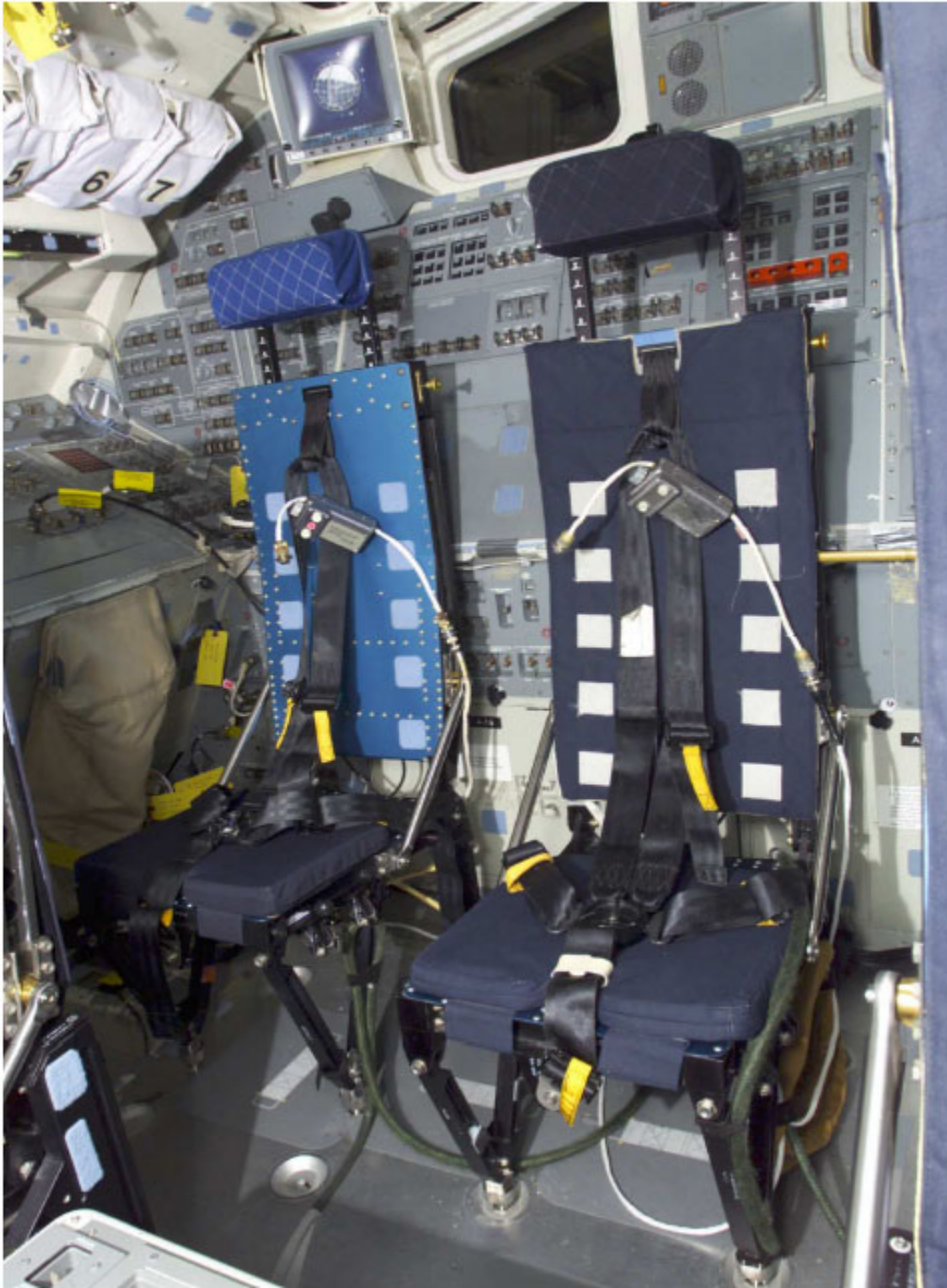
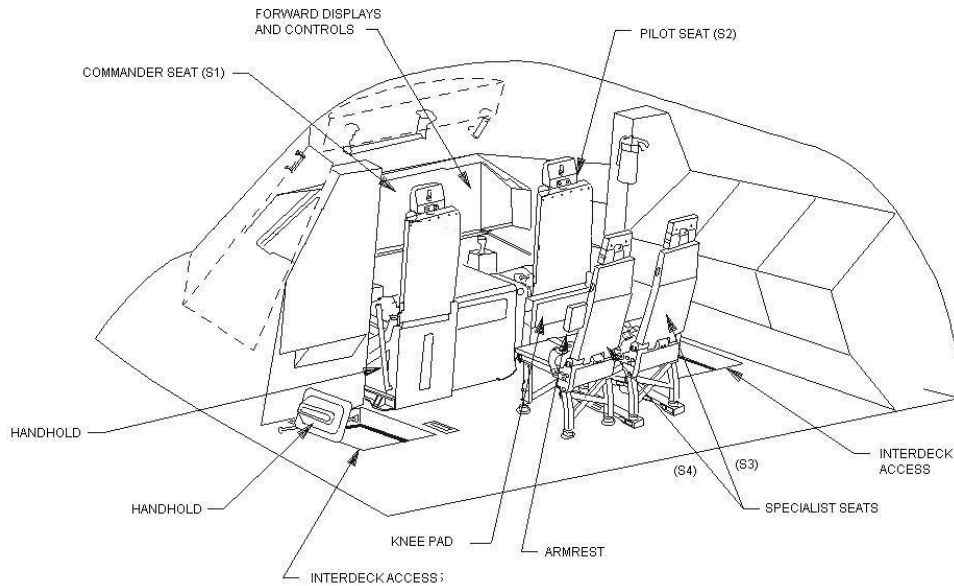
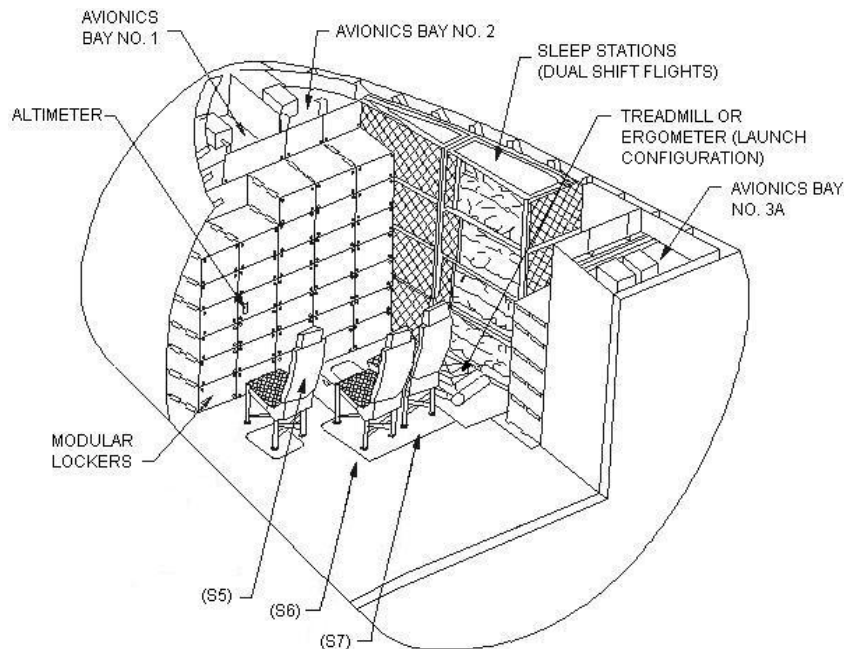


Figure 5-4. Specialist seats

Seat positions are numbered 1 through 7, beginning with the commander's position and ending with the starboard most seat on the middeck. Figure 5-5 shows the seat number positions for the flight deck and the middeck. Seat 1 (S1) through S5 are flown on all missions. S6 and S7 are flown, as required, based on mission requirements.



(a) Flight deck



(b) Middeck

Figure 5-5. Crewmember seat positions

The flight deck and specialist seats have some common functions and features, including:

- a. Seat-back angle adjustment (Figure 5-6). All seat backs have two positions: 2° forward (ascent position) and 10° aft (entry position)



Figure 5-6. Seat-back angle adjust

- b. Backrest fold down (Figure 5-7)



Figure 5-7. Seat backrest fold down

- c. Headrest height adjustment (Figure 5-8)



Figure 5-8. Headrest height adjustment

- d. Inertia reel lock/unlock
- e. Adjustable shoulder harness and lap belts
- f. Cooling unit and FDF mounting provisions
- g. Seat pad

Common functions and features of the crew seats are described in Table 5-1.

Table 5-1. Crew seat function

Function	Operation
Seat back angle adjustment	<ul style="list-style-type: none"> • Pull aft on the lock lever • Reposition back angle • Release lock lever
Headrest height adjustment	<ul style="list-style-type: none"> • Pull headrest height adjustment lock lever • Adjust headrest height • Release lock lever <p style="text-align: center;">NOTE Height adjustments are in 1-in. increments</p>
Inertia reel lock/unlock	<ul style="list-style-type: none"> • Push lever forward to lock shoulder harness in place • Push lever aft to release <p style="text-align: center;">NOTE Inertia reel locks automatically if rapid forward acceleration is experienced, even if inertia reel lever is in the unlocked position</p>
Shoulder harness/lap belt	<p>To connect, insert both ends of the shoulder harness straps and lap belt straps into the connector</p> <p>To disconnect, twist the connector rotary buckle; all ends disconnect</p>

5.2 CDR AND PLT SEATS

5.2.1 CDR and PLT Seat Power

The CDR and PLT seats have redundant power source capability from either AC2 or AC3 (Figure 5-9). The ac power sources are controlled by a relay that is powered by 28 V dc coming from MNB or Main Bus C (MNC). The nominal configuration selects AC2 to power S1 (CDR) and AC3 to power S2 (PLT). Circuit breaker protection for both seats is provided on panels MA73C (ac) and ML86B (dc). (See Table 5-2.) Power selection and seat position adjustment controls are located on the left side of the seat. The power select switch has three positions: AC2, OFF, and AC3. The horizontal and vertical control switches are momentary and correspond with forward and aft or up and down movement.



Figure 5-9. CDR and PLT seat power and position switches

Table 5-2. Seat power circuit breaker protection

Seat	Panel	
	MA73C (ac)	ML86B (dc)
One (CDR)	cb55 (AC2) cb57 (AC3)	cb75 (MNB) cb76 (MNC)
Two (PLT)	cb56 (AC3) cb58 (AC2)	cb85 (MNC) cb86 (MNB)

5.2.2 Manual Seat Positioning

The CDR and PLT seats can be manually positioned in the event of seat motor or electrical failure. Lifting up on the manual adjust cover (vertical adjustment or horizontal adjustment) disengages the seat motor and brake at the clutch. The seat can then be moved up or down by inserting and rotating the manual seat adjustment tool (3/16-in. hex head driver) located in the IFM locker. Manual seat positioning can only be performed while on orbit. See Figure 5-10.



Figure 5-10. CDR and PLT seat manual positioning access

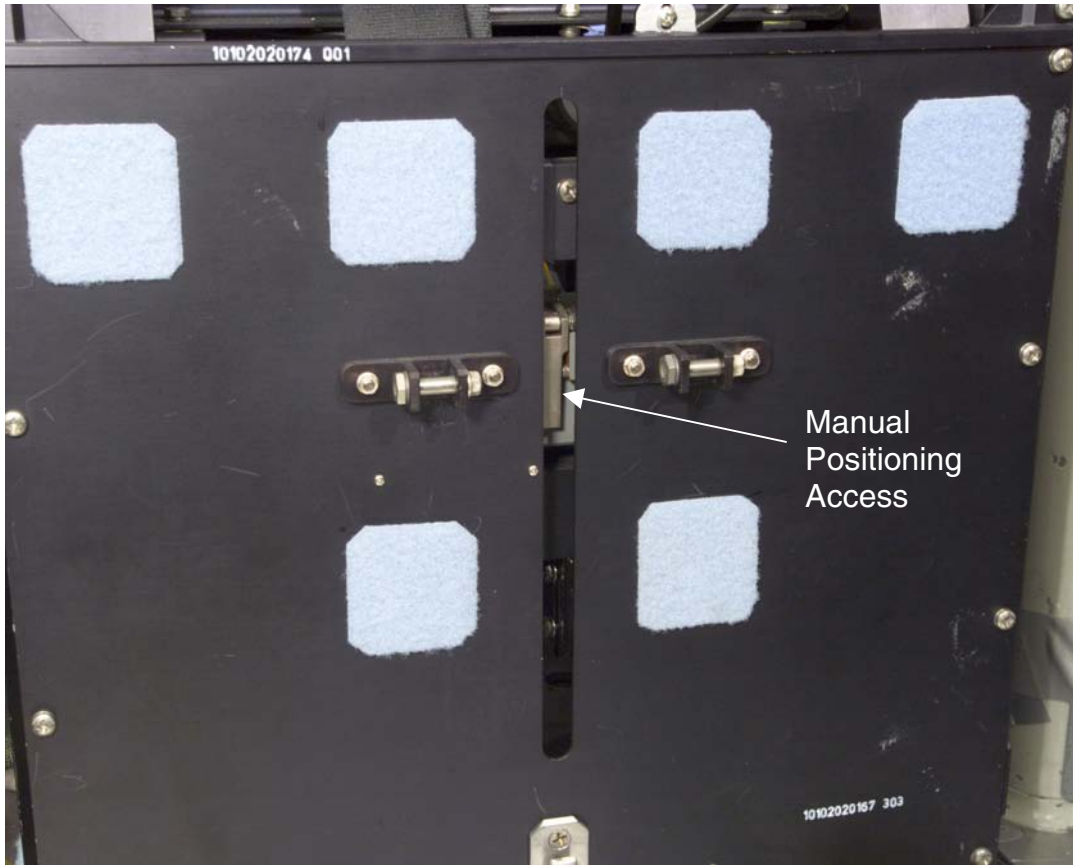


Figure 5-10. CDR and PLT seat manual positioning access (concluded)

5.2.3 Rotational Hand Controller Mount

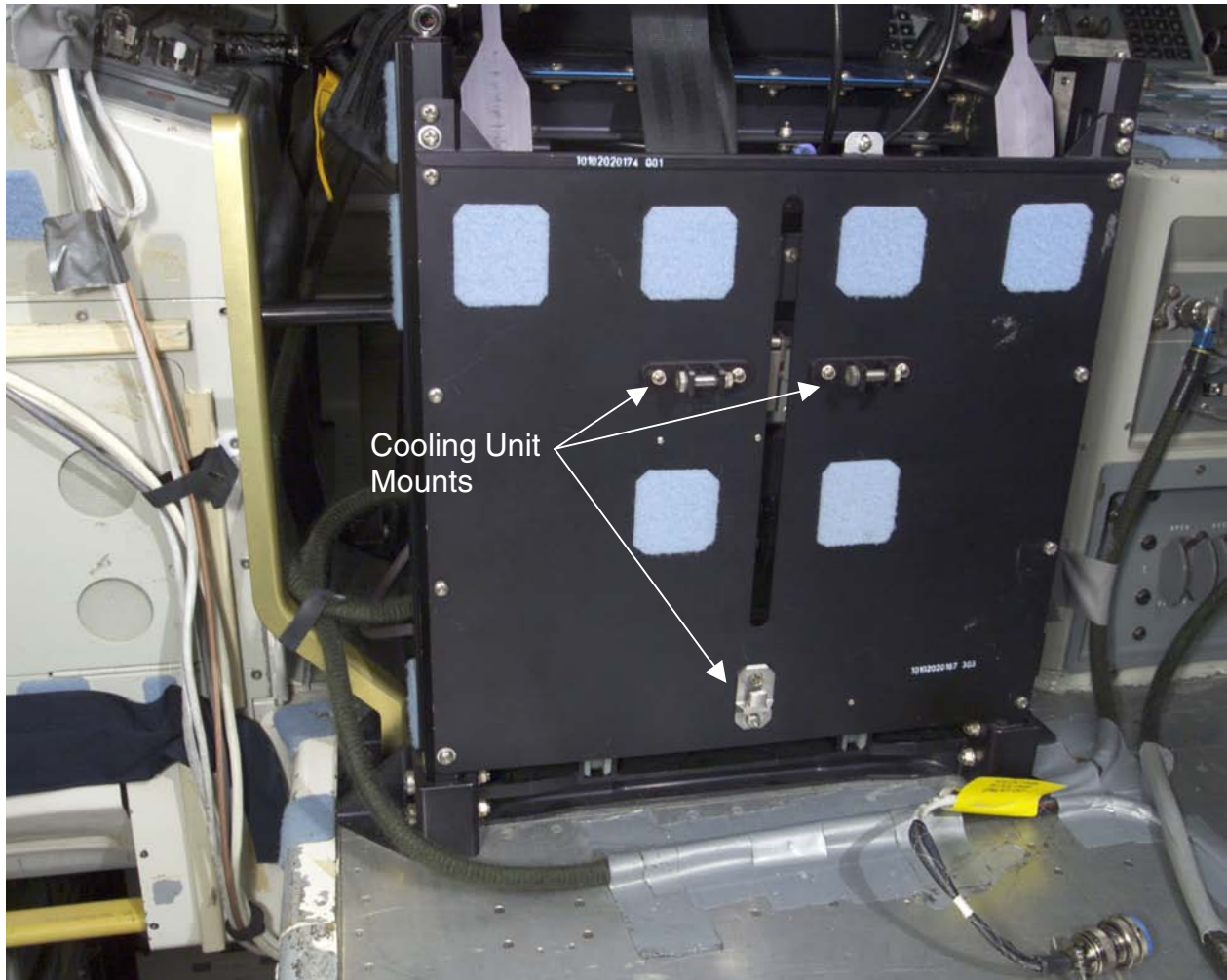
The CDR and PLT seats include a structural mount for the RHC (Figure 5-11). The mount is attached to the front of the seat pan structure, so it moves with the seat when the seat position is adjusted.



Figure 5-11. Rotational Hand Controller

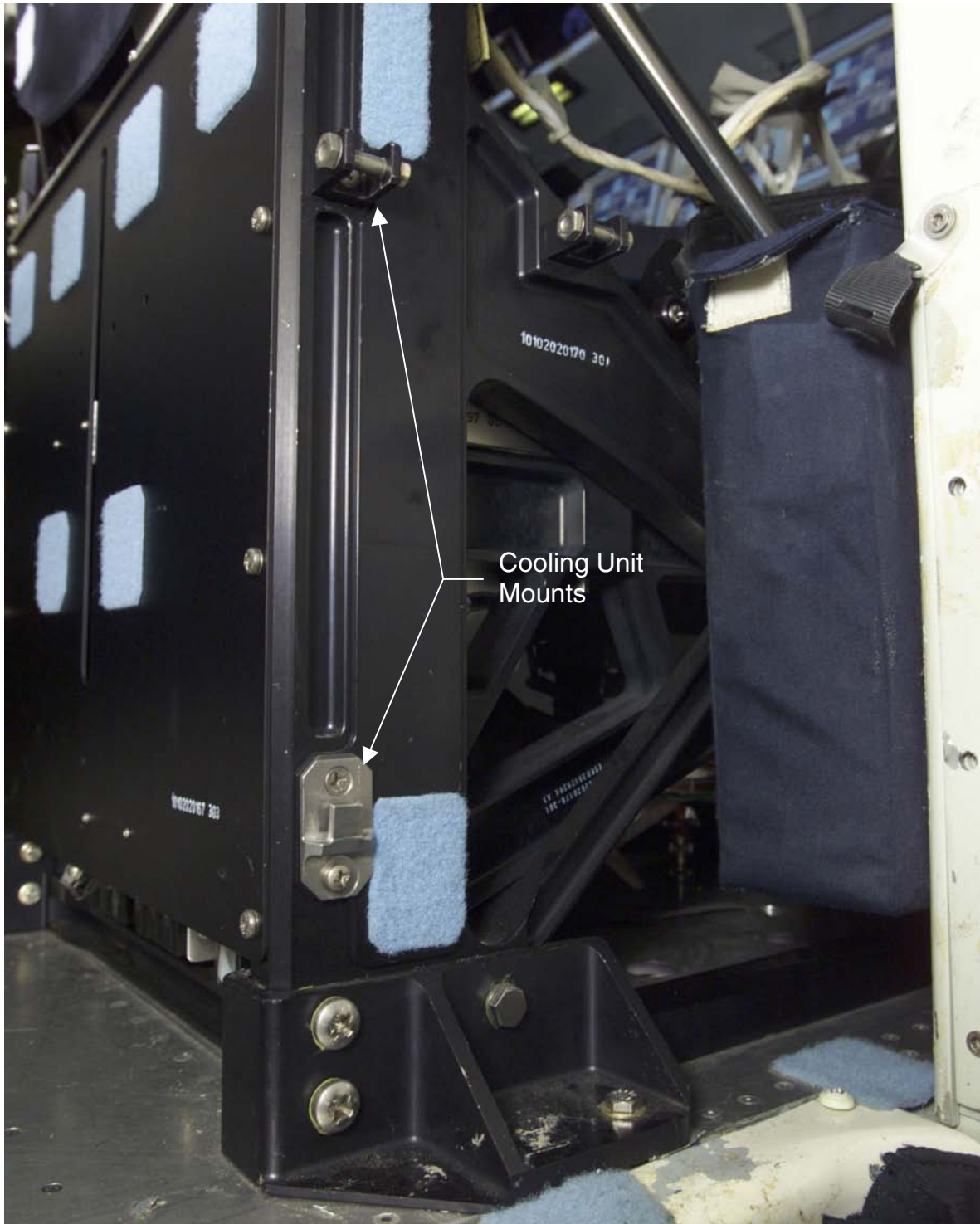
5.2.4 Cooling Unit Mounts

S1 and S2 have mounting brackets for attaching the cooling units (Figure 5-12). The brackets on S1 are on the lower rear of the seat base. For S2, the brackets are located on the right side of the seat base.



(a) Commander

Figure 5-12. CDR and PLT seat cooling unit mount brackets



(b) Pilot

Figure 5-12. CDR and PLT seat cooling unit mount brackets (concluded)

5.2.5 Handhold

A handrail is located on S1 right above the port interdeck access (Figure 5-13). The handrail aids in translation between the middeck and flight deck.



Figure 5-13. Commander's seat handhold

5.3 SPECIALIST SEATS

In addition to the common functions and features described in Section 5.1, the specialist seats have the following features:

- a. Heel rest and seat leg folding capability
- b. Quick disconnect fittings
- c. Removable egress step (S4 only, on the left side) (Section 5.3.2)
- d. Accommodations for mounting to Recumbent Seat Kits (RSKs)

5.3.1 Cooling Unit and FDF Mounting Brackets

The cooling unit and the MS FDF bag use the same mounting brackets. Each seat has mounts located on either side of the seat (Figure 5-14). The FDF bag, if manifested, is mounted opposite from the cooling unit.



Figure 5-14. Specialist seat FDF/ICU bracket

5.3.2 Egress Step

The specialist seats can accommodate an emergency egress step (Figure 5-15) to be used when egressing the vehicle via the escape panel at W8. The step, only used on S4, may be deployed or stowed for launch and entry. The step must be stowed before folding the seat.

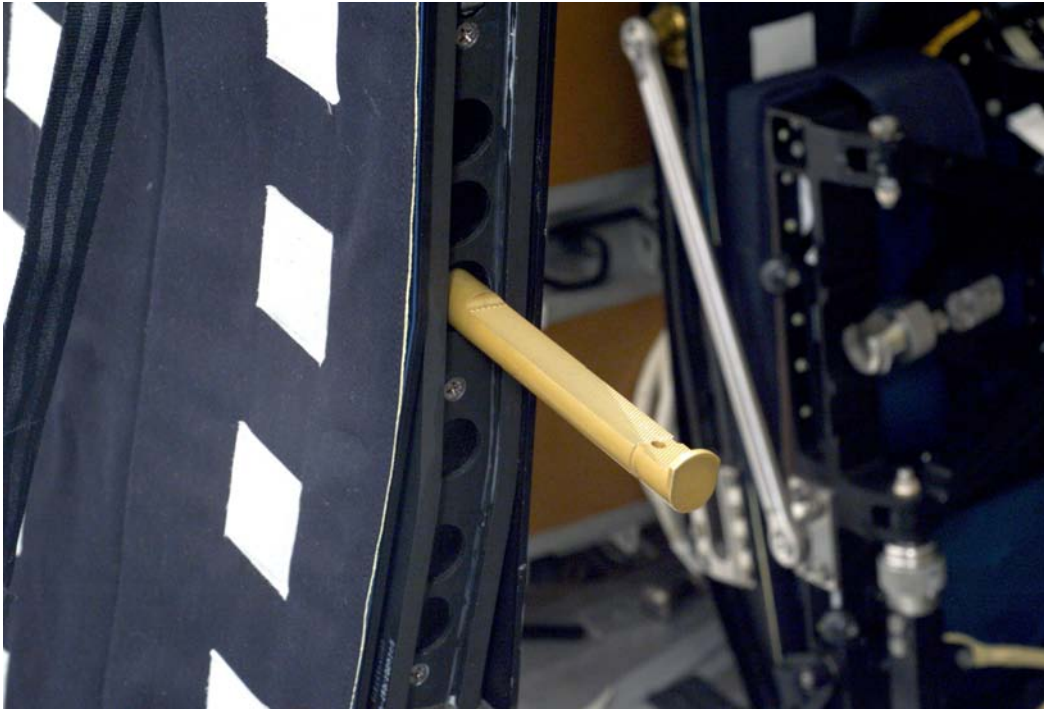


Figure 5-15. Egress step

5.3.3 Seat Stowage

All five specialist seats can be folded and stowed for orbit operations. The parachute must be removed from the seat prior to folding. The seats are folded by performing the following steps:

1. Stow the egress step on S4 by pulling on the spring-loaded retaining pin and pushing the step into the seat back frame (Figure 5-16).



Figure 5-16. Egress step retaining pin

2. Fold down the seat back (Figure 5-17).



Figure 5-17. Seat back –folded

3. Disconnect all four seat floor QD fittings by depressing the spring-loaded ball and lifting the QD lock collar up over the ball (Figure 5-18).

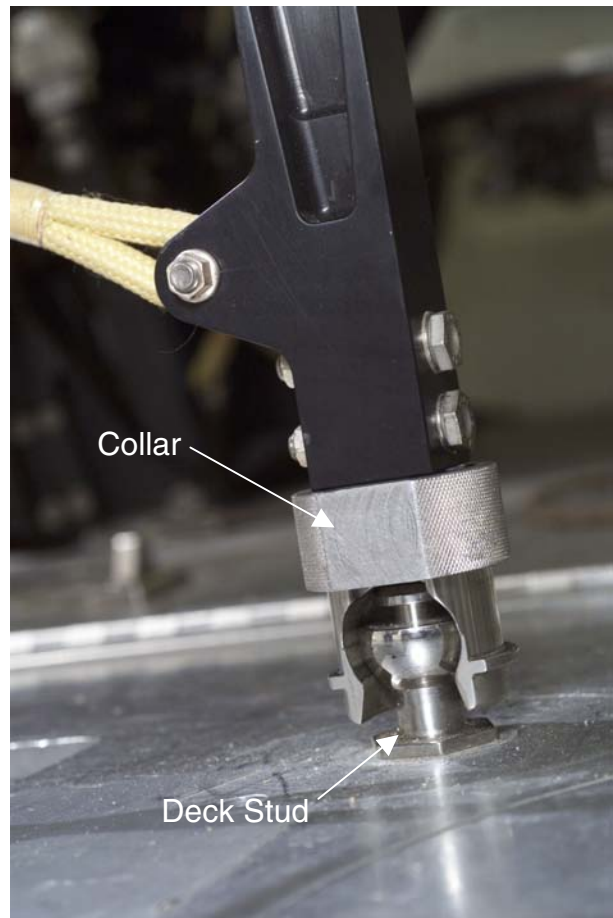
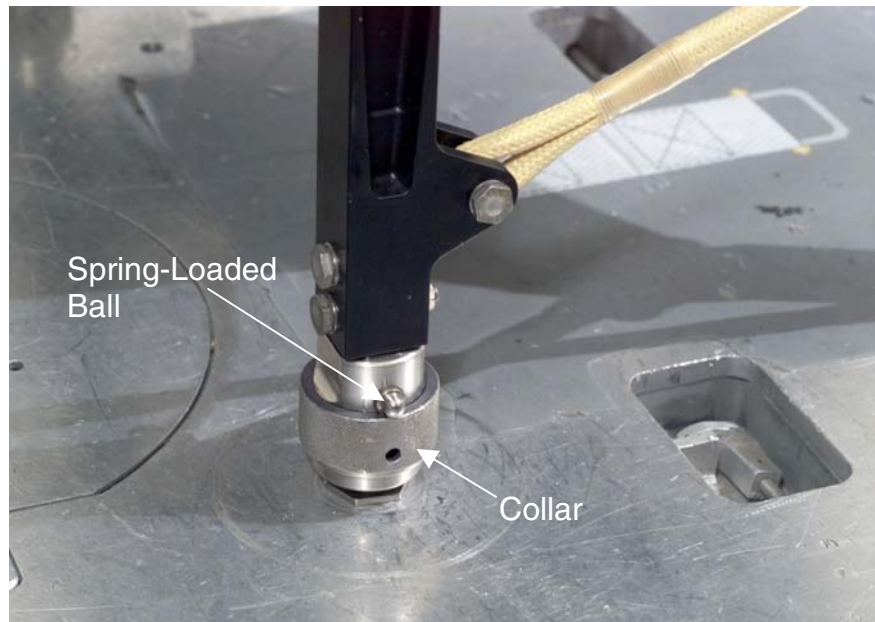


Figure 5-18. Seat/floor disconnect

4. Slide the seat to the rear to remove from the spherical deck studs (Figure 5-19).



Figure 5-19. Seat deck studs

5. Remove heel rest cushion (if flown) from the front legs.
6. Fold the left leg up to the seat pan and then the right leg, followed by both rear legs (Figure 5-20). Secure the front legs with the Velcro strap. Secure the rear legs by engaging the QD onto the retention studs on the seat pan.

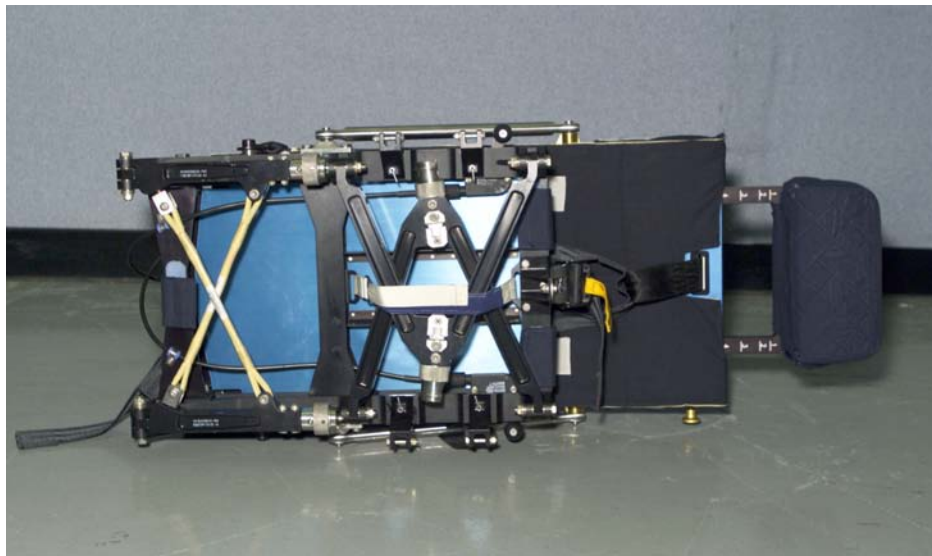


Figure 5-20. Folded seat legs

7. By “inverting” the headrest, the length of the folded seat can be reduced (Figure 5-21). Remove the headrest by pulling out on the headrest height adjustment knob and pulling the headrest off the seat. Reinstall the headrest in the back of the seat.



Figure 5-21. Folded specialist seat

5.4 RECUMBENT SEAT KIT

Reference: SSSH, drawing 18.9 (sheet 3), (shows recumbent seat details)

The RSK is used for returning International Space Station (ISS) crew and allows the returning crew to reenter and land in a position that helps minimize the effects of long-duration space travel.

The RSK consists of three sets of frames that are used to attach the specialist seats to the middeck floor (Figure 5-22). The RSK is stowed for ascent. During deorbit preparation, the RSKs are unstowed and configured using specialist seats used during ascent. Forward middeck lockers MF43K, MF57K, and MF71K are emptied and used as foot rests for the recumbent crew. An additional footrest is mounted at the side of locker MF71K.



Figure 5-22. Recumbent seat kit installed (with old RSS headrest)

RSK 6 is used to mount a specialist seat to the spherical deck studs at the S6 location. Kit 6 attaches to the deck studs with the same QD fittings that are used on the legs of the specialist seats. To mount the specialist seat to the kit frame, the seat legs are folded and the seat back is placed in the entry position. Four tethered pip pins secure the seat to the frame (Figure 5-23 and Figure 5-24).

The forward pip pins are 1/4-inch diameter, and interface with the specialist seat at the lower portion of the seat back. Because the holes into which these pip pins fit are slotted (to ease specialist seat installation), the pip pins are restrained with a strap. The aft pip pins have a 7/16-inch diameter and interface with the specialist seat at the middle portion of the seat back. The hole for the left pip pin is the same hole used for

the egress step (see Section 5.3.2); therefore, a bushing is required to accommodate the 7/16-inch pip pin (Figure 5-25).

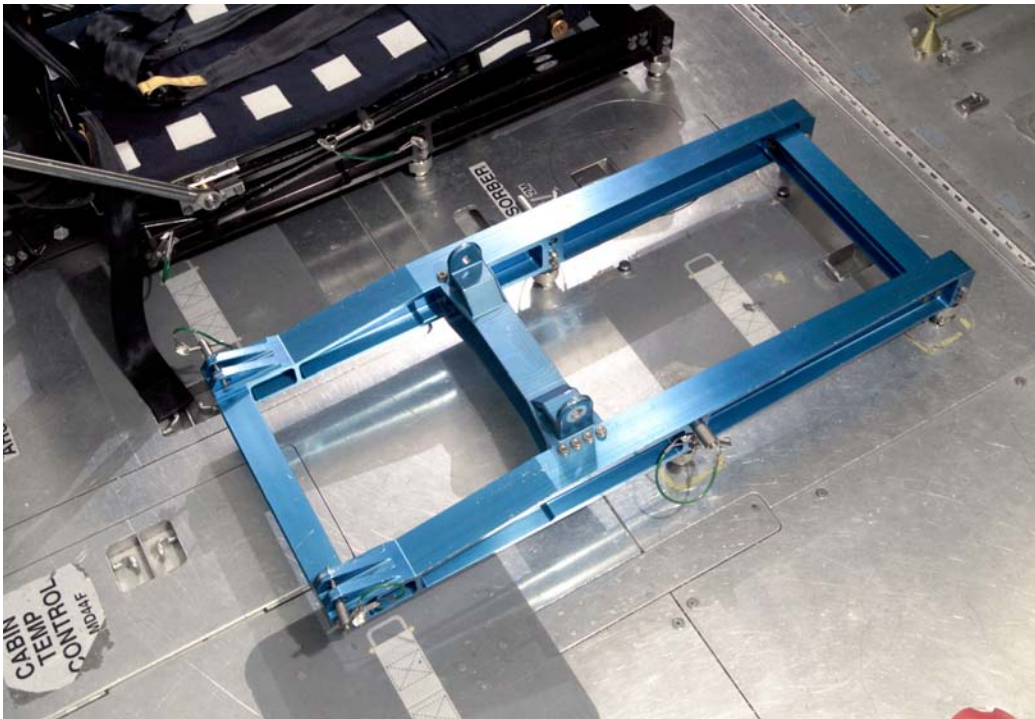


Figure 5-23. Recumbent seat kit 6 frame

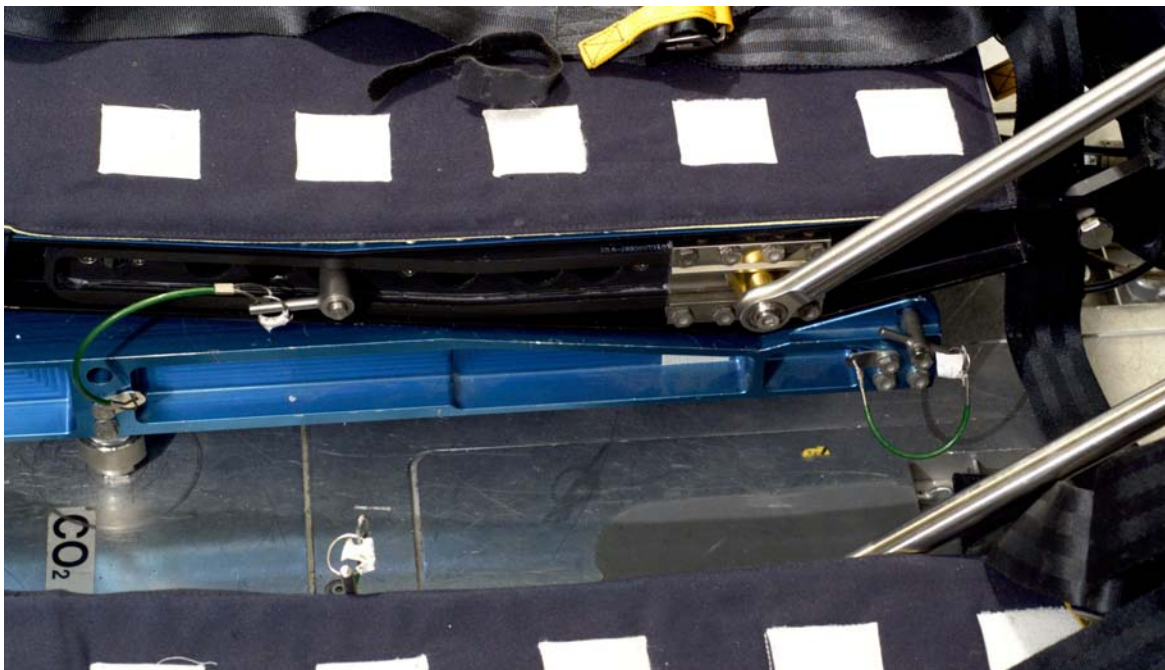


Figure 5-24. Kit 6 seat mounting

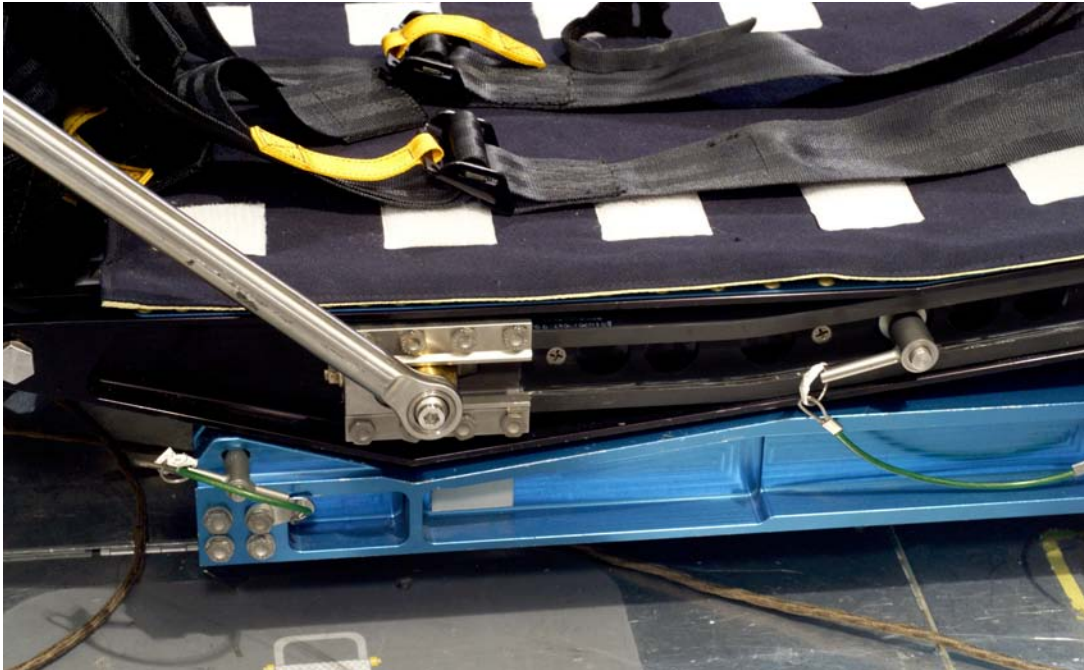


Figure 5-24. Kit 6 seat mounting (concluded)



Figure 5-25. Seat pin bushing

RSK 7 is used to mount a specialist seat in the S7 location on the middeck. It is very similar to RSK 6, with three differences.

- a. Because the S6 deck studs are two inches aft of the S7 studs, kit 7 is two inches shorter than kit 6.
- b. Kit 7 is anodized black, while kit 6 is anodized blue to distinguish it from kit 7.
- c. Brackets can be installed on kit 7 to mount kit 8. When mounted together, kits 7 and 8 make up the dual kit. When kit 7 is flown without kit 8, the dual kit attach brackets do not need to be used. See Figure 5-26 and Figure 5-27.

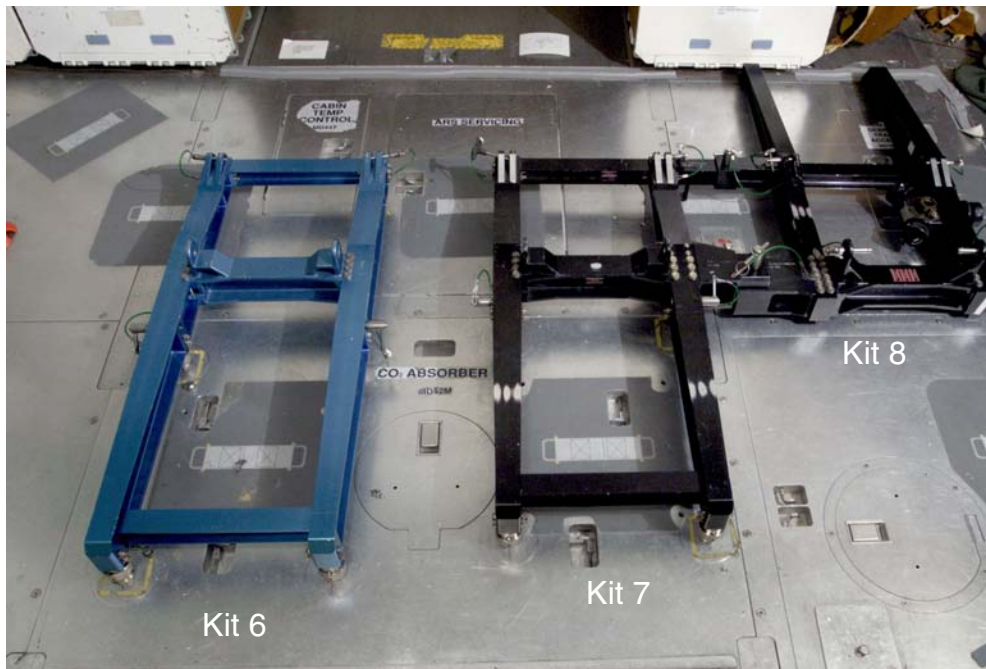


Figure 5-26. RSK 6, 7 and 8



Figure 5-27. RSK 7 and 8 attach brackets

RSK 8 attaches to kit 7 by two pip pins. The forward pip pin has a 1/2-inch diameter and is 2 inches long. The aft pin has a 3/4-inch diameter and is 3.5 inches long. Kit 8 also interfaces with the shuttle middeck via one of the ergometer Brownline fittings and four compression pads (three on kit 8 and one on the mounting bracket attached to kit 7). See Figure 5-28 and Figure 5-29.

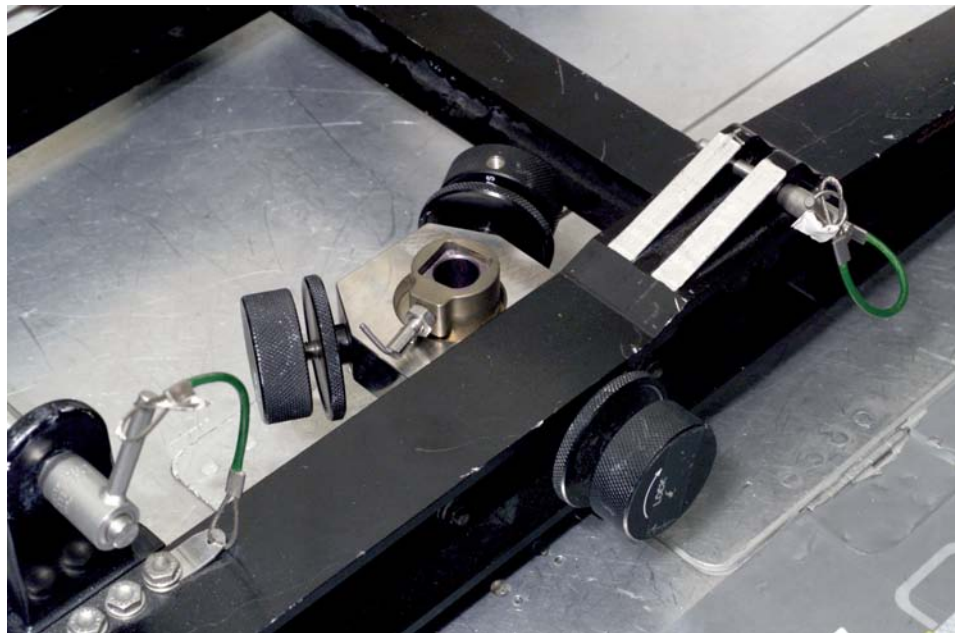


Figure 5-28. RSK 8 deck mount bracket



Figure 5-28. RSK 8 deck mount bracket (concluded)

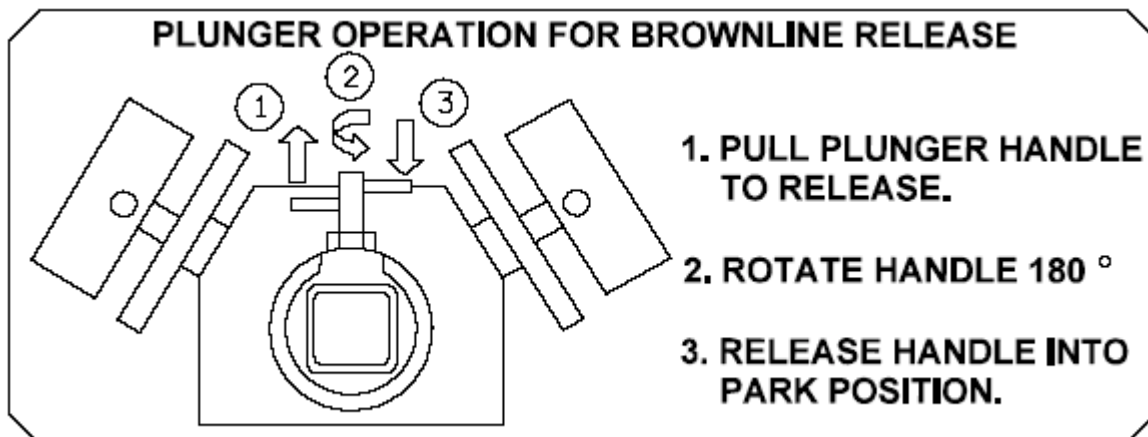


Figure 5-29. RSK 8 procedural decal

To return a single recumbent crewmember, either kit 6 or kit 7 can be flown. Kit 8 cannot be used by itself. To return two recumbent crewmembers, kits 6 and 7 can be flown together, or the dual kit (kits 7 and 8) can be flown. To return three recumbent crewmembers, all three kits are flown.

Because the legs are folded, the specialist seat FDF bag/cooling unit mounting brackets cannot accommodate cooling units when the specialist seat is used on the RSK. The mounting brackets on the starboard side of the seat are replaced with adapter brackets that accommodate the cooling units when the seat legs are folded (Figure 5-30, Figure 5-31, and Figure 5-32). The mounting brackets on the port side of the seat are not used when the seat is used as a recumbent seat.



Figure 5-30. Recumbent seat FDF bracket adapter brackets

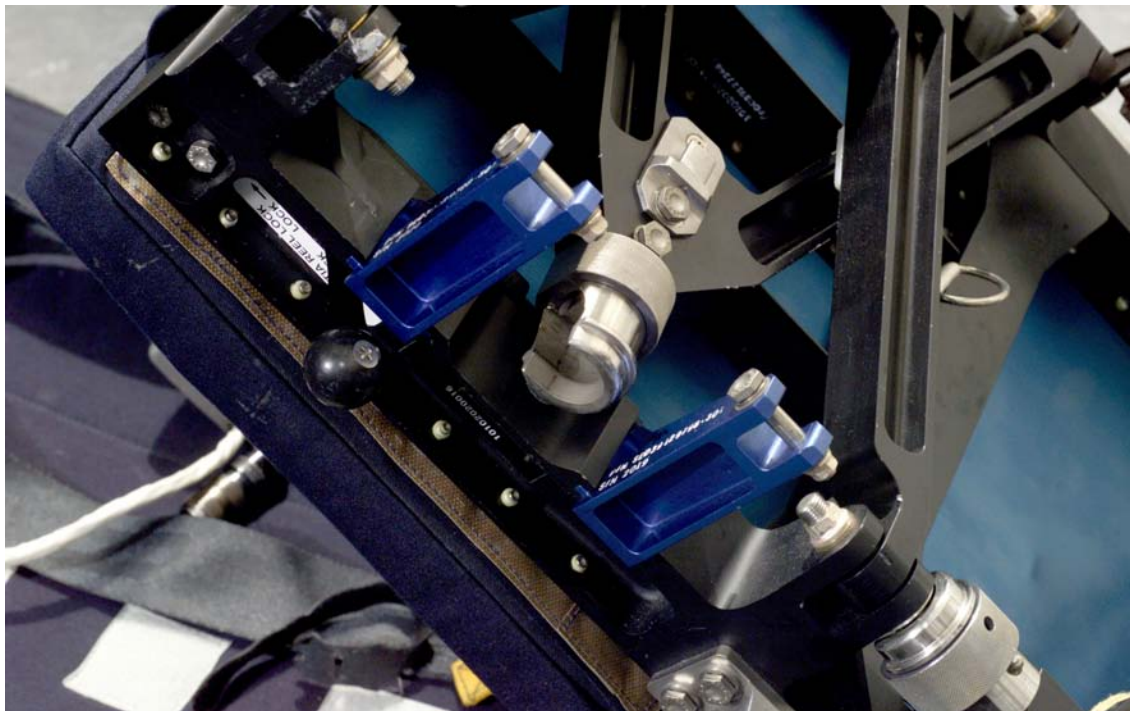


Figure 5-31. Recumbent seat mounting brackets

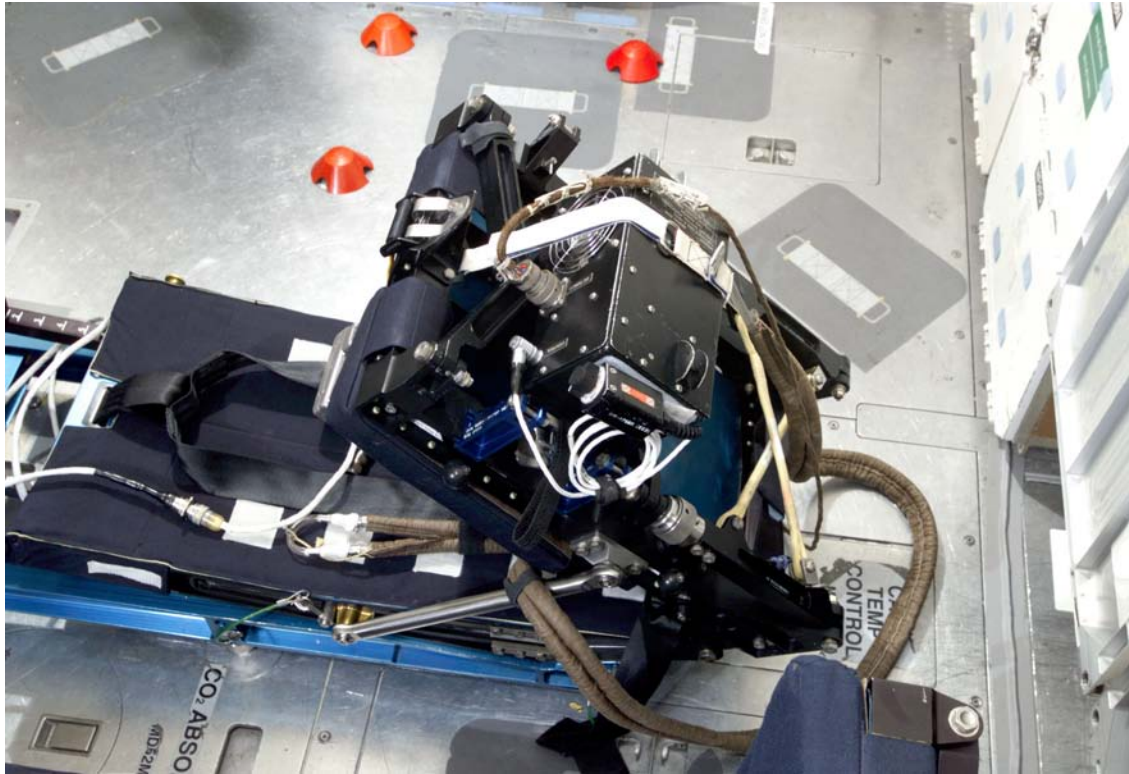


Figure 5-32. Recumbent seat cooling unit installation

5.4.1 CDR, PLT and MS Seat Technical Information

Technical information about the seats is shown in Table 5-3 and Table 5-4.

Table 5-3. Seat technical information

Seat feature	Technical information
CDR, PLT seats	
Weight	112 lb
Power requirement	28 V dc for source selection and brake solenoids 3 phase AC for motors
Circuit breaker locations	MA73C – Main ac power ML86B – Individual switches
Power Source	AC2 – CDR (nominally) AC3 – PLT (nominally)
Vertical travel	10.00 ± 0.10 inch
Horizontal travel	5.0 ± 0.10 inch
Seat speed	0.75 ± 0.25 in/sec horizontal and vertical

Table 5-3. Seat technical information (concluded)

Seat feature	Technical information
Specialists' seats	
P/N	SED39126815-301
Weight	57 lb
Dimensions	TBD
Folded	TBD
Mounted (height)	TBD
Cooling unit mounting	CDR – lower rear of seat base PLT – lower right of seat base S3 – Right side S4 – Left side Middeck – Refer to flight-specific CCCR

Table 5-4. Recumbent seat technical information

Seat item	Technical information
Kit 6	
P/N	SED39129802-301
Weight	19 lb
Dimensions	6.7 in. by 14 in. by 34.79 in.
Kit 7	
P/N	SED39129808-306
Weight	20 lb
Weight (with dual kit brackets)	24 lb
Dimensions	6.7 in. by 14.5 in. by 32.971 in.
Dimensions (with dual kit brackets)	6.855 in. by 19.688 in. by 32.791 in.
Kit 8	
P/N	SED39129814-301
Weight	20.5 lb
Dimensions	6.855 in. by 20.458 in. by 32.003 in.
RSK cooling unit brackets	
P/N	SED39129807-301
Weight	0.2 lb
Dimensions	3.283 in. by 1.374 in. by 1.656 in.
RSK bushing	
P/N	SDD39129809-001
Weight	0.04 lb
Dimensions	TBD

APPENDIX A
ACRONYMS AND ABBREVIATIONS

A/G	Air-to-Ground
AA	American Astronaut
AAD	Automatic Actuation Device
ACES	Advanced Crew Escape Suit
BIP	Bioinstrumentation Passthrough
cb	circuit breaker
CCA	Communications Carrier Assembly
CO ₂	Carbon Dioxide
CCCD	Crew Compartment Configuration Drawing
CDR	Commander
CIL	Critical Items List
CSRM	Crew Systems Reference Manual
DME	Distance Measuring Equipment
ECLSS	Environmental Control and Life Support System
EEN	Emergency Egress Net
EESS	Emergency Egress Slide System
EOS	Emergency Oxygen System
EVA	Extravehicular Activity
DFD	Flight Data File
FMEA	Failure Mode and Effects Analysis
G	gravity
HIU	Headset Interface Unit
ICU	Individual Cooling Unit
ID	Identification
IFM	In-Flight Maintenance
ISS	International Space Station
JSC	Johnson Space Center
LCG	Liquid Cooling Garment
LED	Light-Emitting Diode
LEH	Launch and Entry Helmet
LPU	Life Preserver Unit
LUT	Local User Terminal
MCC	Mission Control Center
MDF	Mild Detonating Fuse
MNA	Main Bus A

MNB	Main Bus B
MNC	Main Bus C
MOD	Mission Operations Directorate
MS	Mission Specialist
MTBF	Mean Time Between Failure
N/A	Not Applicable
NASA	National Aeronautics and Space Administration
O ₂	Oxygen
P/N	Part Number
PAFB	Patrick Air Force Base
PCES	Pole Crew Escape System
PCN	Page Change Notice
PLS	Personal Locator System
PLT	Pilot
PPA	Personal Parachute Assembly
PTT	Push-to-Talk
QD	Quick Disconnect
QDM	Quick-Don Mask
RHC	Rotational Hand Controller
RSK	Recumbent Seat Kit
RSS	Recumbent Seating System
S	Seat
S/N	Serial Number
SAR	Search and Rescue
SARSAT	Search and Rescue Satellite Aided Tracking
SEAWARS	Sea Water Activated Release System
SEBS	Spacelab Emergency Breathing System
SOC	Shuttle Operations Center
SODB	Shuttle Operational Data Book
SSP	Space Shuttle Program
SSSH	Space Shuttle Systems Handbook
TBD	To Be Determined
TELCU	Thermal Electric Liquid Cooling Unit
TV	Television
W	Window
WCS	Waste Collection System
XTA	Expanding Tube Assembly

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