

PORTABLE LIFE SUPPORT SYSTEM

The portable life support system provides an astronaut with a livable atmosphere inside his space suit during excursions on the lunar surface and in space. Worn on the back and connected to the suit's waist by umbilicals, it permits up to seven hours of extravehicular activity, depending on the astronaut's metabolic rate.

The backpack supplies oxygen for breathing and suit ventilation, and refrigerated water and oxygen for body cooling. It pressurizes the suit to 3.9 psi and removes contaminants from the oxygen circulating through the suit. It also has a communication-telemetry set, controls to operate it, and devices to monitor its functions.

For the lunar mission, the LM has two of these life support packs. The LM carries enough supplies to refill each pack's oxygen tank and water reservoir, and replace its battery and two lithium hydroxide canisters twice. This will allow a total of three extravehicular trips.

The life support pack, with its controls, weighs 104 pounds; it is 26 inches high, 20.5 inches wide, and 10.5 inches deep. It is powered by a 16.8-volt silver-zinc battery. A fiberglass cover protects the pack against micrometeoroids.

Five subsystems make up the portable life support system: primary oxygen supply, oxygen-ventilating circuit, water transport loop, feedwater loop, and space suit communication system. For emergency use, an oxygen purge system supplies an additional 30 to 90 minutes of oxygen according to selected flow rate. The OPS is mounted on the pack, but operates separately.

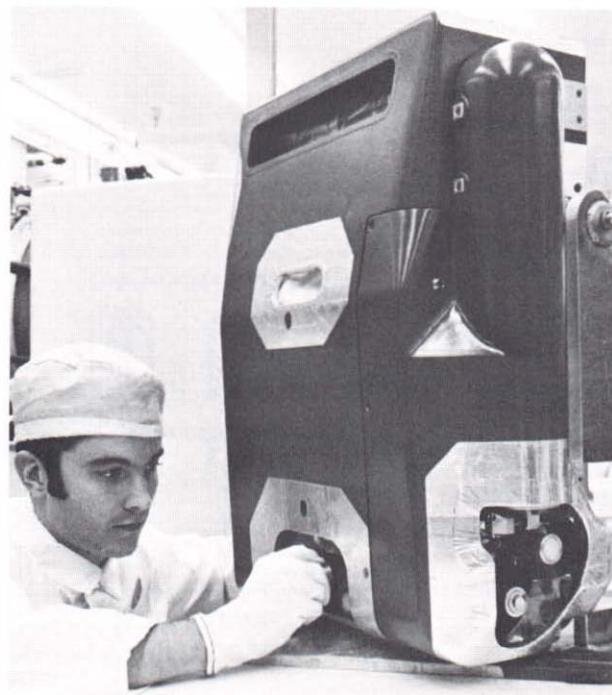
A thermal insulator made of fire-resistant Beta cloth and aluminized Kapton covers the pack and its shell to restrict heat leakage in or out, depending on the moon's temperature. A similar insulator covers the oxygen purge system.

A remote control unit (RCU), which is attached to the suit chest, has switches for the life support pack's water pump and oxygen fan, four-position communication selector switch, a radio volume control, an oxygen quantity gage, and warning indicators. The OPS actuator is attached to the RCU during an EVA.

FUNCTIONAL DESCRIPTION

PRIMARY OXYGEN SUPPLY

This subsystem supplies oxygen for breathing and pressurizes the space suit and helmet. The oxygen is automatically fed into the suit to maintain a pressure of 3.9 psi. Approximately 1.5 pounds of gaseous oxygen is stored at between 1380 and 1440 psi in a tank nearly 6 inches in diameter and slightly more than 17 inches long. The tank is replenished from the LM oxygen supply.



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Portable Life Support System

OXYGEN-VENTILATING CIRCUIT

This subsystem circulates oxygen through the space-suit pressure garment and purifies recirculating oxygen. It also helps cool the astronaut by evaporating moisture that accumulates on his skin.

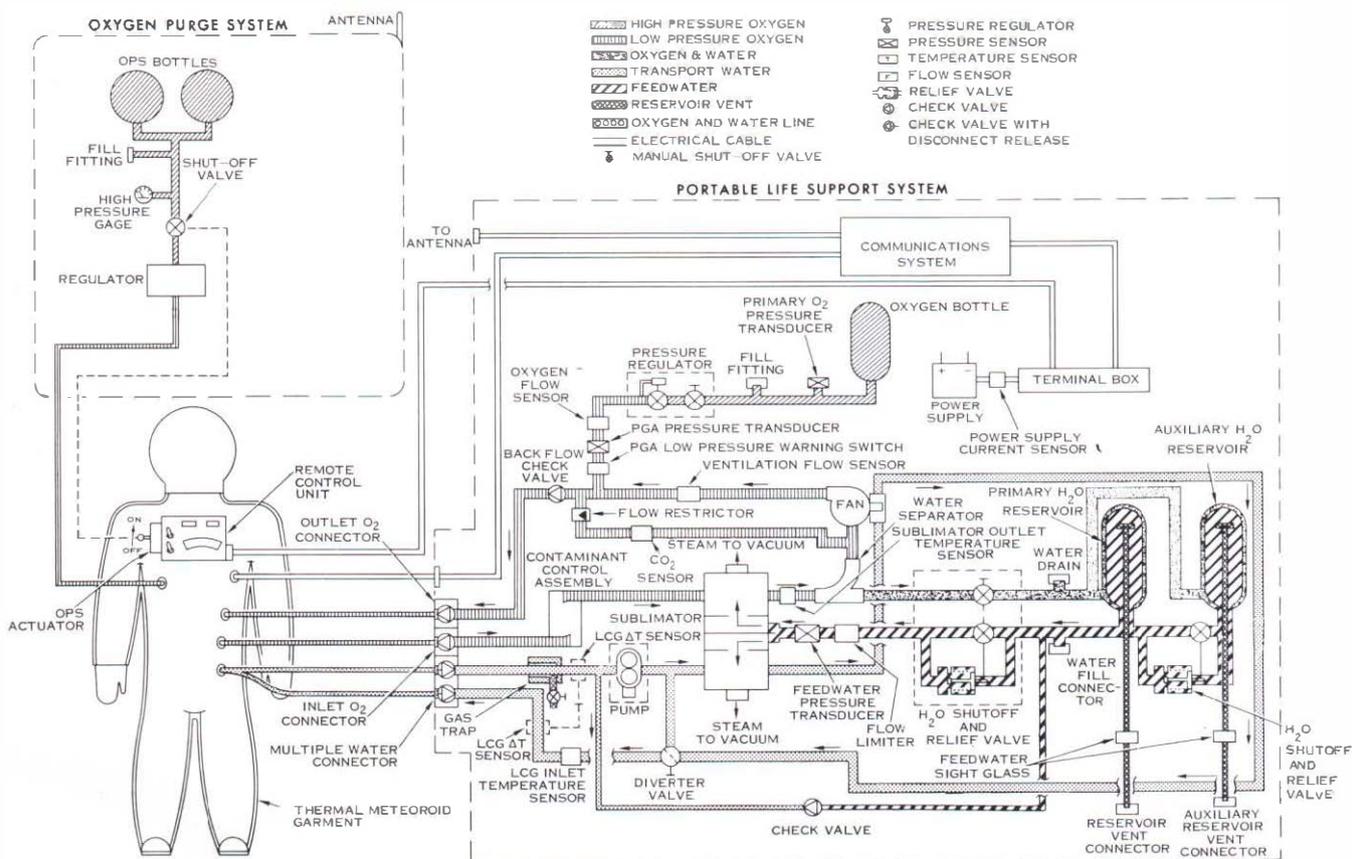
Oxygen entering the backpack from the suit passes through a lithium hydroxide cartridge, where chemicals trap carbon dioxide exhaled by the astronaut. It then goes through an activated-charcoal bed that removes trace contaminants, including body odors. The oxygen flow is cooled by a porous-plate sublimator, a self-regulating heat-rejection device developed by Hamilton Standard. Water in the sublimator absorbs the heat and seeps through the pores of the sublimator's sintered-nickel plates which are exposed to vacuum. The water freezes, forms an ice layer across the plates, then turns from ice to vapor. The rate of this sublimating process is governed by the amount of heat being rejected.

Excess water entering the oxygen flow, mainly from astronaut respiration and perspiration, is removed by a water separator and stored outside the bladder section of the water reservoir. A fan recirculates oxygen to the space suit at a rate of 5.5 cubic feet per minute.

Six extra lithium hydroxide cartridges are carried in the LM to replace used cartridges.

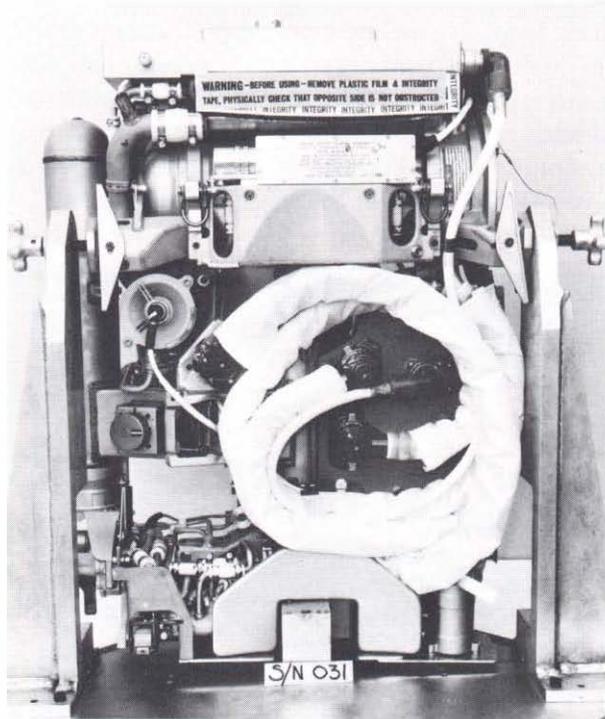
WATER TRANSPORT LOOP

This loop cools the astronaut by removing his metabolic heat and any heat that leaks into the suit from the hot lunar surface. A battery-operated pump continuously circulates 1.35 pounds of chilled water at a rate of 4 pounds per minute through a network of plastic tubing integrated in the liquid cooling garment worn under the space suit. The pack dissipates metabolic heat at an average of 1,600 Btu per hour and can handle peak rates up to 2,000 Btu.



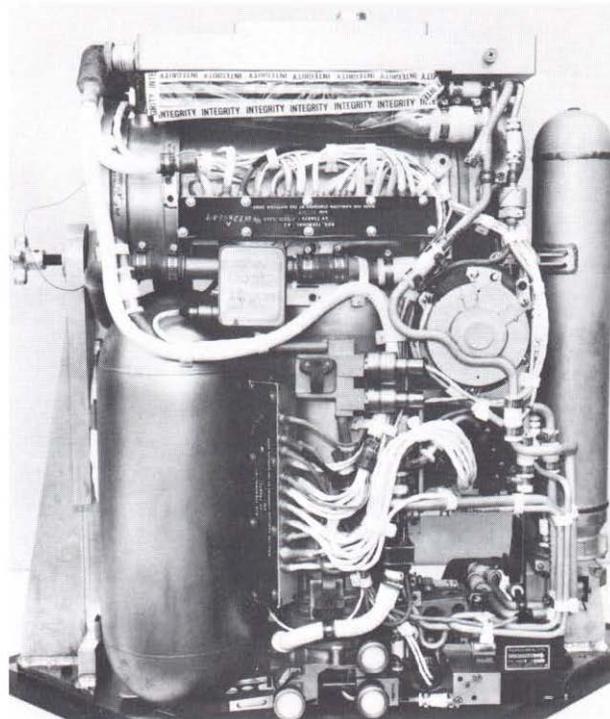
R-114A

Apollo Extravehicular Mobility Unit Schematic – Lunar Configuration



R-115A

Front View of PLSS



R-116A

Rear View of PLSS

The sublimator that cools the oxygen flow extracts heat from the circulating water, which normally leaves the pack at 45° F. To control cooling, the astronaut uses a valve on the pack to select any one of three water temperature ranges (45° to 50°, 60° to 65°, or 75° to 80°). This valve diverts water past the sublimator.

FEEDWATER LOOP

This subsystem supplies 11.8 pounds of expendable water, stored in a rubber bladder reservoir, to the heat-rejecting porous-plate sublimator. Of this expendable feedwater, 8.5 pounds is stored in the main reservoir; an auxiliary tank holds the remaining 3.3 pounds. Suit pressure against the bladder forces water into passages between the sublimator's heat transport fluid passages and its metal plates, which are exposed to space vacuum. The ice layer formed on the porous plates during sublimation prevents the slightly pressurized water from flowing through the metal pores.

Condensed water from the oxygen-ventilating circuit is collected outside the reservoir bladder. Feedwater is replenished from the LM supply.

Refilling the bladder forces water condensed from the oxygen flow into the LM waste management system.

SPACE SUIT COMMUNICATION SYSTEM

This system, manufactured by Radio Corporation of America, provides primary and backup dual voice transmission and reception, telemetry transmission of physiological and backpack performance data, and an audible warning signal. It also regulates the voltage and electrical current of the oxygen quantity gauge and various sensors.

Operation of the communication system in the dual mode, provides crew members with uninterrupted duplex voice communications with one another, with the LM and, via the LM, with Mission Control. A dual volume control permits adjustment of receiver sound level. The transceiver control station on the LM is used as a relay station between crewmen on the lunar surface or in space. It also relays radio-telemetry data to earth monitors and to the Command Module when it is in line-of-sight of the LM.

Telemetry information is transmitted without interrupting or interfering with voice communication. Nine telemetry channels transmitted to the LM carry suit operational and environmental data - oxygen supply pressure, suit water inlet temperature, sublimator oxygen outlet temperature, suit pressure, feedwater pressure, suit water temperature rise, CO₂ partial pressure, and backpack battery current and voltage. A tenth channel transmits an electrocardiogram signal.

Indicators mounted on the remote control unit provide the astronaut with a visual warning of high oxygen usage rate, low suit pressure, low ventilation flow and low feedwater pressure. An audible tone sounds to alert the astronaut that an abnormal condition exists. Flags trip into view in the indicator windows, identifying the problem so that the astronaut can take corrective action.

OXYGEN PURGE SYSTEM

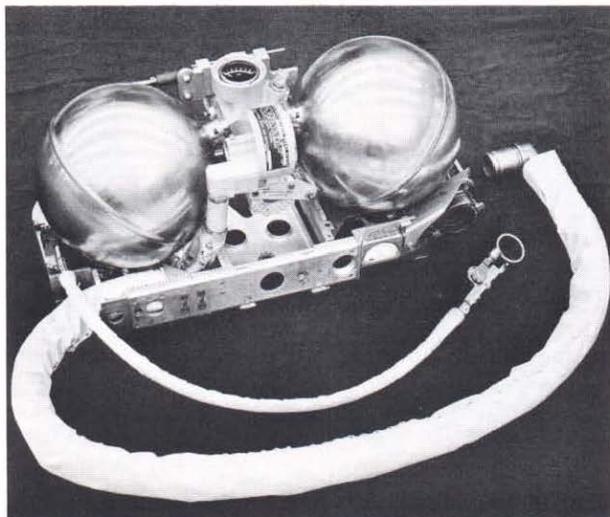
The oxygen purge system OPS, connected to the suit by a separate umbilical, is designed for backup use in the event of emergencies such as loss of suit pressure or depleted oxygen supply. However, an astronaut can use it independently as a life support chest pack during extravehicular transfer between the LM and CM spacecraft.

The system supplies either an open-loop purge flow or makeup flow directly to the suit. In both cases, it maintains suit pressure at 3.7 psi. In the full purge mode, it provides a 30-minute flow at a rate of 8.3 pounds of oxygen an hour, fulfilling breathing and cooling requirements, flushing out carbon dioxide, and defogging the helmet visor.

When used in conjunction with the Buddy Secondary Life Support System (BSLSS), the OPS flow is reduced to 4.2 pounds per hour, which permits emergency operation for up to 75 minutes.

The OPS, mounted separately on top of the backpack, is operated by a lever, attached to the pack's remote control unit. Its umbilical is attached to the suit connector that connects the suit to the LM Environmental Control Subsystem when the astronaut is inside the LM.

The purge unit weighs 35.1 pounds; is 18.4 inches long, 10 inches high, and 8 inches deep. Two spherical containers hold a total of 5.7 pounds of oxygen stored at 6,950 psi. A battery-powered, temperature-controlled heater warms the rapidly expanding oxygen to prevent subzero oxygen temperatures at the space-suit flow inlet.



R-117A

Oxygen Purge System

BUDDY SECONDARY LIFE SUPPORT SYSTEM

The buddy system consists of two flexible hoses which feed cooling water from one astronaut's life support backpack to the other space suit if its cooling equipment fails.

Addition of the buddy system doubles the time the emergency oxygen available in the OPS can last. The oxygen purge system support pack previously supplied oxygen not only for breathing purposes and pressurizing the suit but to cool the astronaut by its high flow rate.

With the buddy system taking over the cooling function, emergency oxygen flow can be slowed down to extend its supply from 30 minutes to 60 to 90 minutes. The length of time is governed by the level of the astronaut's physical activity.

The emergency water-cooling hoses are eight and a half feet long. One hose carries water into the

suit, the other out of it. A six-foot tether on the hoses snaps on the space suits and prevents the hoses from reaching their full length when they are connected, protecting the hoses and space suits against possible damage during the walk back to the LM. Water and tether lines are stowed in a pouch which is carried on the PLSS or Lunar Rover during each EVA.

In event of an emergency, the astronauts will remove the buddy system from the stowage pouch and hook the tether to the waist-restraint rings on their space suits. The astronaut whose life support pack cooling system has failed will disconnect the pack water hose. Assisting each other, the astronauts then will plug the buddy system water-cooling hoses into multiple connectors which join the life support backpack's water lines to the suits.

Information in this section relative to the Portable Life Support System was provided by Hamilton Standard, Division of United Aircraft. Complete details on the Portable Life Support System can be obtained from Hamilton Standard.