

The Space Shuttle Extravehicular Mobility Unit (EMU)

As NASA changed from launching astronauts on expendable rockets to the Space Shuttle system with its reusable orbiter and solid rocket boosters, spacesuit engineers began development of a reusable EMU. Previously, all spacesuits were one-time garments. Spacesuits were custom-built to each astronaut's body size. In the Apollo program, for example, each astronaut had three custom suits—one for flight, one for training, and one for flight backup. Shuttle suits, however, are tailored from a stock of standard-size parts to fit astronauts with a wide range of measurements.

In constructing the Shuttle spacesuit, developers were able to concentrate all their designs toward a single function—going EVA. Suits from earlier manned spaceflight programs had to serve multiple functions. They had to provide backup pressure in case of cabin pressure failure and, on Gemini missions, protection if ejection became necessary during launch. They also had to provide an environment for EVA in microgravity and in low gravity while walking on the Moon (Apollo missions). Suits were worn during lift off and reentry and had to be comfortable under the high-g forces experienced during acceleration and deceleration. Shuttle suits are worn only when it is time to venture outside the orbiter cabin. At other times, crew members wear comfortable shirts and slacks, or shorts. For launch

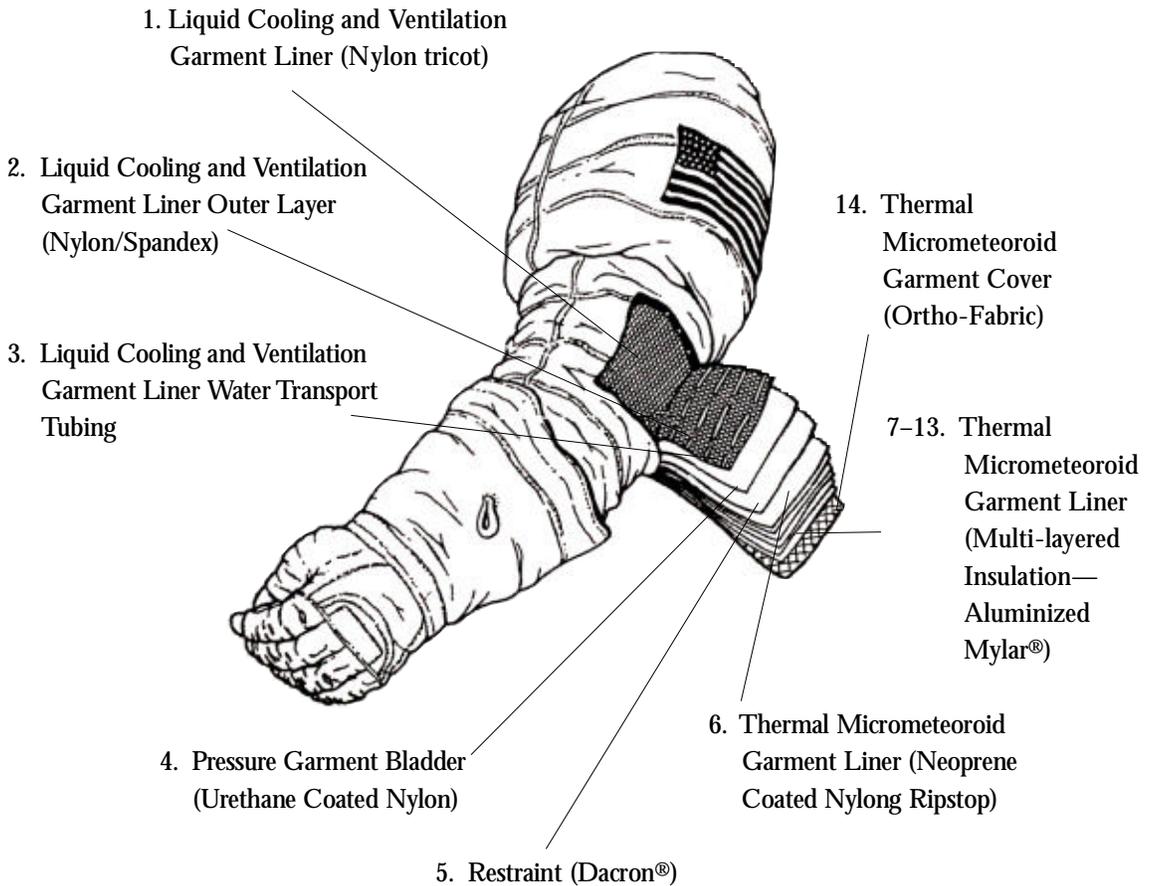


and reentry, special orange-colored flight suits with helmets are worn.

Many Layers

The Shuttle EMU has 14 layers to protect astronauts on EVAs. The inner layers comprise the liquid-cooling-and-ventilation garment. First comes a liner of Nylon tricot over which is a layer of spandex fabric laced with plastic tubing. Next comes the

pressure bladder layer of urethane-coated nylon and fabric layer of pressure-restraining Dacron®. Above the bladder and restraint layer is a liner of Neoprene coated Nylon Ripstop. This is followed by a seven-layer thermal micrometeoroid garment of aluminized Mylar®, laminated with Dacron® scrim. The outer layer of the suit is made of Ortho-Fabric which consists of a blend of Gortex®, Kevlar®, and Nomex® materials.

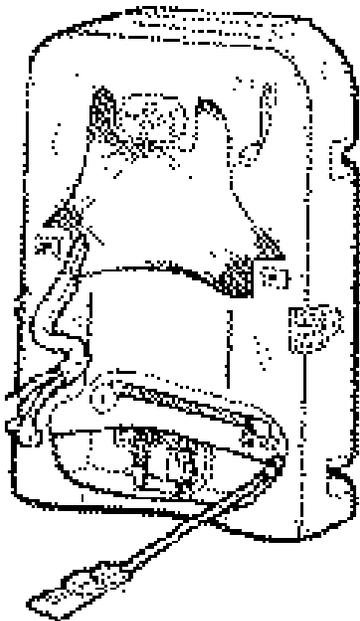


Shuttle EMU End Items

The Shuttle extravehicular mobility unit (EMU) consists of 18 separate items. Fully assembled, the Shuttle EMU becomes a nearly complete short-term spacecraft for one person. It provides pressure, thermal and micrometeoroid protection, oxygen, cooling water, drinking water, food, waste collection, (including carbon dioxide removal), electrical power, and communications. The EMU lacks only maneuvering capability, but this capability can be added by fitting a gas jet-propelled Simplified Aid for Extravehicular Activity Rescue (SAFER) over the EMU's primary life-support system. On Earth, the suit and all its parts, fully assembled but without SAFER, weighs about 113 kilograms. Orbiting above Earth it has no weight at all. It does, however, retain its mass in space, which is felt as resistance to a change in motion.

1. Primary Life-Support System (PLSS)

Self-contained backpack unit containing an oxygen supply, carbon-dioxide-removal equipment, caution and warning system, electrical power, water-cooling equipment, ventilating fan, machinery, and radio.



2. Displays and Control Module (DCM)

Chest-mounted control module containing all controls, a digital display, the external liquid, gas, and electrical interfaces. The DCM also has the primary purge valve for use with the Secondary Oxygen Pack.



3. EMU Electrical Harness (EEH)

A harness worn inside the suit to provide bioinstrumentation and communications connections to the PLSS.



4. Secondary Oxygen Pack (SOP)

Two oxygen tanks with a 30-minute emergency supply combined, valve, and regulators. The SOP is attached to the base of the PLSS. The SOP can be removed from the PLSS for ease of maintenance.



5. Service and Cooling Umbilical (SCU)

Connects the orbiter airlock support system to the EMU to support the astronaut before EVA and to provide in-orbit recharge capability for the PLSS.



The SCU contains lines for power, communications, oxygen and water recharge, and water drainage. The SCU conserves PLSS consumables during EVA preparation.



6. Battery

Battery that supplies electrical power for the EMU during EVA. The battery is rechargeable in orbit.



7. Contaminant Control Cartridge (CCC)

Cleanses suit atmosphere of contaminants with an integrated system of lithium hydroxide, activated charcoal, and a filter contained in one unit. The CCC is replaceable in orbit.

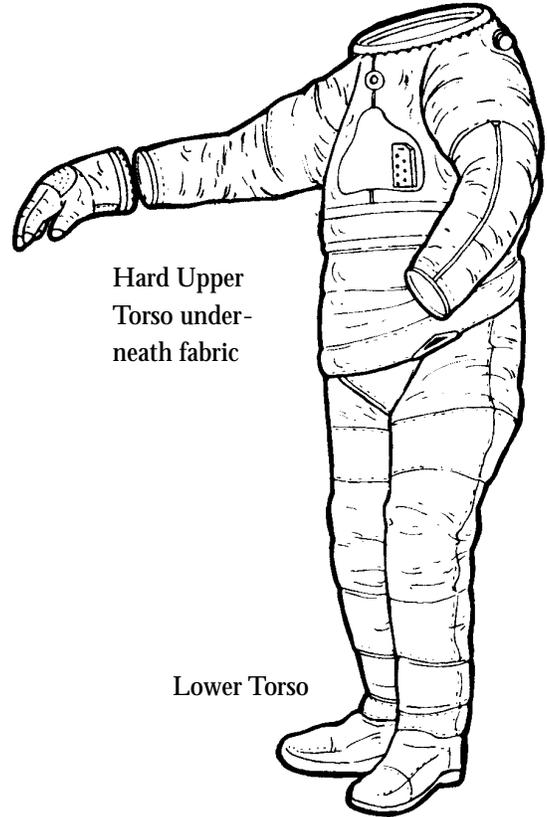


8. Hard Upper Torso (HUT)

Upper torso of the suit, composed of a hard fiberglass shell. It provides structural support for mounting the PLSS, DCM, arms, helmet, In-Suit Drink Bag, EEH, and the upper half of the waist closure. The HUT also has provisions for mounting a mini-workstation tool carrier.

9. Lower Torso

Spacesuit pants, boots, and the lower half of the closure at the waist. The lower torso also has a waist bearing for body rotation and mobility, and D rings for attaching a safety tether.



Reference Numbers 8–11.

10. Arms (left and right)

Shoulder joint and shoulder bearing, upper arm bearings, elbow joint, and glove-attaching closure.

11. EVA Gloves (left and right)

Wrist bearing and disconnect, wrist joint, and fingers. The gloves have loops for attaching tethers for restraining small tools and equipment. Generally, crew members also wear thin fabric comfort gloves with knitted wristlets under the EVA gloves.



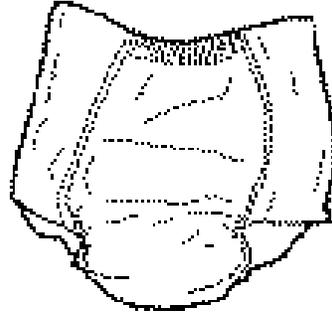
12. Helmet

Plastic pressure bubble with neck disconnect ring and ventilation distribution pad. The helmet has a backup purge valve for use with the secondary oxygen pack to remove expired carbon dioxide.



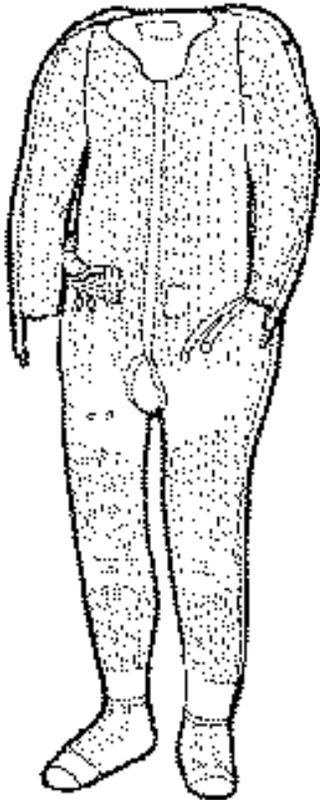
14. Maximum Absorption Garment (MAG)

An adult-sized diaper with extra absorption material added for urine collection.



13. Liquid Cooling-and-Ventilation Garment (LCVG)

Long underwear-like garment worn inside the pressure layer. It has liquid cooling tubes, gas ventilation ducting, and multiple water and gas connectors for attachment to the PLSS via the HUT.



15. Extravehicular Visor Assembly (EVA)

Assembly containing a metallic-gold-covered Sun-filtering visor, a clear thermal impact-protective visor, and adjustable blinders that attach over the helmet. In addition, four small "head lamps" are mounted on the assembly; a TV camera-transmitter may also be added.



16. In-Suit Drink Bag (IDB)

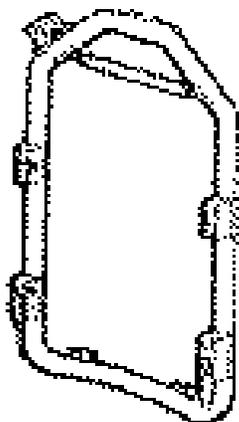
Plastic water-filled pouch mounted inside the HUT. A tube projecting into the helmet works like a straw.



17. Communications Carrier Assembly (CCA)
Fabric cap with built-in earphones and a microphone for use with the EMU radio.



18. Airlock Adapter Plate (AAP)
Fixture for mounting and storing the EMU inside the airlock and for use as an aid in donning the suit.



Putting on the EMU

Putting on a Shuttle EMU is a relatively simple operation that can be accomplished in a matter of about 15 minutes. However, the actual process of preparing to go EVA takes much longer. When working in the Shuttle cabin, crew members breathe a normal atmospheric mix of nitrogen and oxygen at 101 kilopascals. The suit's atmosphere is pure oxygen at 29.6 kilopascals. A rapid drop from the cabin pressure to the EMU pressure could result in a debilitating ailment that underwater divers sometimes experience—the bends. The bends, also

known as caisson disease, are produced by the formation and expansion of nitrogen gas bubbles in the bloodstream when a person breathing a normal air mixture at sea-level pressure is exposed to a rapid drop in external pressure. In severe cases, the bends are characterized by pains in the joints, cramps, paralysis, and eventual death if not treated by gradual recompression. To prevent an occurrence of the bends, crew members intending to go EVA spend a period of time prebreathing pure oxygen. During that time, nitrogen gas in the bloodstream is replaced by pure oxygen.

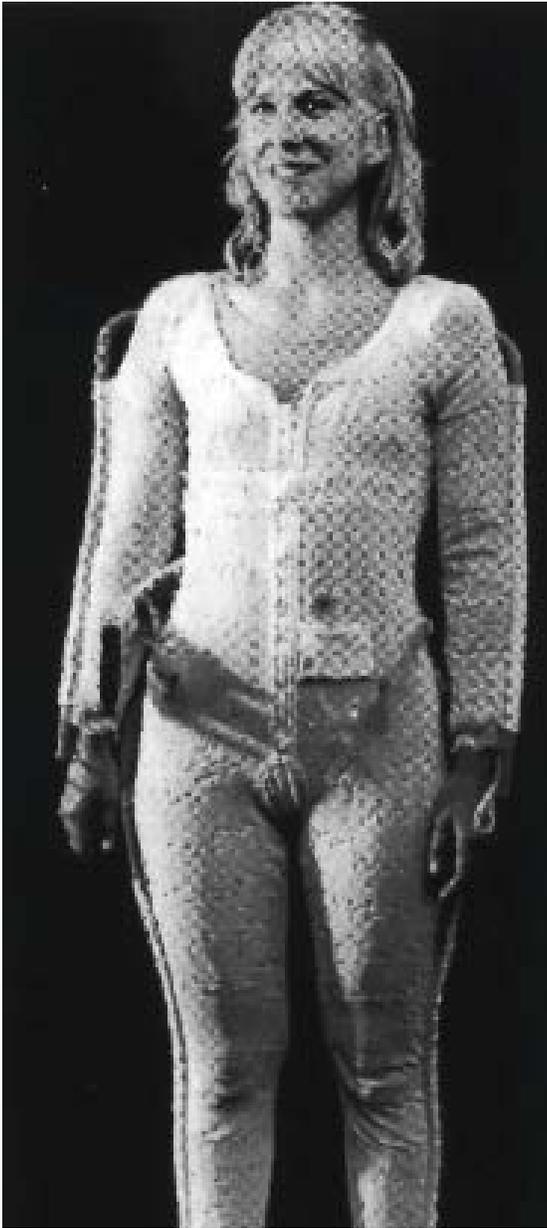
Prior to prebreathing, the atmospheric pressure of the entire orbiter cabin is depressed from the normal 101 kilopascals to 70.3 pascals while the percentage of oxygen is slightly increased. Prebreathing begins when the crew members who plan to go EVA don a mask connected to an oxygen supply. A short hose permits them to continue their EVA preparations during this period. The length of time for cabin decompression and the time for prebreathing is related. Without any cabin decompression, prebreathing must last at least four hours. A prebreathe of 30 minutes is safe providing cabin decompression takes place at least 24 hours before the exit into space.

By now, much of the dissolved nitrogen gas has been cleared from the EVA crew members, and they can remove their helmets. Later, when they don their spacesuits and seal the helmets, an additional 30 to 40 minutes of pure oxygen prebreathing takes place before the suits are lowered to their operating pressure of 29.6 kilopascals.

Most of the EMU-donning process takes place inside the airlock. The airlock is a cylindrical chamber located on the orbiter's mid-deck. One hatch leads from the middeck into the airlock, and a second hatch leads from the airlock out to the unpressurized payload bay.

Before entering the hatch, but following their initial prebreathing, the crew members put on the maximum absorbency garment (MAG). The MAG is an adult-size diaper.





Spacesuit technician prepares to put on the Space Shuttle EMU by first donning the Liquid Cooling-and-Ventilation garment.

Next comes the Liquid Cooling-and-Ventilation Garment (LCVG). The LCVG has the general appearance of long underwear. It is a one-piece suit with a zippered front, made of stretchable spandex fabric laced with 91.5 meters of plastic tubing. When the EMU is completely assembled, cooling and ventilation become significant problems. Body heat, contaminant gases, and perspiration—all waste

products—are contained by the insulation and pressure layers of the suit and must be removed. Cooling of the crew member is accomplished by circulating chilled water through the tubes. Chilling the water is one of the functions of the Primary Life-Support System (PLSS). The PLSS device for water cooling and the tubing system are designed to provide cooling for physical activity that generates up to two million joules of body heat per hour, a rate that is considered “extremely vigorous.” (Approximately 160 joules are released by burning a piece of newsprint one centimeter square.) Ducting attached to the LCVG ventilates the suit by drawing ventilating oxygen and expired carbon dioxide from the suit’s atmosphere into the PLSS for purification and recirculation. Body perspiration is also drawn away from the suit by the venting system and recycled in the water cooling system. The intakes are located near the hands and feet of the suit. Ducts, running along the arms and legs on the back of the LCVG channel, the ventilation gases to a circular junction on the back of the LCVG and into the torso vent duct. From there, the gases are returned to the PLSS via the LCCGV multiple water connector. Purified oxygen from the PLSS reenters the suit through another duct, mounted in the back of the helmet, that directs the flow over the astronaut’s face to complete the circuit.

The EMU electrical harness is attached to the HUT and provides biomedical and communications hookups with the PLSS. The biomedical hookup monitors the heart rate of the crew members, and this information is radioed via a link with the orbiter to Mission Control on Earth. Voice communications are also carried on this circuit.

Next, several simple tasks are performed. Antifog compound is rubbed on the inside of the helmet. A wrist mirror and a small spiral-bound 27-page checklist are put on the left arm of the upper torso. The wrist mirror was added to the suit because some of the knobs on the front of the displays and control module are out of the vision range of the crew member. The mirror permits the knob



settings to be read. Setting numbers are written backwards for ease of reading in the mirror.

Another task at this time is to insert a food bar and a water-filled In-Suit Drink Bag (IDB) inside the front of the HUT. The food bar of compressed fruit, grain, and nuts is wrapped in edible rice paper, and its upper end extends into the helmet area near the crew member's mouth. When hungry, the crew member bites the bar and pulls it upward before breaking off a piece to chew. In that manner, a small piece of the bar remains extended into the helmet for the next bite. It is necessary to eat the entire bar at one time, because saliva quickly softens the protruding food bar, making it mushy and impossible to break off. The IDB is placed just above the bar. Two sizes of bags are available and the one chosen is filled with water from the water supply of the orbiter's galley prior to entry into the airlock. The largest bag contains nearly 1 liter of water. A plastic tube and valve assembly extends up into the helmet so that the crew member can take a drink whenever needed. Both the food bar and drink bag are held in place by Velcro attachments.

During EVAs, the crew members may need additional lighting to perform their tasks. A light-bar attachment (helmet-mounted light array) is placed above the helmet visor assembly. Small built-in flood lamps provide illumination to places that sunlight and the regular payload bay lights do not reach. The EVA light has its own battery system and can be augmented with a helmet-mountable television camera system with its own batteries and radio frequency transmitter. The camera's lens system is about the size of a postage stamp. Through this system, the crew remaining inside the orbiter and the mission controllers on Earth can get an astronaut's eye view of the EVA action. During complicated EVAs, viewers may be able to provide helpful advice for the tasks at hand.

Next, the Communications Carrier Assembly (CCA), or "Snoopy cap," is connected to the EMU electrical harness and left floating above the HUT. The CCA earphones and microphones are held by

a fabric cap. After the crew member dons the EMU, the cap is placed on the head and adjusted.

When the tasks preparatory to donning the suit are completed, the lower torso, or suit pants, are pulled on. The lower torso comes in various sizes to meet the varying size requirements of different astronauts. It features pants with boots and joints in the hip, knee, and ankle, and a metal body-seal closure for connecting to the mating half of the ring mounted on the hard upper torso. The lower torso's waist element also contains a large bearing. This gives the crew member mobility at the waist, permitting twisting motions when the feet are held in workstation foot restraints.

Joints for the lower and upper torsos represent an important advance over those of previous spacesuits. Earlier joint designs consisted of hard rings, bellows-like bends in the pressure bladder, or cable- and pulley-assisted fabric joints. The Shuttle EMU joints maintain nearly constant volume during bending. As the joints are bent, reductions in volume along the inner arc of the bend are equalized by increased volume along the outer arc of the bend.

Long before the upper half of the EMU is donned, the airlock's Service and Cooling Umbilical (SCU) is plugged into the Displays and Control Module Panel on the front of the upper torso. Five connections within the umbilical provide the suit with cooling water, oxygen, and electrical power from the Shuttle itself. In this manner, the consumables stored in the Primary Life-Support System will be conserved during the lengthy prebreathing period. The SCU also is used for battery and consumable recharging between EVAs.

The airlock of the Shuttle orbiter is only 1.6 meters in diameter and 2.1 meters high on the inside. When two astronauts prepare to go EVA, the space inside the airlock becomes crowded. For storage purposes and as an aid in donning and doffing the EMU, each upper torso is mounted on airlock adapter plates. Adapter plates are brackets on the airlock wall for supporting the suits' upper torsos.



With the lower torso donned and the orbiter providing consumables to the suits, each crew member “dives” with a squirming motion into the upper torso. To dive into it, the astronaut maneuvers under the body-seal ring of the upper torso and assumes a diving position with arms extended upward. Stretching out, while at the same time aligning arms with the suit arms, the crew member slips into the upper torso. As two upper and lower body-seal closure rings are brought together, two connections are made. The first joins the cooling water-tubing and ventilation ducting of the LCVG to the Primary Life-Support System. The second connects the biomedical monitoring sensors to the EMU electrical harness that is connected to the PLSS. Both systems are turned on, and the crew member then locks the two body-seal closure rings together, usually with the assistance of another crew member who remains on board.

One of the most important features of the upper half of the suit is the HUT, or Hard Upper Torso. The HUT is a hard fiberglass shell under the fabric layers of the thermal-micrometeoroid garment. It is similar to the breast and back plates of a suit of armor. The HUT provides a rigid and controlled mounting surface for the Primary Life-Support System on the back and the Displays and Control Module on the front.

In the past, during the Apollo Moon missions, donning suits was a very lengthy process because the life-support system of those suits was a separate item. Because the Apollo suits were worn during launch and landing and also as cabin-pressure backups, a HUT could not be used. It would have been much too uncomfortable to wear during the high accelerations and decelerations of lift-off and reentry. The life-support system had to be attached to the suit inside the lunar module. All connections between PLSS and the Apollo suit were made at that time and, with two astronauts working in cramped quarters, preparing for EVA was a difficult process. The Shuttle suit HUT eliminates that lengthy procedure because the PLSS is already attached. It also elimi-

nates the exposed and vulnerable ventilation and life-support hoses of earlier EMU designs that could become snagged during EVA.

The last EMU gear to be donned includes eyeglasses if needed, the communications carrier assembly (CCA), comfort gloves, the helmet with lights and optional TV, and EVA gloves. The two gloves have fingertips of silicone rubber that permit some degree of sensitivity in handling tools and other objects. Metal rings in the gloves snap into rings in the sleeves of the upper torso. The rings in the gloves contain bearings to permit rotation for added mobility in the hand area. The connecting ring of the helmet is similar to the rings used for the body-seal closure. Mobility is not needed in this ring because the inside of the helmet is large enough for the crew member’s head to move around. To open or lock any of the connecting rings, one or two sliding, rectangular-shaped knobs are moved to the right or the left. When opened, the two halves of the connecting rings come apart easily. To close and lock, one of the rings slides part way into the other against an O-ring seal. The knob is moved to the right, and small pins inside the outer ring protrude into a groove around the inside ring, thereby holding the two together.

All suit openings have locking provisions that require a minimum of three independent motions to open. This feature prevents any accidental opening of suit connections.

With the donning of the helmet and gloves, the spacesuits are now sealed off from the atmosphere of the air lock. The crew members are being supported by the oxygen, electricity, and cooling water provided by the orbiter. A manual check of suit seals is made by pressurizing each suit to 29.6 kilopascals d. (The “d” stands for differential, meaning greater than the air lock pressure.) Inside the air lock, the pressure is either 70.3 or 101 kilopascals. The suit’s pressure is elevated an additional 29.6 kilopascals, giving it a pressure differential above the air lock pressure. Once pressure reaches the desired level, the oxygen supply is shut off and the



digital display on the chest-mounted control module is read. To assist in reading the display, an optional Fresnel lens inside the space helmet may be used to magnify the numbers. Some leakage of spacesuit pressure is normal. The maximum allowable rate of leakage of the Shuttle EMU is 1.38 kilopascals per minute, and this is checked before the suit is brought back down to air lock pressure.

As the suit pressure is elevated, crew members may experience discomfort in their ears and sinus cavities. They compensate for the pressure change by swallowing, yawning, or pressing their noses on an optional sponge mounted to the left on the inside of the helmet ring. Attempting to blow air through the nose when pressing the nose on the sponge forces air inside the ears and sinus cavities to equalize the pressure.

During the next several minutes the two spacesuits are purged of any oxygen/nitrogen atmosphere remaining from the cabin; this is replaced with pure oxygen. Additional suit checks are made while the final oxygen prebreathe takes place.

The inner door of the air lock is sealed, and the air lock pressure bleed-down begins. A small depressurization valve in the air lock latch is opened to outside space, permitting the air lock atmosphere to escape. While this is taking place the EMU automatically drops its own pressure to 66.9 kilopascals and leak checks are conducted. Failure of the leak test would require repressurizing the air lock, permitting the EVA crew to reexamine the seals of their suits.

Final depressurization is begun by opening the air lock depressurization valve. The outer air lock hatch is then opened and the suited astronauts prepare to pull themselves out into the payload bay. As a safety measure, they tether themselves to the orbiter to prevent floating away as they move from place to place by hand holds. It is at this point that they disconnect the orbiter Service and Cooling Umbilical from the EMU. The PLSS begins using its own supply of oxygen, cooling water, and electricity. The astronauts pull themselves through the outer air lock hatch, and the EVA begins.

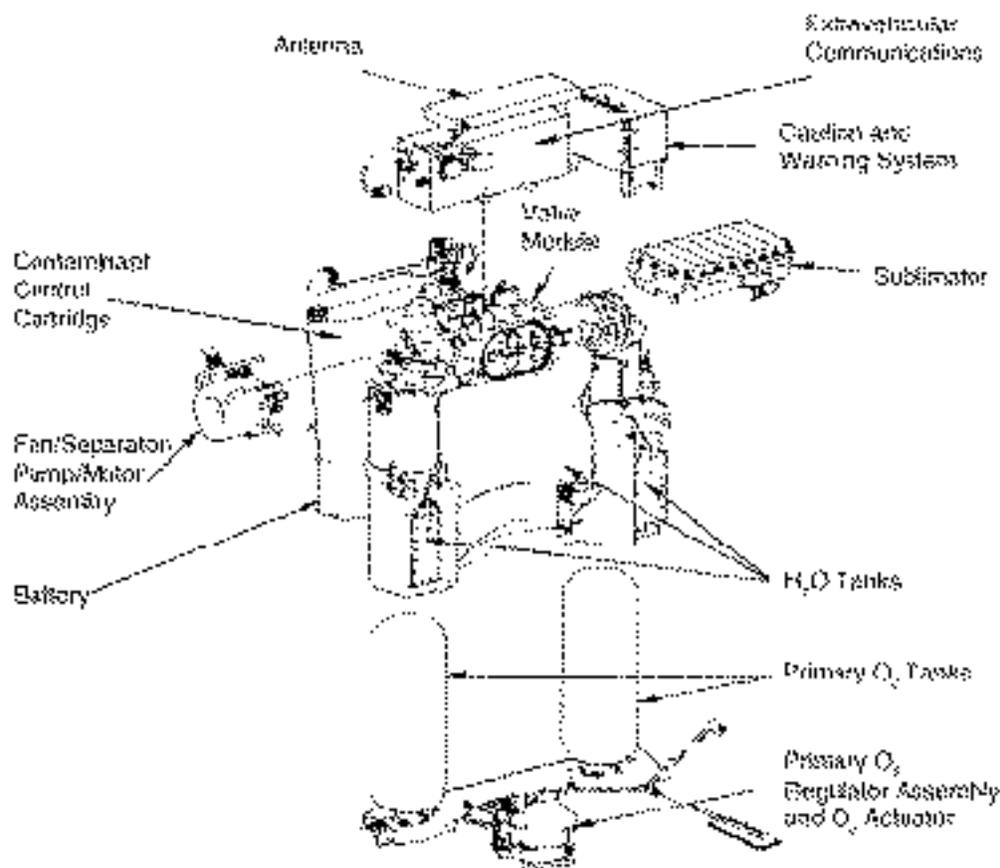
The Primary and Secondary Life-Support Systems

Astronauts experienced their first real freedom while wearing spacesuits during the Apollo Moonwalk EVAs, because of a portable life-support system worn on their backs. All other EVAs up to that time were tied to the spacecraft by the umbilical-tether line that supplied oxygen and kept crew members from drifting away. In one sense, the tether was a leash, because it limited movements away from the spacecraft to the length of the tether. On the Moon, however, astronauts were not hampered by a tether and, in the later missions, were permitted to drive their lunar rovers up to 10 kilometers away from the lander. (That distance limit was imposed as a safety measure. It was determined that 10 kilometers was the maximum distance an astronaut could walk back to the lander if a lunar rover ever broke down.)

Space Shuttle astronauts have even greater freedom than the Apollo lunar astronauts because their EVAs take place in the microgravity environment of space. They do employ tethers when EVAs center in and about the Shuttle's payload bay, but those tethers act only as safety lines and do not provide life support. Furthermore, the tethers can be moved from one location to another on the orbiter along a slide wire, permitting even greater distances to be covered.

The freedom of movement afforded to Shuttle astronauts on EVAs is due to the Primary Life-Support System (PLSS) carried on their backs. The PLSS, an advanced version of the Apollo system, provides life support, voice communications, and biomedical telemetry for EVAs lasting as long as seven hours. Within its dimensions of 80 by 58.4 by 17.5 centimeters, the PLSS contains five major groups of components for life support. Those are the oxygen-ventilating, condensate, feedwater, liquid transport, and primary oxygen circuits.





Primary Life-Support System

The oxygen-ventilating circuit is a closed-loop system. Oxygen is supplied to the system from the primary oxygen circuit or from a secondary oxygen pack that is added to the bottom of the PLSS for emergency use. The circulating oxygen enters the suit through a manifold built into the Hard Upper Torso. Ducting carries the oxygen to the back of the space helmet, where it is directed over the head and then downward along the inside of the helmet front. Before passing into the helmet, the oxygen warms sufficiently to prevent fogging of the visor. As the oxygen leaves the helmet and travels into the rest of the suit, it picks up carbon dioxide and humidity from the crew member's respiration. More humidity from perspiration, some heat from physical activity, and trace contaminants are also

picked up by the oxygen as it is drawn into the ducting built into the Liquid Cooling-and-Ventilation Garment. A centrifugal fan, running at nearly 20,000 rpm, draws the contaminated oxygen back into the PLSS at a rate of about 0.17 cubic meters per minute, where it passes through the Contaminant Control Cartridge.

Carbon dioxide and trace contaminants are filtered out by the lithium hydroxide and activated charcoal layers of the cartridge. The gas stream then travels through a heat exchanger and sublimator for removal of the humidity. The heat exchanger and sublimator also chill water that runs through the tubing in the Liquid Cooling and Ventilation Garment (LCGV). The humidity in the gas stream condenses out in the heat exchanger and sublima-





Astronaut Joe Tanner works on the Hubble Space Telescope during the STS-82 mission. The curvature of Earth and the Sun are over his left shoulder.

tor. The relatively dry gas (now cooled to approximately 13 degrees Celsius) is directed through a carbon dioxide sensor before it is recirculated through the suit. Oxygen is added from a supply and regulation system in the PLSS as needed. In the event of the failure of the suit fan, a purge valve in the suit can be opened. It initiates an open loop purge mode in which oxygen is delivered from both the primary and secondary oxygen pack. In this mode, moisture and the carbon dioxide-rich gas are dumped outside the suit just before they reach the Contaminant Control Cartridge.

One of the by-products of the oxygen-ventilating circuit is moisture. The water produced by perspiration and breathing is withdrawn from the oxygen supply by being condensed in the sublimator and is carried by the condensate circuit. (The small amount of oxygen that is also carried by the condensate circuit is removed by a gas separator and returned to the oxygen-ventilating system.) The water is then sent to the

water-storage tanks of the feedwater circuit and added to their supply for eventual use in the sublimator. In this manner, the PLSS is able to maintain suit cooling for a longer period than would be possible with just the tank's original water supply.

The function of the feedwater and the liquid transport circuits is to cool the astronaut. Using the pressure of oxygen from the primary oxygen circuit, the feedwater circuit moves water from the storage tanks (three tanks holding a total of 4.57 kilograms of water) to the space between the inner surfaces of two steel plates in the heat exchanger and sublimator. The outer side of one of the plates is exposed directly to the vacuum of space. That plate is porous and, as water evaporates through the pores, the temperature of the plate drops below the freezing point of water. Water still remaining on the inside of the porous plate freezes, sealing off the pores. Flow in the feedwater circuit to the heat exchanger and sublimator then stops.



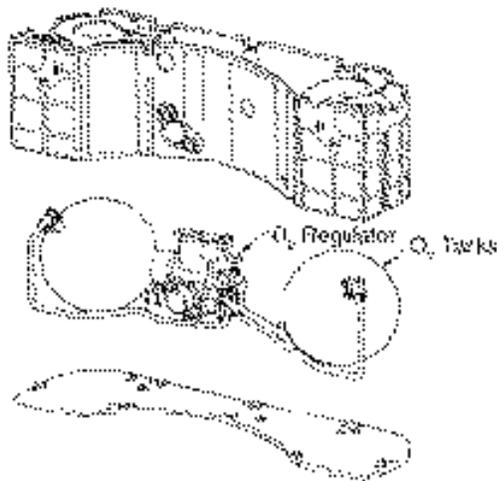
On the opposite side of the other steel plate is a second chamber through which water from the liquid transport circuit passes. The liquid transport circuit is a closed-loop system that is connected to the plastic tubing of the LCVG. Water in this circuit, driven by a pump, absorbs body heat. As the heated water passes to the heat exchanger and sublimator, heat is transferred through the aluminum wall to the chamber with the porous wall. The ice formed in the pores of that wall is sublimated by the heat directly into gas, permitting it to travel through the pores into space. In this manner, water in the transport circuit is cooled and returned to the LCVG. The cooling rate of the sublimator is determined by the workload of the astronaut. With a greater workload, more heat is released into the water loop, causing ice to be sublimated more rapidly and more heat to be eliminated by the system.

The last group of components in the Primary Life-Support System is the primary oxygen circuit. Its two tanks contain a total of 0.54 kilograms of oxygen at a pressure of 5,860.5 kilopascals, enough for a normal seven-hour EVA. The oxygen of this

circuit is used for suit pressurization and breathing. Two regulators in the circuit step the pressure down to usable levels of 103.4 kilopascals and 29.6 kilopascals. Oxygen coming from the 103.4-kilopascal regulator pressurizes the water tanks, and oxygen from the 29.6-kilopascal regulator goes to the ventilating circuit.

To insure the safety of astronauts on EVAs, a Secondary Oxygen Pack (SOP) is added to the bottom of the PLSS. The two small tanks in this system contain 1.2 kilograms of oxygen at a pressure of 41,368.5 kilopascals. The Secondary Oxygen Pack can be used in an open-loop mode by activating a purge valve or as a backup supply should the primary system fall to 23.79 kilopascals. The supply automatically comes on line whenever the oxygen pressure inside the suit drops to less than 23.79 kilopascals.

If the Displays and Control Module (DCM) purge valve (discussed below) is opened, used-oxygen contaminants and collected moisture dump directly out of the suit into space. Because oxygen is not conserved and recycled in this mode, the large quantity of oxygen contained in the SOP is consumed in only 30 minutes. This half-hour still gives the crew member enough time to return to the orbiter's airlock. If carbon dioxide control is required, the helmet purge valve may be opened instead of the DCM purge valve. That valve has a lower flow rate than the DCM valve.



Secondary Oxygen Pack

Displays and Control Module

The PLSS is mounted directly on the back of the Hard Upper Torso, and the controls to run it are mounted on the front. A small, irregularly-shaped box, the Displays and Control Module (DCM), houses a variety of switches, valves, and displays. Along the DCM top are four switches for power, feedwater, communications mode selection, and caution and warning. A suit-pressure purge valve projects from the top at the left. It is used for depressurizing the suit at the end of an EVA and can be used in an emergency to remove heat and

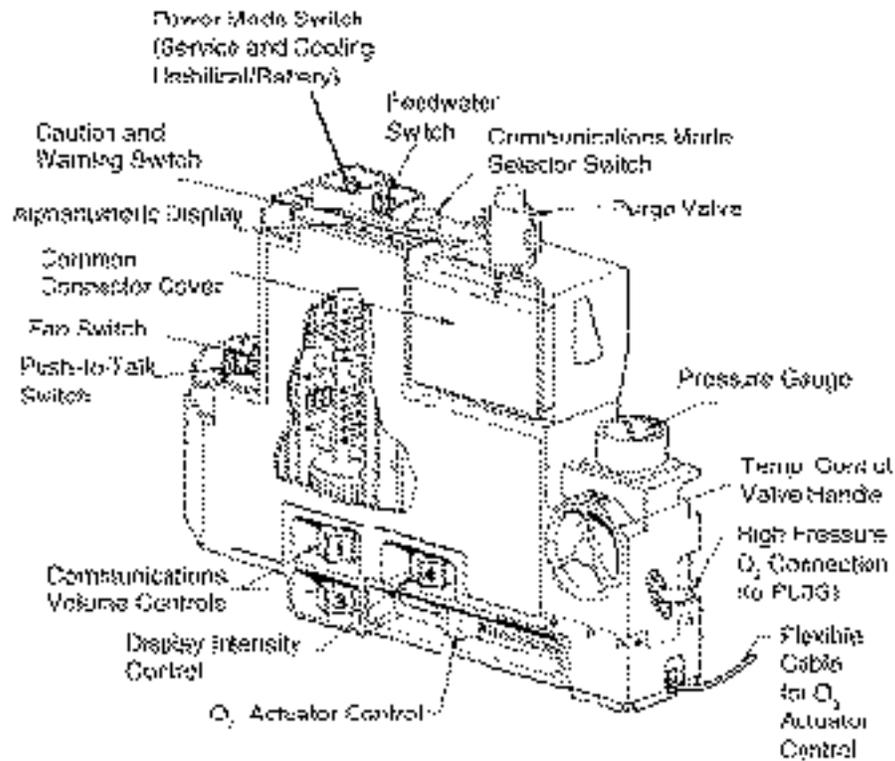


humidity when oxygen is flowing from both the primary and secondary oxygen systems. Near the front on the top is an alpha-numeric display. A microprocessor inside the PLSS permits astronauts to monitor the condition of the various suit circuits by reading the data on the display.

Stepped down from the top of the DCM, on a small platform to the astronaut's right, is a ventilation-fan switch and a push-to-talk switch. The

astronaut has the option of having the radio channel open at all times or only when needed.

On a second platform, to the left, is an illuminated mechanical-suit pressure gauge. At the bottom, on the front of the DCM, are additional controls for communications volume, display lighting intensity, temperature control, and a four position selector for controlling suit pressure in different EVA operating modes.



Display and Control Module

