

## PORTABLE LIFE SUPPORT SYSTEM/OXYGEN PURGE SYSTEM DESCRIPTION

The Portable Life Support System (PLSS) is a self-contained life support system that provides life support, voice communications, and telemetry for an astronaut performing Apollo Mission extravehicular tasks.

The PLSS performs the following functions:

1. Provides breathing oxygen and controls the pressure of the astronaut's suit.
2. Provides thermal control by recirculating oxygen in the Pressure Garment Assembly (PGA) and water through the Liquid Cooling Garment (LCG).
3. Removes humidity, carbon dioxide, odors, and other contaminants from the recirculating oxygen.
4. Provides communication and telemetry between the astronaut and the Lunar Module (LM) or the Lunar Communications Relay Unit (LCRU).

The Oxygen Purge System (OPS) adds an independent backup life support capability. It provides oxygen for respiration, pressure control, and cooling.

The BSLSS is a portable backup system which supplies LCG cooling water to two astronauts from one PLSS.

Five main subsystems comprise the PLSS: the extravehicular communications system (EVCS), oxygen ventilating circuit, feedwater loop, liquid transport loop, and primary oxygen subsystem.

## PRIMARY OXYGEN SUBSYSTEM

The primary oxygen subsystem consists of a primary oxygen bottle, primary oxygen fill connector, primary oxygen regulator assembly, oxygen flow rate sensor, PGA low differential pressure warning switch, PGA differential pressure transducer, primary oxygen pressure transducer, and connecting tubing. The primary oxygen bottle is charged on the ground to approximately 1500 psia (1.85 pounds of O<sub>2</sub>). Subsequent recharges in the LM yield charge pressures of approximately 1420 psia (1.72 pounds of O<sub>2</sub>).

The primary oxygen subsystem provides oxygen for system leakage and metabolic needs, and regulates the pressure in the PLSS oxygen ventilating circuit to  $3.85 \pm .15$  psid. This subsystem is rechargeable.

The shutoff valve of the primary oxygen regulator assembly is actuated by a linkage assembly. The linkage is connected to an operating lever at the lower right-front corner of the PLSS.

The oxygen shutoff valve is closed when the PLSS is not in use or when the primary oxygen subsystem is being charged. An orifice limits the flow of oxygen to the PGA in the event of a regulator failure.

The primary oxygen fill connector is a quick-disconnect type used for recharging the primary oxygen subsystem.

The oxygen flow sensor and the primary oxygen pressure transducer provide electrical signals to the audio warning system and telemetry system, respectively. The oxygen pressure transducer also sends a signal to a visual display on the RCU.

The PGA differential pressure transducer provides an electrical signal to telemetry for monitoring suit differential pressure.

The PGA differential pressure switch provides a signal to the audio warning system.

## OXYGEN VENTILATING CIRCUIT

The oxygen ventilating circuit consists of a contaminant control assembly, section of the sublimator, water separator, fan motor assembly, CO<sub>2</sub> sensor, ventilation flow sensor, back-flow check valve, and PLSS inlet and outlet oxygen connectors.

The oxygen ventilating circuit cools reconditioned oxygen through the PGA. Oxygen from the PGA enters the oxygen ventilating circuit of the PLSS through the inlet oxygen connector. The oxygen flow then passes through the contaminant control assembly where odors are removed by activated charcoal. Carbon dioxide is removed through a chemical reaction with lithium hydroxide, and foreign particles are filtered out by a Teflon felt filter.

The oxygen passes from the contaminant control assembly to the sublimator where it is cooled. This water-saturated oxygen then passes to the water separator where condensed water is removed.

The oxygen passes from the water separator to the fan motor assembly. The fan motor assembly forces the oxygen at approximately 7.0 cfm through the vent flow sensor and backflow check valve to the outlet oxygen connector of the PLSS. Approximately 1% of the oxygen flow is passed through the CO<sub>2</sub> sensor for measurement of CO<sub>2</sub> partial pressure. Drainwater is ducted from the water separator to the outer section of the feedwater reservoir, through the water shutoff and relief valve, when the valve is in the on position.

In addition to providing oxygen circulation, the oxygen ventilating circuit pressurizes the feedwater bladder to expel water from the reservoir assembly.

## LIQUID TRANSPORT LOOP

The liquid transport loop consists of a pump/motor assembly, water diverter valve, multiple water connector, water differential temperature transducer, LCG inlet water temperature transducer, the transport section of the sublimator, gas trap, and connecting tubing.

The liquid transport section of the sublimator chills the water that circulates through the LCG. The check valve, located between the feedwater loop and the liquid transport loop, maintains proper inlet pressure on the water pump.

The pump/motor assembly circulates the chilled water through the liquid transport loop and the LCG at approximately 4.0 lbs/min.

The water diverter valve permits the selection of three transport water cooling ranges. The differential temperature of the water entering and leaving the PLSS is sensed by the water differential temperature transducer, which supplies electrical inputs to the telemetry system.

The gas trap removes entrained gas from the LCG to prevent degradation of the pump, sublimator, and LCG performance.

The cooled water from the sublimator circulates around the fan motor to cool the fan electronic package.

## FEEDWATER LOOP

The feedwater loop consists of a bladder in a main reservoir, and in an auxiliary reservoir, a water fill connector, water drain connector, two feedwater vent indicators (sight glass), main and auxiliary water shutoff and relief valves, flow limiter (orifice), feedwater pressure transducer and switch, check valve, the feedwater loop section of the sublimator, and connecting tubing. The primary water tank contains approximately 8.5 lbs. of water. The auxiliary feedwater tank holds approximately 3.5 lbs. of water and is activated when the primary feedwater reservoir has been depleted.

The feedwater loop feeds expendable water to the sublimator where the water freezes. Heat absorbed from the oxygen ventilating circuit and the liquid transport loop causes the ice to sublimate to vacuum.

The sublimator is a device that dissipates heat by sublimating ice. An ice layer formed on a porous plate provides a barrier between the liquid feedwater and space vacuum, thus preventing the loss of free water overboard. The ice film regulates the feedwater flow rate in response to heat load changes without moving mechanical parts. An inherent advantage of the simplicity of the sublimator is its high reliability.

Each feedwater reservoir is separated into two sections by a bladder. The inner section stores the expendable water used to operate the sublimator. The outer section stores the drainwater from the water separator.

Each water shutoff and relief valve is a two-position valve that permits a flow of water from the bladder to the sublimator, restricted by a flow-limiting orifice downstream of the valve. In the off position, the water shutoff and relief valve relieves excess pressure in the feedwater reservoir and permits simultaneous feedwater filling and draining of the drainwater section of the reservoir. In the on position, the drain from the water separator to the drainwater reservoir is open, permitting the separated water to flow to the feedwater reservoir and allowing the oxygen ventilating circuit pressure to force the feedwater to the sublimator during free space, lunar, and earth-gravity operations.

## EXTRAVEHICULAR COMMUNICATIONS SYSTEM

The Extravehicular Communications System (EVCS) has two configurations: Type 1 and 2. The type 1 configuration consists of two AM transmitters, two AM receivers, one FM receiver, signal conditioning, a telemetry system, a warning system, and other components required for proper system operation. The type 2 configuration consists of two AM transmitters, one FM transmitter, two AM receivers, one FM receiver, signal conditioning, a telemetry system, and other components required for system operation.

The system provides for three modes of operation:

1. Primary Mode (Mode Selector Switch Position A) - Duplex (simultaneous transmission and reception) voice communication between either astronaut and the LM or LCRU, and telemetry signals (TM).
2. Secondary (backup) Mode (Mode Selector Switch Position B) - Duplex voice communication between either astronaut and the LM (LM must be switched to secondary mode).
3. Dual Mode (Mode Selector Switch Position AR) - Duplex conference between astronaut one, astronaut two, and LM (or LCRU)-Earth; simultaneous TM from each astronaut.

During normal mission operation with two astronauts on the lunar surface, the dual mode is used for EVCS Types 1 and 2.

EVCS/PLSS SYSTEM INTERFACES

The EVCS provides voltage-regulated power for the oxygen quantity indicator and for the transducers of the PLSS system instrumentation. The following table lists the PLSS and Pressure Garment Assembly (PGA) instrumentation signals.

<u>System Instrumentation</u>	<u>Type of Signal</u>
LCG inlet temp. transducer	TM
Battery current sensor	TM
EKG (Electrocardiogram)	TM
O <sub>2</sub> bottle press. transducer	TM
LCG differential temp. transducer	TM
Sublimator outlet gas temp. transducer	TM
Battery voltage	TM
CO <sub>2</sub> Partial Pressure	TM (warning nonfunctional)
PGA press. transducer	TM, warning - "O" (activate OPS) appears in "PRES" window when PGA pressure is less than 3.1 - 3.4 psid
Feedwater press. transducer	TM, warning - "A" (activate Auxiliary Supply or abort) appears in "H <sub>2</sub> O" window when Feedwater pressure is less than 1.2 - 1.7 psia
High primary O <sub>2</sub> flow sensor	Warning - "O" (activate OPS) appears in "O <sub>2</sub> " window when PLSS O <sub>2</sub> flow is greater than .50 - .65 lb./hr.
Low vent flow sensor	Warning - "P" (activate OPS in Purge Mode) appears in "VENT" window when flow in PLSS Ventilation Loop is less than 4.7 - 5.3 ACFM

Alarm Tone

An alarm tone functions in all modes of operation to warn the astronaut of a dangerous condition. Low suit pressure, low feedwater pressure, high oxygen flow, and low vent flow sensors each send a signal to an alarm control module which activates a 1500 Hz alarm tone generator. For low vent flow and high O<sub>2</sub> flow a 5 second time delay is incorporated. The specific problem area is indicated by warning flags on the Remote Control Unit (RCU). Due to the design of the time delay system, it is possible to get a warning tone with no flag if the warning condition lasts for 2 to 5 seconds.

The warning flags will remain activated until the problem has been corrected. However, the alarm tone will deactivate after 10 seconds.

## REMOTE CONTROL UNIT

The Remote Control Unit (RCU) provides the astronaut with control functions and instrumentation. It contains, in addition to the warning flags, a volume control, O<sub>2</sub> indicator, panel lights, and four switches (fan, pump, mode selector, and push-to-talk). The push-to-talk switch has three positions as follows:

1. MAIN - VOX (voice actuated transmitter) mode. The first syllable of a voice transmission automatically actuates the transmitter. Transmission and reception can occur simultaneously.
2. OFF - VOX is grounded and there is no voice transmission.
3. MOM - Momentary voice communication. Voice transmission and reception is maintained as long as the switch is held in the MOM position. When released, the switch automatically returns to OFF.

The RCU O<sub>2</sub> Quantity Indicator and all five warning flag windows are covered with lexan panels to prevent dust from covering the indicators permanently.