The suit demand pressure regulator (figure 2.7-2) controls suit circuit pressure in normal and emergency modes. It supplies oxygen to the suits whenever the suit circuit is isolated from the cabin, and during depressurized operations. It also relieves excess gas to prevent over-pressurizing the suits.

The regulator consists essentially of two redundant demand regulators, and a relief valve. A selector valve is provided for selecting either or both regulators. Normally both are in operation.

Each regulator section consists of an aneroid control, and a differential diaphragm housed in a reference chamber. The diaphragm is connected by a rod to the demand valve. The demand valve will be opened whenever a pressure differential is sensed across the diaphragm. In operation there is a constant bleed flow of oxygen from the supply into the reference chamber,

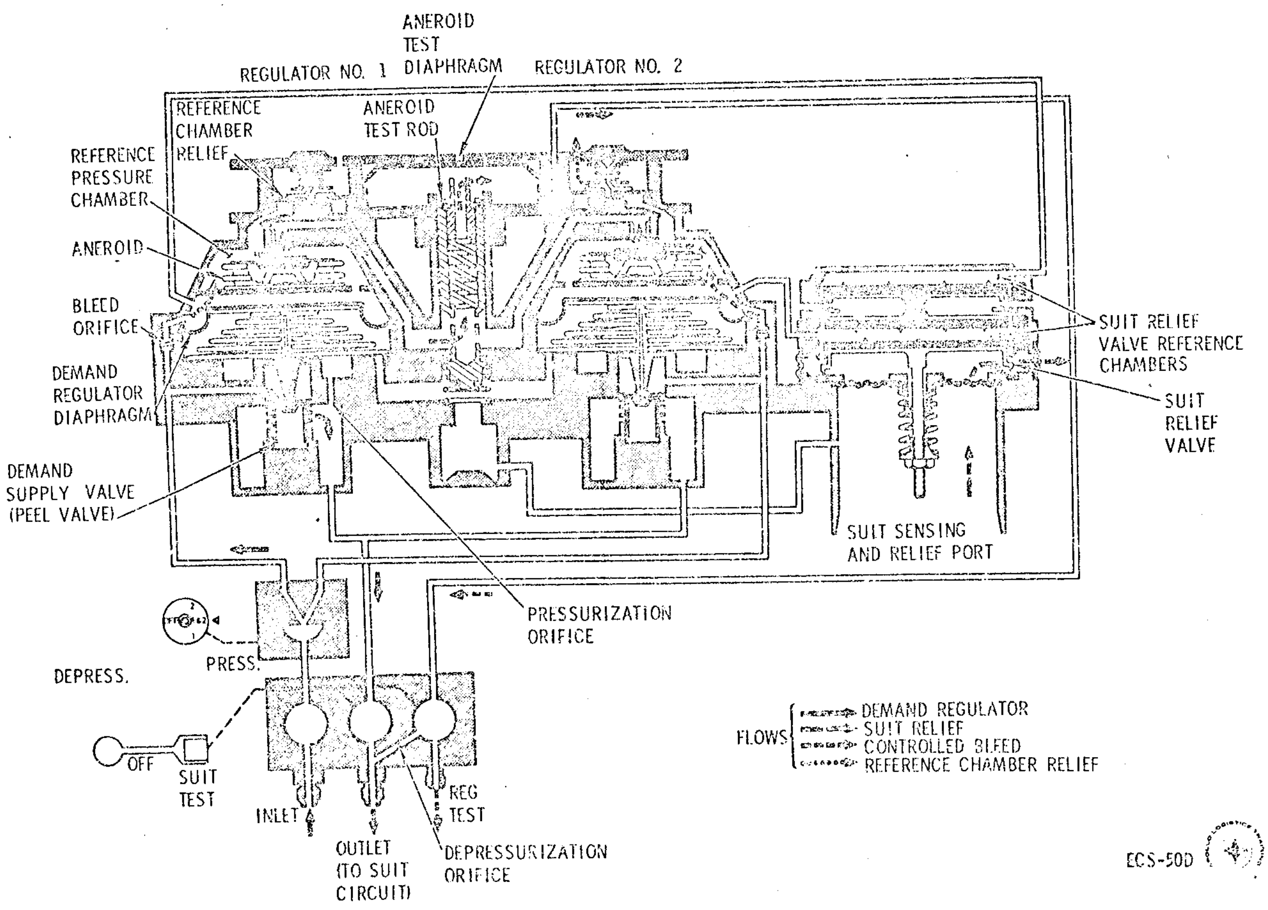

Figure 2.7-2. Oxygen Demand Pressure Regulator and Relief Valve

around the aneroid, and out through the control port into the cabin. As long as the cabin pressure is greater than 3.75 psia, the flow of oxygen through the control port is virtually unrestricted, so that the pressure within the reference chamber is essentially that of the cabin. This pressure acts on the upper side of the diaphragm, while suit pressure is applied to the underside. The diaphragm can be made to open the demand valve by either increasing the reference chamber pressure, or by decreasing the sensed suit pressure.

The increased pressure mode occurs during depressurized operations. As the cabin pressure decreases the aneroid expands. At 3.75 psia the aneroid will have expanded sufficiently to restrict the outflow of oxygen through the control port, thus increasing the reference chamber pressure.

Decreased suit pressure mode occurs whenever the suit circuit is isolated from the cabin, and cabin pressure is above 5 psia. In the process of respiration the crew will exhale carbon dioxide and water vapor. In circulating the suit gases through the CO_2-odor absorber and the suit heat exchanger, the CO_2 and water are removed. The removal reduces the pressure in the suit circuit, which is sensed by the regulator on the underside of the diaphragm. When the pressure drops approximately 2 inches H_2O below cabin pressure, the diaphragm will open the demand valve.

The regulator assembly contains a poppet-type relief valve which is integral with the suit pressure sense port. During operations when the cabin pressure is above 3.75 psia, the relief valve is loaded by a coil spring which allows excess suit gas to be vented whenever suit pressure rises 2 to 9 inches H_2O above cabin pressure. When the cabin pressure decreases to 3.75 psia, the reference chamber pressure is increased by the throttling effect of the expanding aneroid. The reference chamber pressure is applied through ducts to two relief-valve loading chambers which are arranged in tandem above the relief valve poppet. The pressure in the loading chambers acts on tandem diaphragms which are forced against the relief valve poppet. The relief portion of the valve is thus increased to 3.75 psia plus 2 to 9 inches H_2O.

Two parallel CO_2-odor absorber canisters, downstream of the suit compressors, function in the removal of carbon dioxide and odors. A removable filter within each canister contains sufficient lithium hydroxide (for CO_2 removal) and activated charcoal (for odor removal) to last 1.5 man-days of operation. This operational limit requires each filter be changed, on an alternating basis, every 12 hours. An internal bypass is incorporated within each filter to furnish the required flow during the ECS emergency mode (cabin depressurized), but will also increase the flow under normal conditions. Although 50 percent of the flow is permitted to bypass the lithium hydroxide, the total flow must pass through the charcoal filter.

The CO_2-odor absorber filter change sequence involves numerically identified filters and alphabetically identified filter stowage containers. Although the filters are replaced in numerical sequence, the stowage containers are not opened in alphabetical sequence relative to filter replacement. Odd-numbered filters will always be installed in suit circuit canister A (upper) and even-numbered filters installed in canister B (lower). After the proper filter stowage container is located by the crewman, the correct filter is obtained and the filter change accomplished. The used filter is then stowed in the container from which the unused replacement came. Where two filters are stowed one above the other, the used filter will always be placed below the remaining unused filter. This provides a more readily accessible unused filter at the next 12-hour replacement period. Filter replacement data, such as filter number and mission time, is recorded by the crew in the flight log.

A diverter valve located at the canisters inlet is normally positioned to direct gas flow through both filters. In conjunction with check valves, located at each canister outlet, repositioning the diverter valve isolates an expended filter. A manually operated vent valve for each canister allows equalization to cabin pressure prior to the removal of a filter.

Suit circuit gases, upon leaving the CO_2-odor absorber canister assembly, are at a higher temperature and humidity level than at any other point in the suit circuit. Heat has been generated in flowing through the compressors and the canister assembly. Also, the already humid gases have picked up additional moisture due to chemical reaction between the carbon dioxide and lithium hydroxide. The suit heat exchanger removes this heat and humidity from the suit gases.

Normally the heat transfer fluid, water-glycol, flowing through the suit heat exchanger removes the suit circuit heat loads to space through space radiators. A water-glycol evaporator supplements heat transfer when the space radiators are inadequate. A suit evaporator (part of the suit heat exchanger) is provided and used only in the event of an emergency. Under all other conditions the suit evaporator controls are to remain in the OFF position. The control switch (SUIT EVAP, AUTO - MAN, located on panel 13) controls electrical power to the system. This operational change will not impose added constraints on the mission; however, if the water-glycol evaporator should fail when it is required for cooling of electronics, etc., this would be sufficient cause to terminate the mission.

Should the ability of the suit evaporator system demonstrate proper operation, the control switch would be placed to the AUTO position. When water-glycol inlet temperatures to the suit heat exchanger exceed 52°F or the outlet temperatures of the suit circuit gases from the heat exchanger exceed 60°F, the suit heat exchanger is bypassed by the water-glycol flow through a diverter valve. When the automatic-controlled diverter valve is in the full bypass position, an integral switch in the diverter valve assembly is activated. The diverter valve switch activates the suit evaporator steam pressure control unit. The correct steam duct pressure is automatically established for a given temperature error by the steam pressure control unit, pressure transducer, and the steam pressure control valve. Initial opening of the steam pressure control valve causes a switch in that valve assembly to activate the wetness control unit. Water inlet through a solenoid valve to the suit evaporator is automatically controlled by sensing the suit evaporator wetness and the temperature of the suit gases at the heat exchanger outlet. When suit gas temperatures return to normal, the evaporator mode is sequencially deactivated and water-glycol flow is re-established. By overriding the suit gases temperature sensor at the outlet of the heat exchanger the system may also be activated, providing the SUIT EVAP control switch is in the AUTO position. Simulated high heat load is initiated by the SUIT HT EXCH switch (LHEB-310).

As the moisture-laden suit gases are cooled, condensation takes place within the heat exchanger. This moisture is absorbed by a wick-like material, removed by capillary action and the suction of the H_2O accumulator, and pumped into the waste water system.

The two accumulators are automatically controlled, self-cycling, reciprocating pumps. Oxygen at 100±10 psig periodically activates the pumps on the expulsion stroke, while a return spring is utilized for the suction stroke. Only one accumulator can be operated at a time with the second for standby use in the event of a malfunction. A manual backup mode of accumulator operation is also incorporated. Following the discharge of suit circuit gases from the suit heat exchanger, the normal flow is to the three suit hose connector assemblies. A suit flow relief valve is incorporated in the bypass line between the outlet of the suit heat exchanger and the inlet to the suit compressor. The valve opens at a ΔP of 5.0±0.2 in. H_2O and automatically maintains a nearly constant flow in the event of suit circuit flow resistance fluctuations.

2.7.3.2.1 CO_2 Sensor.

The CO_2 sensor, situated between the inlet and outlet manifolds of the suit circuit, is a compact unit that operates on the infrared absorption principle. The unit measures the amount of infrared energy absorbed by the CO_2 in the atmospheric sample passing through the sensor. This is accomplished by comparing two different wavelengths in the infrared spectrum. One wavelength is absorbed by CO_2, while the other acts as a reference. This establishes a ratio signal which is amplified and reads out as a d-c voltage proportional to the partial pressure of CO_2 in the sample gas.

The sensor is divided into the optics section and the electronics section. The optics section includes an infrared energy source (a small tungsten filament lamp), and optical lenses and mirror for focusing the beam through two wavelength filters and the atmospheric sample onto a detector. Both wavelength filters (4.3 microns for sampling and 4.0 microns for reference) are attached to a tuning fork which vibrates at

600 cycles per second. The filters move back and forth across the focused light beam, alternately transmitting energy at the sample and reference wavelengths.

The basic purpose of the electronics section is to detect and transform signal information. Miniaturized components are mounted on seven printed circuit boards, which accomplish all the electrical functions. These functions include supplying the power for the infrared source lamp and the operation of the tuning fork, the detector, and the various preamplifiers and amplifiers. The output signal activates the CO_2 PP HI systems status light (MDC-11) and the CO_2 PART PRESS indicator (MDC-13).

2.7.3.2.2 Gas Chromatograph.

The gas chromatograph is an item of GFE that is installed in several of the Apollo Block I spacecraft for flight qualification purposes. The unit is capable of identifying and measuring the concentrations of 28 gas components, and the resulting data is then telemetered to MSFN. This compact item of equipment is installed in the LEB, and it interfaces the inlet and outlet manifolds of the suit circuit in the LHEB.

The gas chromatograph operates on the basic principle of routing samples of the suit circuit and/or cabin atmosphere through three separate capillary columns and detectors. Low-pressure helium is used as the carrier gas for the sample streams. The helium supply, even under continuous demand, will last the length of any proposed mission. The helium is stored in a reservoir at 6000 psig and is regulated to its normal working pressure of 42 psia. In the event of regulator malfunction, pressure relief is provided by a 200-psig rupture disc. Each capillary column and detector identifies a specific number of gas components. One column-detector will identify five of the permanent gases; namely, hydrogen, nitrogen, oxygen, methane, and carbon monoxide. Another is concerned only with the separation and detection of ammonia, carbon dioxide, and water. The third column-detector identifies 20 trace contaminants listed as follows: Freon II, methyl alcohol, methylene chloride, ethyl alcohol, benzene, P-dioxane, acetone, hydrochloric acid, hydrogen sulfide, ethylene oxide, isoprene, diethyl sulphide, nitrogen dioxide, ethylene glycol, vinylidene chloride, methyl chloroform, acetylene, dimethyl sulfide, Freon 114, and 1, 1 trichloroethane.

Cross-section ionization-type detectors are used in conjunction with the three columns for gas component identification. The output current of the detectors produces a minimum-strength signal that must be greatly amplified, then conditioned for telemetry. The capillary columns, the detectors, and the electrometer amplifiers are housed in an oven, the temperature of which is maintained within a very close tolerance. The balance of the electronics, installed in a separate package, consist of a transformer, a programmer, and a regulated power supply. Solid-state circuitry is used exclusively throughout the electronics of the unit.

The gas chromatograph will complete one identification cycle in approximately 80 minutes, regardless of the sampling mode selected. Samples are taken from the suit circuit atmosphere, the cabin atmosphere, or from each atmosphere on alternating cycles depending on the positioning of a selector switch located on the LEB panel 120. The selector switch may be positioned to CABIN AIR/AUTO/SUIT AIR by command.

The gas chromatograph is serviced and installed by ground support personnel prior to flight crew ingress.

A three-position START/OFF/PREHEAT switch, controls power for operation, and must be placed to the PREHEAT position for a minimum of 80 minutes before switch is set to START. A push-type switch, AMPL-CAL, for bench calibration only and the START/OFF/PREHEAT switch, are located on panel 120.

During the mission, the flight crew will not be required to make control adjustments to the unit unless directed to do so by MSFN. During descent, the remaining helium in the reservoir is dumped into the cabin by the action of a pyro valve inside the unit. A full tank (abort condition) can be emptied in a maximum of 3 minutes. Pyro valve initiation is simultaneous with the C/M-RCS propellant purge operation.

2.7.3.3 Cabin Pressure and Temperature Control Subsystem.

The pressurization and temperature control of the C/M cabin are primarily automatic functions with manual backup and override modes provided. Cabin pressurization is maintained by the cabin pressure regulator assembly (figure 2.7-3). This unit consists of dual regulators and a manual repressurization valve operated by a knurled knob. Both regulators operate simultaneously as there is no selector valve incorporated and no off position. The regulators automatically maintain the cabin at 5±0.2 psia during normal conditions and at a maximum oxygen flow rate of 1.3 pounds per hour. If the cabin should become depressurized for any reason, the regulators close at a pressure of 3.5 psia to conserve oxygen. The manual valve, with a maximum flow rate of 7.2 pounds per hour, may be adjusted to maintain cabin pressure in event of regulator malfunction. However, it is primarily used to repressurize the cabin following decompression, requiring approximately 1 hour to raise the cabin pressure back to 5.0±0.2 psia.

An emergency cabin pressure regulator assembly (figure 2.7-4) will flood the cabin with oxygen to prevent rapid decompression in the event of cabin wall puncture. As cabin decompression is hazardous to life only when a crewman is in the shirtsleeve mode, the regulators are not selected for use until just prior to a crewman removing his PGA. The regulator

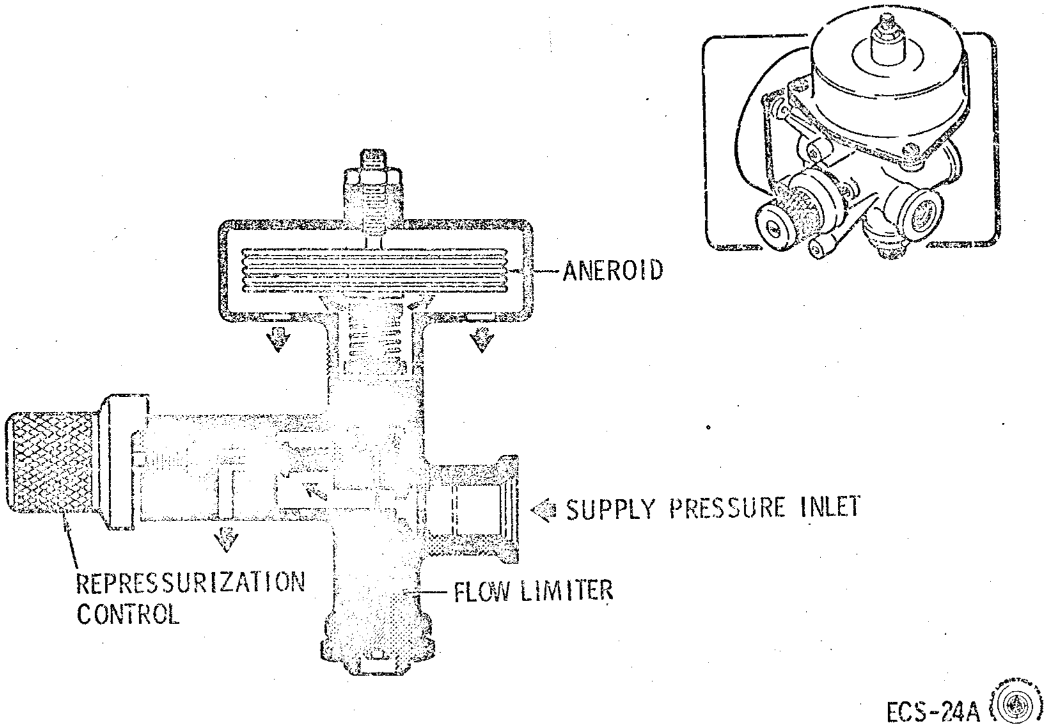

Figure 2.7-3. Cabin Pressure Regulator

assembly consists of a four-position manual selector valve and two redundant regulators which, when selected for use, automatically open when the cabin pressure drops to 4.5±0.1 psia. The emergency cabin pressure mode of 3.5 psia is contingent upon Apollo design limits and meteorite tests and allows unsuited crewmen time to don their PGAs. This minimum pressure can be maintained for 5 minutes, providing that meteorite holes do not exceed the total equivalent area of a hole 0.5 inch in diameter. At the end of this time, the pressure will drop more rapidly, going to 2.0 psia in 10 minutes and to 1.0 psia in 15 minutes.

The dual cabin pressure relief valve (figure 2.7-5) provides positive and negative pressure relief for the cabin throughout the entire mission. Although they function automatically, cable-operated manual override controls, located on panel 307, are provided for adjustments during flight to close relief valves for a malfunction, or to prevent sea water inflow during postlanding phase and ground checkout procedures. When the cabin pressure becomes higher than the external ambient pressure, the relief valves limit the differential pressure to 6 (+0.2, -0.4) psi. During the ascent phase, this differential pressure may go as high as 7.0 psi for a short period of time. Conversely, when the cabin pressure becomes lower than the external ambient pressure (as during descent), the relief valves limit the differential pressure to a maximum of 25 inches of water. The assembly is located in the steam duct overboard line which provides the means of venting the positive and negative cabin pressures.

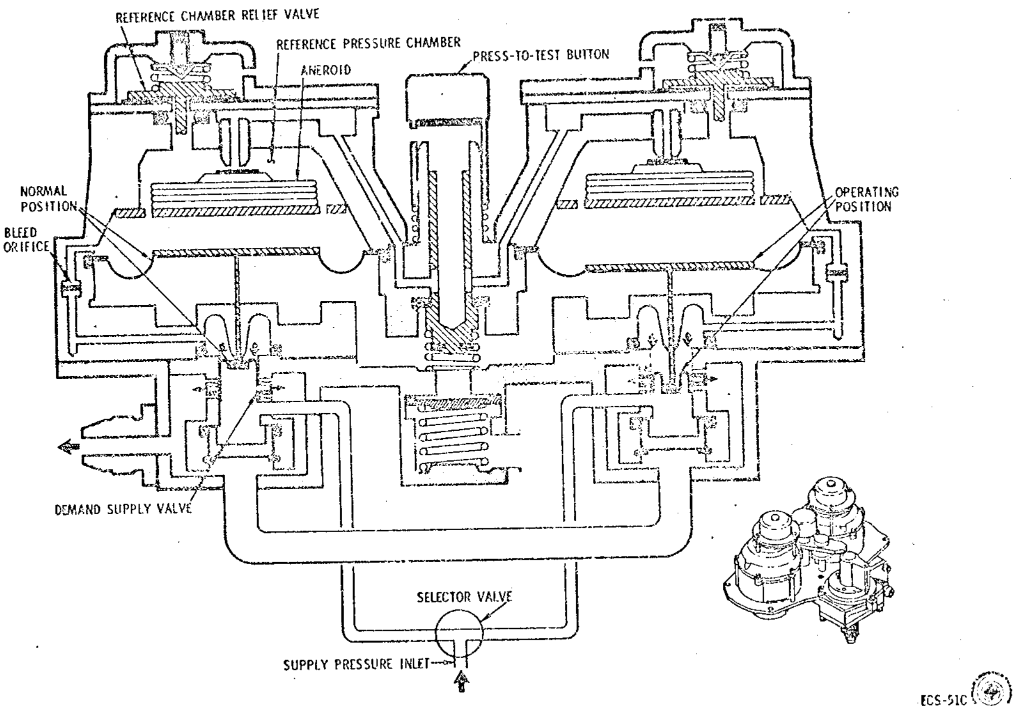

Figure 2. 7-4. Emergency Inflow Regulator

Ventilation within the C/M is provided by dual fans, which circulate cabin gases through the cabin heat exchanger. Normally, both cabin air fans are selected by the crew for simultaneous operation. If either fan malfunctions or is shut down for any reason, a closure (cover) is manually installed over the inlet of the inoperative fan to prevent backflow. A cabin air control louver, located at the outlet of the cabin heat exchanger, is manually adjusted for directional flow of gases within the cabin.

Although cabin temperature control is normally an automatic function, resort to manual backup and override modes of operation may be utilized. Cabin gases are heated or cooled by their circulation through the cabin heat exchanger, which uses water-glycol as the heat transfer medium. A cabin temperature control unit compares a desired temperature, selected by the crew, to the temperature that is sensed at the inlet to the cabin air fans. Any difference results in a signal that repositions the motor-operated cabin temperature control valve. This valve regulates the amount of hot or cold water-glycol flowing into the cabin heat exchanger. At each end of valve full travel, the total hot or cold flow is routed through the heat exchanger; whereas, at intermediate valve positions, the water-glycol flow through the heat exchanger varies. A cabin temperature anticipator, located at the cabin air control louver discharge, senses the temperature rate of change and signals the cabin temperature control unit, preventing overcorrection by the control valve.

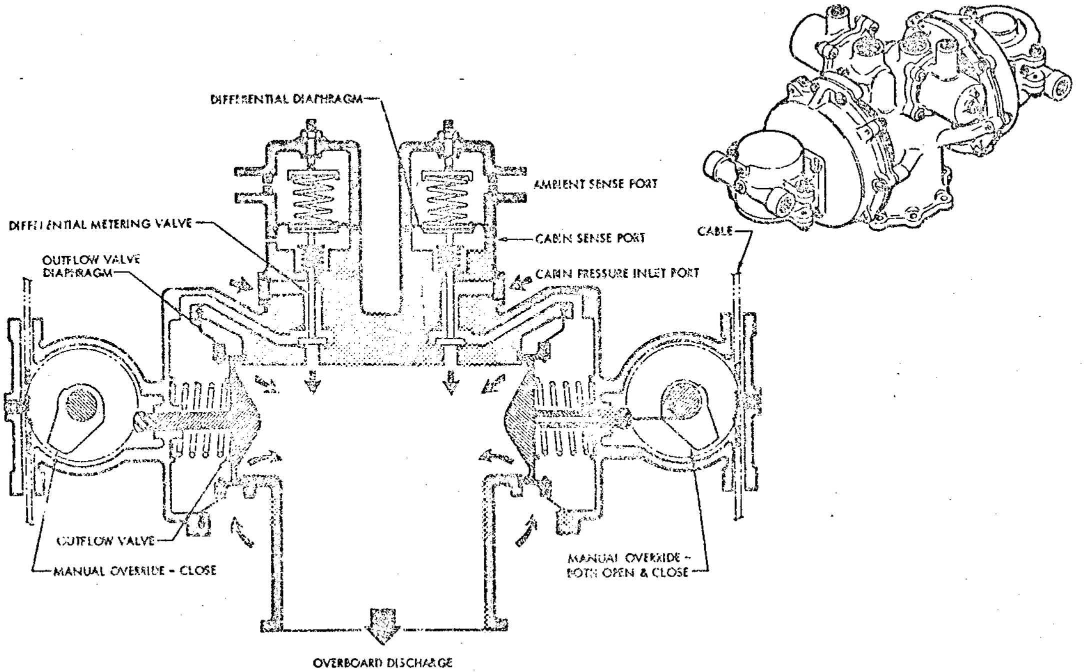

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Figure 2.7-5. Cabin Pressure Relief Valve

Ventilation during the postlanding phase is accomplished by circulating outside ambient air through the cabin. All of the equipment necessary to carry out this function (other than controls) is located on the C/M forward tunnel cover. Outside air is drawn into the cabin through an inlet duct containing a shutoff valve and fan. The inlet duct includes a flexible extension for promoting more efficient ventilation. After circulating within the cabin, the air is expelled overboard through an adjacent outlet duct and shutoff valve. Both motor-operated shutoff (vent) valves and the vent fan are controlled by the VENT FAN switch on MDC-25. High- or low-speed fan operation is available, and either switch position will simultaneously activate the fan and open the cabin vent valves. An assembly consisting of a pendulum-type attitude sensing switch and an adjacent override control switch (PLVC) are installed in the LHEB. The pendulum is free to move only in the Z-axis. Should the C/M roll beyond a specified limit or become inverted (stable II condition), the attitude sensing switch activates the cabin vent valves to the closed position to prevent water ingestion. If all efforts to return the C/M to the upright (stable I) condition should fail, the PLVC switch (LHEB-141) is set to OPEN. This overrides the closing action of the attitude sensing switch by opening both cabin vent valves and flooding the forward portion of the C/M. The pressure on the tunnel hatch then becomes equalized, thus allowing its removal for the escape of the crew. The PLVC switch may also be used to open the cabin vent valves if the attitude sensing switch should fail after having closed the valves. In order to prevent the inadvertent opening of the vent valves in flight, two precautions are taken. A lockpin is installed in each vent valve, and the circuit breaker applying power to the PLV system is not engaged during flight. Therefore, before the PLV system can be operated, the lockpins must be removed (pulled out approximately 0.5 in.) prior to CSM separation and the applicable circuit breaker engaged after landing.

2.7.3.4 Water-Glycol Coolant Subsystem.

The water-glycol coolant subsystem is a closed loop through which an aqueous ethylene-glycol mixture (water-glycol) is continuously circulated. The mixture ratio by weight consists of 62.5 parts of glycol to 37.5 parts of water. Basically, the subsystem provides a heat transport fluid loop for the cabin atmosphere, the suit circuit atmosphere, the electronic equipment, and a portion of the potable water. It also serves as a source of heat for the cabin atmosphere when required. All of the unwanted heat absorbed by the water-glycol is transported either to the space radiators, where it is radiated to space, or to the water-glycol evaporator, where it is rejected by the evaporation of water.

The water-glycol (W/G) evaporator outlet temperature must be maintained between 40° and 43°F (nominal 41.5°F). Sensed at the W/G evaporator inlet from the space radiators W/G temperatures between 42.9° and 45.9°F (nominal 45°F) activates the automatic mixing valve control system (figure 2.7-6). High-temperature W/G from the water-glycol pump is mixed with the lower W/G temperature from the space radiators to maintain the evaporator outlet nominal temperature of 41.5°F. The manual override for the mixing valve is located on the coolant control panel 311 (GLYCOL EVAP TEMP IN) and a switch located on panel 13 allows selection of AUTO or MAN operation.

Three lines from the water-glycol pump assembly are paralleled to the water-glycol evaporator inlet. The aforementioned oxygen supply capillary restrictors are wound around the line routed to the space radiators and relief valves. The other line is routed to the mixing valve. To insure proper operation of the oxygen supply restrictors, in the line between the cryogenic O_2 storage in the S/M to the surge tanks in the C/M during cabin repressurization, full water-glycol flow through the line to the space radiators is required. Sufficient heat must be available to prevent cryogenic oxygen entering the C/M oxygen system and preclude the possibility of freezing the water-glycol. To achieve this, the mixing valve must be manually placed to the full closed position 15 to 30 minutes before repressurization and remain closed until the surge tank returns to maximum pressure after repressurization of the C/M.

High-temperature water-glycol between 48° and 50.5°F from the space radiators and sensed at the evaporator inlet initiates the water-glycol evaporator temperature control system. Once the evaporator mode is initiated by the evaporator inlet sensor, an evaporator outlet sensor supplies the controlled variable signals to the controller. If a heating temperature error is sensed by the evaporator outlet sensor, the steam pressure valve begins to open and repositions at a velocity proportional to

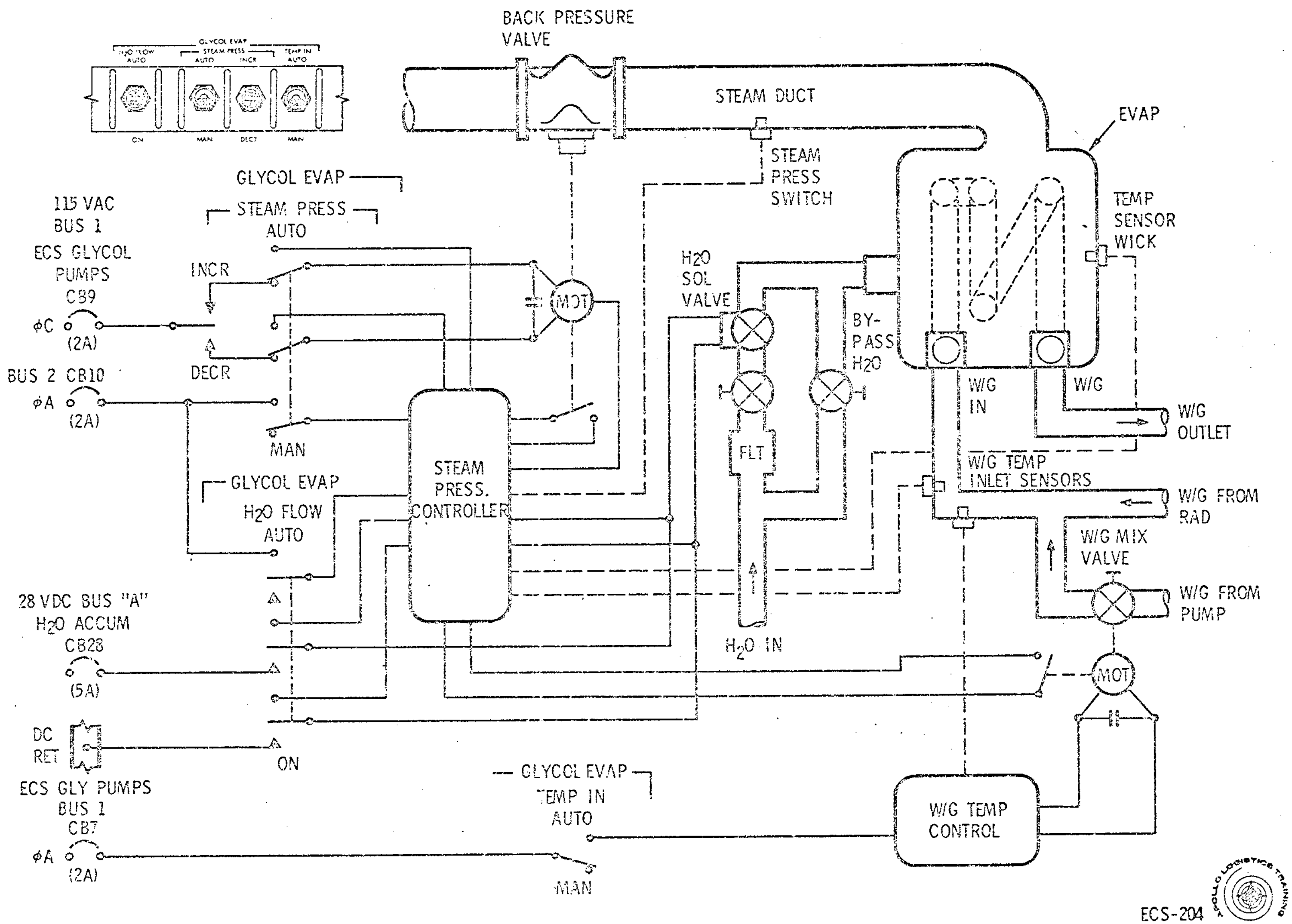


Figure 2.7-6. Water-Glycol Evaporator Temperature Control

the temperature error. Evaporator wicks are maintained in a wet condition to provide immediate boiling when the steam pressure valve is opened. Should the steam pressure drop below 5.0±0.2 mm Hg abs, a pressure switch overrides the temperature signal and closes the steam pressure valve. The override pressure switch provides adequate pressure margin above the freezing pressure of 4.58 mm Hg abs. A switch in the steam pressure valve assembly is activated when the valve is initially cracked open. The switch activates the wetness control for replenishing water to the evaporator through a water-solenoid control valve. Signals from the wick temperature sensor are indicative of the relative wetness of the evaporator wicks. As water evaporates, the wick sensor temperature increases and exceeds an evaporator inlet reference sensor signal and cycles the water control valve open. The reference input sensor varies the control as a function of heat load to maintain the desired wick temperature with no water carryover into the steam duct. When the evaporator wicks become replenished with water, the wick sensor temperature decreases and approaches the saturation temperature corresponding to the steam pressure and cycles the water control valve closed. The water control valve continues to cycle as long as water-glycol cooling by water evaporation is required.

The steam pressure control valve can be electrically repositioned to control the steam pressure for 40° to 43°F outlet glycol temperature using the pressure monitor indicator (panel 13, GLY EVAP-OUTLET TEMP). The control switches (GLYCOL EVAP - STEAM PRESS) must be placed to the MAN position, and then to INCR for open and DECR for closing the steam pressure valve. The H_2O FLOW switch (panel 13) should be in the AUTO position for the automatic wetness control to be effective. Should the wetness control fail, the water inlet control valve can be energized open by placing the H_2O FLOW switch to ON. When operating in this mode, a portable indicating unit should be used to prevent water carryover into the steam duct. The portable indicating unit consists of a four-position selector switch for selecting OFF, WICK TEMP., EVAP INLET TEMP. AND NUL. The unit has its own 175-hour battery-operated power supply. WICK TEMPERATURE indicator markings are 40° to 70°F, WATER-GLYCOL INLET TEMPERATURE indicator markings are 40° to 100°F, and the NUL indicator markings are a red line across the midlength section of the dial face and is marked above the red line on the dial WATER ON, and below on dial WATER OFF. A water control tabulation chart (figure 2.7-7) for operation of W/G evaporator in the manual mode, is provided showing wick temperature versus inlet glycol temperature. The portable indication unit should also be used when manual water bypass control valve (GLY EVAP WATER CONTROL BYPASS panel 317) is used. The portable indicator unit will connect to J39 (panel 311). The main water-glycol flow next enters the cabin temperature control valve, where it is routed either to the cabin heat exchanger or to the remaining thermal coldplates. The action is dependent upon the temperature control unit, which automatically controls the movements of the motor-operated cabin temperature control valve. The valve is so constructed that in the cabin full cooling mode, the total flow of cool water-glycol (167 pounds per hour) is routed first through the cabin

Evaporator Inlet Temperature Sensor (°F)	Wick Temperature Sensor (°F)	Evaporator Inlet Temperature Sensor (°F)	Wick Temperature Sensor (°F)
40	41.62	71	54.63
41	42.13	72	54.96
42	42.65	73	55.28
43	43.15	74	55.60
44	43.65	75	55.91
45	44.14	76	56.21
46	44.63	77	56.51
47	45.11	78	56.80
48	45.58	79	57.08
49	46.04	80	57.37
50	46.50	81	57.66
51	46.95	82	57.93
52	47.39	83	58.19
53	47.82	84	58.46
54	48.25	85	58.71
55	48.67	86	58.96
56	49.08	87	59.21
57	49.49	88	59.46
58	49.89	89	59.71
59	50.30	90	59.94
60	50.39	91	60.17
61	51.07	92	60.40
62	51.45	93	60.63
63	51.83	94	60.85
64	52.20	95	61.06
65	52.56	96	61.28
66	52.92	97	61.49
67	53.27	98	61.69
68	53.62	99	61.90
69	53.96	100	62.10
70	54.30		

Figure 2.7-7. Water Flow Control Chart

heat exchanger and then through the thermal coldplates. In the cabin full heating mode, the total flow is routed through the thermal coldplates first, where the water-glycol absorbs heat, and from there flows through the cabin heat exchanger. The intermediate valve positions are for the partial cooling or partial heating modes. In the intermediate positions, the quantity of cool or warm water-glycol flowing through the heat exchanger is reduced in proportion to the demand for cooling or heating. Although the amount of water-glycol flowing through the cabin heat exchanger will vary, the total flow through the thermal coldplates will always be 200 pounds per hour. (See figure 2.7-8.) An orifice restrictor is installed between the cabin temperature control valve and the inlet to the coldplates. Its purpose is to maintain a constant flow rate through the coldplates by reducing the

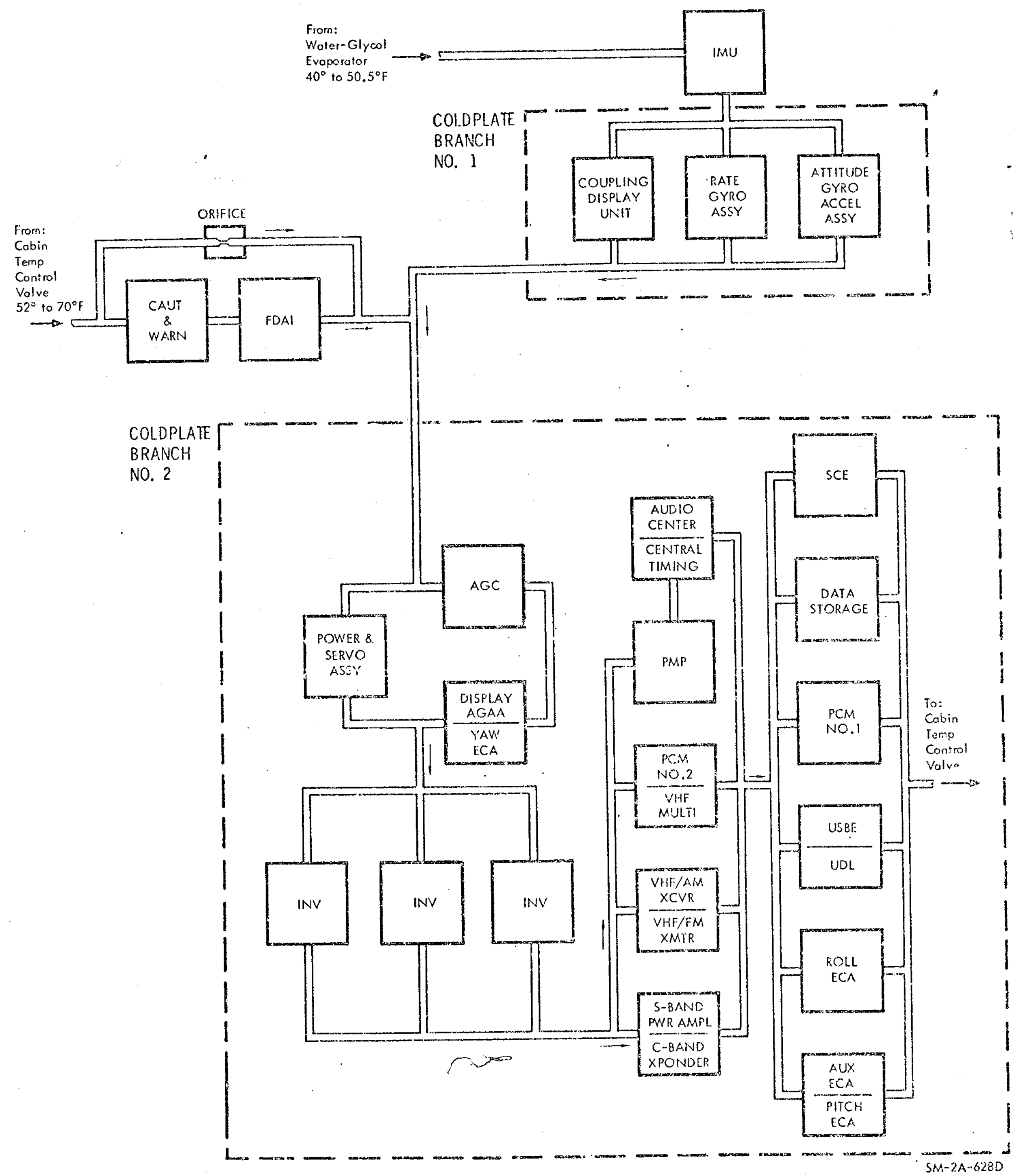


Figure 2.7-8. Equipment Coldplate Flow Diagram

heating mode flow rate to that of the cooling mode flow rate. Another orifice restrictor, located in the coolant line from the IMU, maintains a constant flow rate through this component regardless of system flow fluctuations.

The total flow leaving the cabin temperature control valve enters the water-glycol pump assembly which provides the continuous coolant circulation within the subsystem. The assembly consists of two water-glycol pumps, two pump outlet check valves, a full-flow filter, an accumulator, and an accumulator isolation shutoff valve. The two pumps, mounted in parallel, can only be operated one at a time with the second pump for standby redundancy. Each pump outlet check valve prevents coolant backflow through the nonoperating pump. Water-glycol entering the assembly first passes through the full-flow filter before reaching the pumps. There is also a side passage that leads to the accumulator.

The purpose of the accumulator is to maintain correct pump inlet pressure and to compensate for small amounts of leakage and/or thermal expansion/contraction. The manual shutoff valve in the side passage is closed to isolate the accumulator in case of a punctured bellows, which would permit the coolant to leak into the cabin, causing contamination. If the water-glycol accumulator quantity indicator on the main display console shows a steady decay to zero, a leak in the water-glycol system is the probable cause. However, an indication showing a slow steady decrease, which stops at a point above zero, is probably due to thermal contraction indicating the water-glycol temperature is below the nominal range. Located downstream of the pump assembly is the water-glycol pump outlet pressure transducer which measures the static pressure of the water-glycol at the pump outlet, thus giving an indication of pump performance.

At this point in the subsystem, the temperature of the water-glycol has greatly increased due to the absorption of the various heat loads. The total flow of hot water-glycol is routed through a passage in the steam pressure control valve to prevent ice from forming within the valve opening. Icing at this location could result in valve malfunction and/or blocking of the steam duct. To prevent ice from forming at the outlet of the steam duct, two redundant electric heaters are used. The two 3-watt heater elements inside the duct extend approximately 8 inches upstream from the outlet.

The water-glycol next flows to the water-glycol evaporator inlet temperature control valve (previously described). The hot water-glycol that is not used for mixing by this valve is routed to the space radiators for cooling. Any pressure losses in the space radiator circuit, regardless of the number of radiators in operation, will be limited by the action of the dual water-glycol pressure relief valves. These two valves are in parallel and are located between the inlet and outlet lines of the radiator circuit. Just upstream of each pressure relief valve is a manual shutoff valve. By controlling the shutoff valves, one relief valve at a time is normally selected for use with the second for standby redundancy. When a ΔP of

11 psi is reached, the relief valves open to bypass coolant to the radiator return line, closing at a ΔP of 8.5 psi. In order to preserve the water-glycol closed loop, the relief valves function as a bypass when all space radiator isolation valves are closed or when the water-glycol radiator shutoff valve is closed. This is a manual shutoff valve that controls the flow of water-glycol from the C/M to the S/M. It is placed to the closed position shortly before CSM separation to prevent the coolant in the C/M from flowing overboard after separation.

Two space radiators with an area of 30 square feet each are located on opposite sides of the S/M in sectors II and V. Each radiator panel contains two separate sets of tubes. The flow of water-glycol through the four tube circuits is individually regulated by a motor-operated radiator isolation valve located on the inlet side of each tube circuit. The four valves are remotely controlled from the C/M and give the crew some degree of latitude in their selection of cooling area. However, the primary purpose of the valves is to isolate tube circuits should they develop leaks. A check valve in each tube circuit outlet line prevents the backflow of coolant from entering any radiator tube circuit that is leaking. Freezing within the radiators is the point at which flow ceases, and may be prevented by maintaining the inlet temperature above 75°F. This temperature is obtained on the AUX DC VOLTS meter (RHFEB-200) or from MSFN if the crew is unable to leave the couches.

The water-glycol, after leaving the space radiators and re-entering the C/M, flows through a capillary restrictor. This is placed in the line to make the pressure drop through the radiators compatible with that through the water-glycol temperature control valve during the mixing mode. Upon leaving the restrictor, the water-glycol flows through two check valves in series. These valves prevent coolant from flowing overboard following CSM separation. A temperature sensor, located between these check valves, gives an indication on the main display console of the temperature of the coolant leaving the radiators. The indicator is located on MDC-13.

Under normal space flight conditions the water-glycol reservoir is isolated from the coolant subsystem by the proper positioning of three glycol reservoir manual shutoff valves. The water-glycol reservoir inlet and outlet valves are closed, and the reservoir bypass valve between the inlet and outlet lines is opened. During the prelaunch and ascent phases, however, the position of these three valves is reversed to permit coolant flow through the reservoir. The one gallon of water-glycol contained in the reservoir is then utilized as a heat sink, which becomes necessary during the ascent phase. The space radiators are not effective during ascent and evaporative cooling takes place only after the ambient pressure reaches 0.05 psia, which is approximately 150,000 feet altitude (T + 2 minutes and 10 seconds).

If a water-glycol leak should occur, the coolant subsystem may be refilled from the limited supply in the water-glycol reservoir after the leak is isolated. The glycol reserve shutoff valve, located in the line from the reservoir to the inlet side of the pump, is used for this purpose. As the reservoir contains a bladder that is under 20±2 psig oxygen pressure, positive expulsion of the coolant is assured. The pressurized reservoir may also serve as an accumulator for the coolant subsystem, if the regular water-glycol accumulator becomes inoperative and is isolated. The flow of water-glycol, either through the reservoir or bypassing it, next enters the water-glycol evaporator (previously described), thus completing the coolant loop.

During prelaunch operations, the flow of temperature-controlled water-glycol is furnished by GSE through lines connected to the fill and vent couplings in the S/M. The solenoid-operated water-glycol shutoff valve, upstream of the outlet coupling, is controlled at the GSE and is opened to permit coolant flow through the spacecraft loop and back to the GSE.

2.7.3.5 Water Supply Subsystem.

The primary function of the water supply subsystem is the storage and collection of potable and waste water. Potable water produced by the fuel cells and waste water recovered from the suit heat exchanger water separator are stored in separate tanks in the C/M. Supplementing this supply are two water tanks in the S/M that contain potable water for refilling the C/M potable water storage tank. The water supply subsystem also supplies hot and cold potable water to the crew and waste water to the water-glycol evaporator and suit heat exchanger for evaporative cooling.

The water produced by the fuel cells in the S/M is a steady source of potable water and is stored in a 36-pound capacity tank located in the aft compartment of the C/M. The tank, which contains a bladder, is pressurized with oxygen at 20±2 psig by the tank pressure regulator and relief valve assembly, thus assuring positive expulsion of fluid. Fuel cell water flows into the tank at a potential pressure of approximately 61.5 psia, which is high enough to overcome the tank pressure. The potable water tank may be serviced before flight by the manually operated servicing valve, which is also in the aft compartment and not accessible to the crew. A quantity indicator on the main display console gives the measurements obtained by the tank quantity transducer. Located in a water line between the fuel cells and the potable water tank is a check valve and the potable tank inlet shutoff valve. The check valve prevents any reverse flow of potable water. The shutoff valve, when closed, prevents fuel cell water that has become contaminated from entering the C/M potable water network.

Temperature-controlled potable water is available to the crew from two components within the C/M. Cold water, which is maintained to 50°F (at the water chiller), is available at both the food preparation water supply unit and the water delivery unit. Hot water, however, is available only at the food preparation water supply unit. This component utilizes a small tank with an electric heater to raise the water temperature to 154°±4°F. By selecting the proper valve, hot or cold water is metered out for food reconstitution or other crew needs. The water delivery unit is used by the crew exclusively for drinking purposes. It consists of a housing containing a coiled flexible tube and a water delivery valve for use with the individual mouthpieces of the three crewmen. Upstream of this unit is the drinking water supply shutoff valve that is closed if the water delivery valve should leak.

Waste water collected from moisture condensate within the suit heat exchanger is drawn into one of the cyclic accumulators and from there pumped into the waste water network. If, however, there is a water demand by either the water-glycol evaporator or the suit heat exchanger evaporator, the waste water flows directly to the water control valve of the appropriate evaporator. The 56-pound capacity waste water tank contains the pressurization and quantity measuring features of the potable water tank. A servicing valve is located on the water control panel in the C/M cabin and, therefore, is accessible to the crew, if necessary.

Although waste water never enters the potable water network, potable water may enter the waste water network under certain conditions. If the potable tank becomes full, the differential pressure between the networks will eventually overcome the 6.0±0.5 psi at the waste tank inlet valve, thus permitting water flow. Potable water also enters the waste water network if the waste tank is empty and there is a water demand by either evaporator. The low pressure created by this water demand is responsible for waste tank inlet valve activation. The valve also incorporates a manual shutoff feature for use if the relief valve portion malfunctions. Closing the valve thus prevents the premature dumping of potable water into the waste water network. A check valve, located downstream of the relief valve, separates the potable and waste water networks by permitting flow in one direction only.

To prevent overpressurizing the water supply subsystem, a pressure relief assembly is installed downstream of the check valves that separate the potable and waste water networks. The assembly consists of a selector valve and two redundant pressure relief valves in parallel. When the potable and waste water tanks are full, the continued supply of water produced by the fuel cells will be dumped overboard by these relief valves. Normally, both valves are selected for simultaneous use, and dumping occurs when the water pressure reaches approximately 32 psi above the outside ambient pressure. Another line, with two check valves in series, bypasses fuel cell water output directly to the pressure relief assembly. However, this action will take place only in event the waste tank inlet valve fails closed. The bypass prevents fuel cell water flow from being blocked, thereby preventing total fuel cell failure due to flooding within the cells.

To provide sufficient water for a maximum duration earth orbital mission, two 56-pound water tanks are installed in the S/M. These tanks are similar to the C/M waste water tank but lack the quantity measuring capability. A separate tank pressurizing system is used for positive expulsion of the water. Nitrogen at 900 psig is stored in a small tank that is protected against overpressure by a relief valve set at 1045±25 psig. In addition to a nitrogen fill valve, there is a pressure regulator and relief valve to reduce and regulate nitrogen pressure in the water tanks. These tanks are pressurized at 40±2 psig, and the relief valve will function at 44 to 48 psig.

At the water outlet of each tank, there is a manual fill valve and a solenoid shutoff valve. The shutoff valves are controlled by the WASTE H_2O TK REFILL switch in the C/M. These valves control the flow of water from the tanks to a common line in the S/M that subsequently connects into the potable water line from the fuel cells. When the C/M potable water tank quantity is low, it will be refilled from these S/M water tanks at a flow rate of 2.92 pounds per minute.

2.7.3.6 ECS-Waste Management System Interface.

Although the waste management system (WMS) and C/M battery venting network are not subsystems of the ECS, they will be covered as such in the AOH because of system interface. The interface mentioned is in reference to the ECS water overflow line. All of the urine and the fecal odors of the WMS, as well as gas pressure from the C/M batteries, are also routed overboard through this single ECS water dump line. Incorporated at the outlet of the dump line (urine/water) is a 0.055 inch orifice nozzle that restricts gas flow to a maximum of 1 cfm and liquid flow to less than 1 cfm. The gas flow is limited to prevent excessive loss of cabin atmosphere during fecal canister usage. The restriction on liquid flow, in conjunction with a 5.7-watt, continuously operating dump nozzle heater, prevents the formation of ice at the nozzle, which could block all flow.

The function of controlling and/or disposing of waste solids, liquids, and gases is accomplished by the WMS. Except for the fecal canister and other items of stowed equipment, the major portion of the system is located in the RHEB. The WMS is basically divided into the urine/fecal and the vacuum cleaner subsystems. Several components that are no longer functional have not been removed from the WMS, as shown in figure 2.7-9. This is due to recent modifications that would not permit their removal because of schedule impact.

The components for the urine portion of the urine/fecal subsystem consist of a separate urine sample volume measuring system unit (USVMS) for each crewmember. (Refer to section 5.) The unit is used for each urination in order to provide a urine sample, with the remainder of the contents being dumped overboard in the following manner. The USVMS is first attached by quick-disconnect to an inline filter, which remains attached (by quick-disconnect) to the waste management dump line. The USVMS valve is set to the DUMP position, followed by setting the WASTE MANAGEMENT-SELECTOR valve on RHEB-201 to URINE FECES and the adjacent OVBD DRAIN valve to DUMP. A 5-psi differential pressure, provided by the valve settings, will empty the contents of the collection bag overboard through the urine/water dump line. Should a USVMS unit fail, direct overboard urination may be accomplished by using the urine

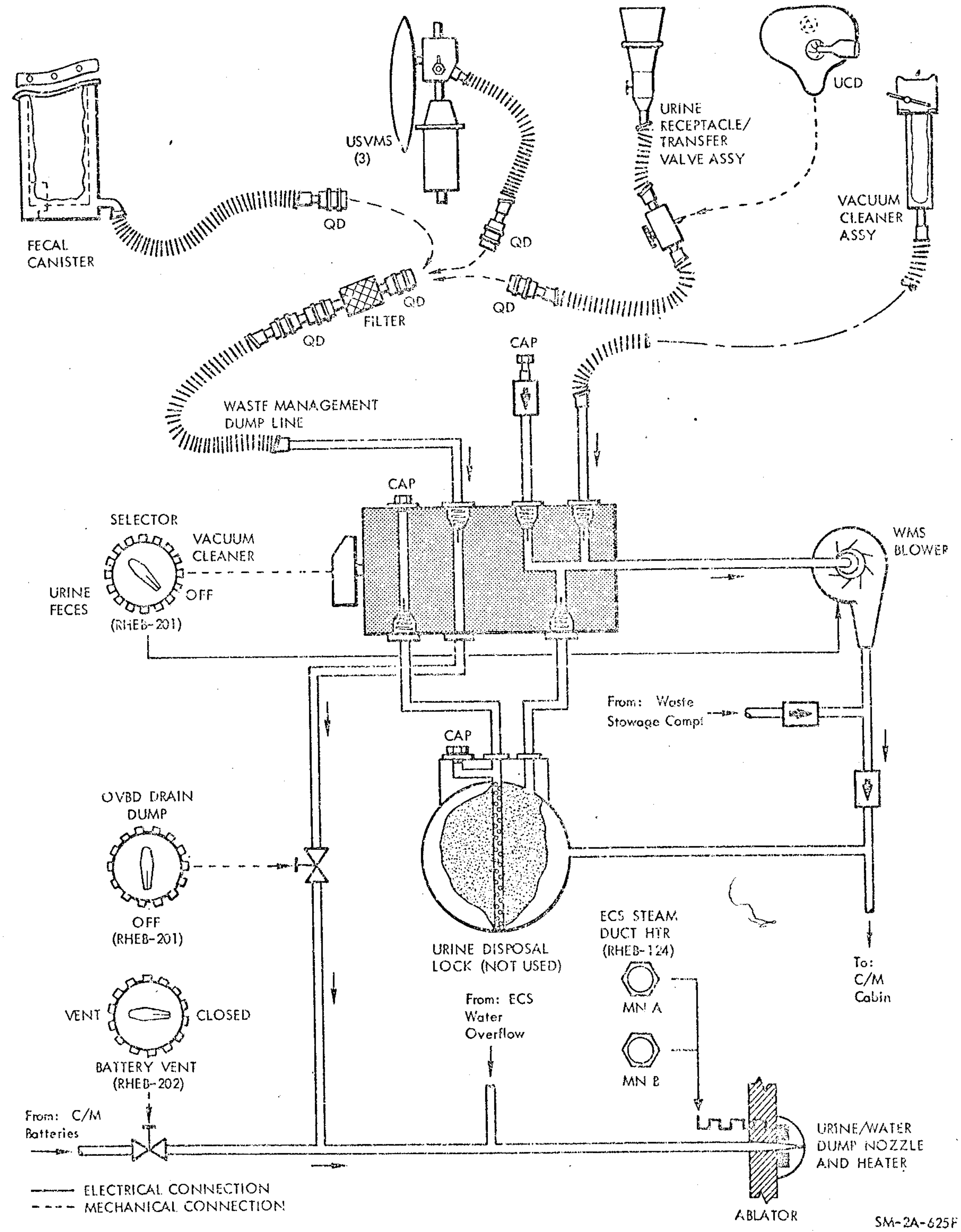


Figure 2.7-9. WMS Functional Flow Diagram

receptacle, which is a backup component. The PHA urine collection device (UCD) may be used during prelaunch, and if so, is emptied in much the same way. The transfer valve (of the urine receptacle/transfer valve assembly) is inserted into the UCD after it is removed from the PGA. The urine receptacle is then attached by quick-disconnect to the filter on the waste management dump line. The WASTE MANAGEMENT-SELECTOR and OVBD DRAIN valves are set to the URINE FECES and DUMP positions respectively, emptying the contents overboard. Upon completion, the PGA UCD is stowed in the PGA stowage bag. Although the WMS blower will operate whenever the SELECTOR valve is set to the URINE FECES position, functional operation of the blower is for vacuum cleaning only.

For the fecal portion of the urine/fecal subsystem, components consist only of the fecal canister and hose assembly. Normally stowed out of the way, the canister is secured to the center CO_2-odor absorber filter storage container at the LEB. The hose is then attached by quick-disconnect to the filter on the waste management dump line. The WASTE MANAGEMENT-SELECTOR valve is set to URINE FECES and the OVBD DRAIN valve is set to DUMP. Differential pressure of 5 psi is thus created, routing the odors overboard through the urine/water dump line.

The vacuum cleaner subsystem is made up of the vacuum assembly and an 8-foot flex hose, which are stowed in the vacuum stowage compartment. After removing the vacuum cleaner from the storage compartment, it is placed in operation by setting the WASTE MANAGEMENT-SELECTOR valve to VACUUM CLEANER. This single action activates the WMS blower and opens the valve port that connects the vacuum cleaner line to the blower. The WMS blower provides a gas flow of 5 cfm at a ΔP of -4.9 inches H_2O to effectively remove debris, either solid or liquid. A porous bag, inserted into the vacuum assembly, traps the debris while the gases are exhausted into the C/M cabin.

The C/M battery venting network consists of a manifold, a BATTERY VENT valve (RHEB-202), and lines that are routed to connect into the urine/water dump line. The vent valve is to remain in the VENT position during normal operation to provide unrestricted flow for intermittent battery relief valve operation. Only in event of a battery case rupture or vent manifold leakage will the vent valve be closed. This prevents loss of cabin atmosphere overboard, thereby, conserving oxygen.

2.7.3.7 Electrical Power Distribution.

The types of electrical power required for the operation of the ECS are 28 volts dc and 115/200-volts 400-cycles 3-phase ac. (See figure 2.7-10.) The larger motors of the system utilize 200-volt 3-phase power, whereas the smaller motors and control circuits operate from a single phase of the ac at 115 volts. Except for the postlanding ventilation system, those components using 28 volts dc will receive power from the fuel cells before CSM separation and from batteries after separation. The postlanding ventilation system will operate from batteries, exclusively.

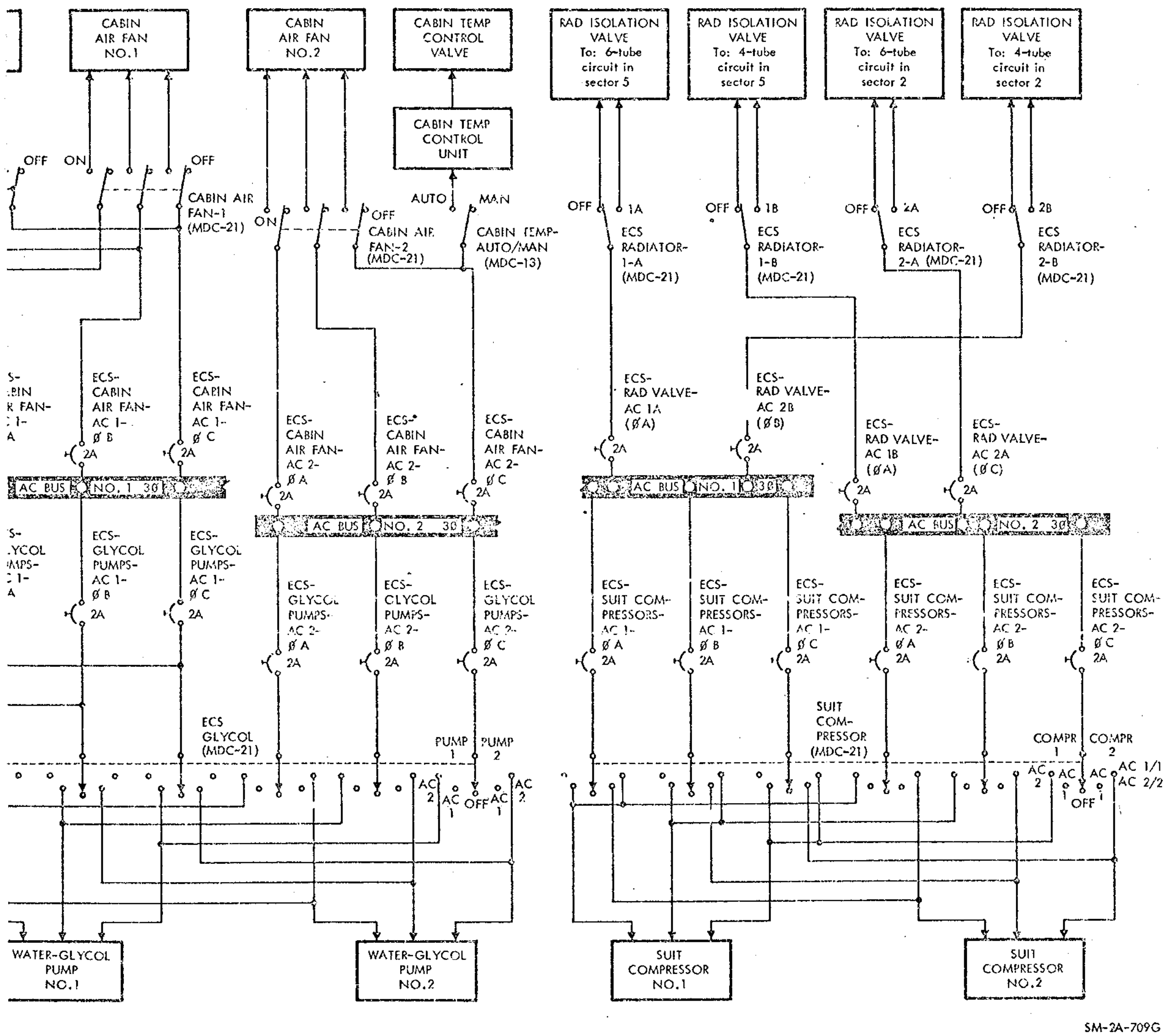
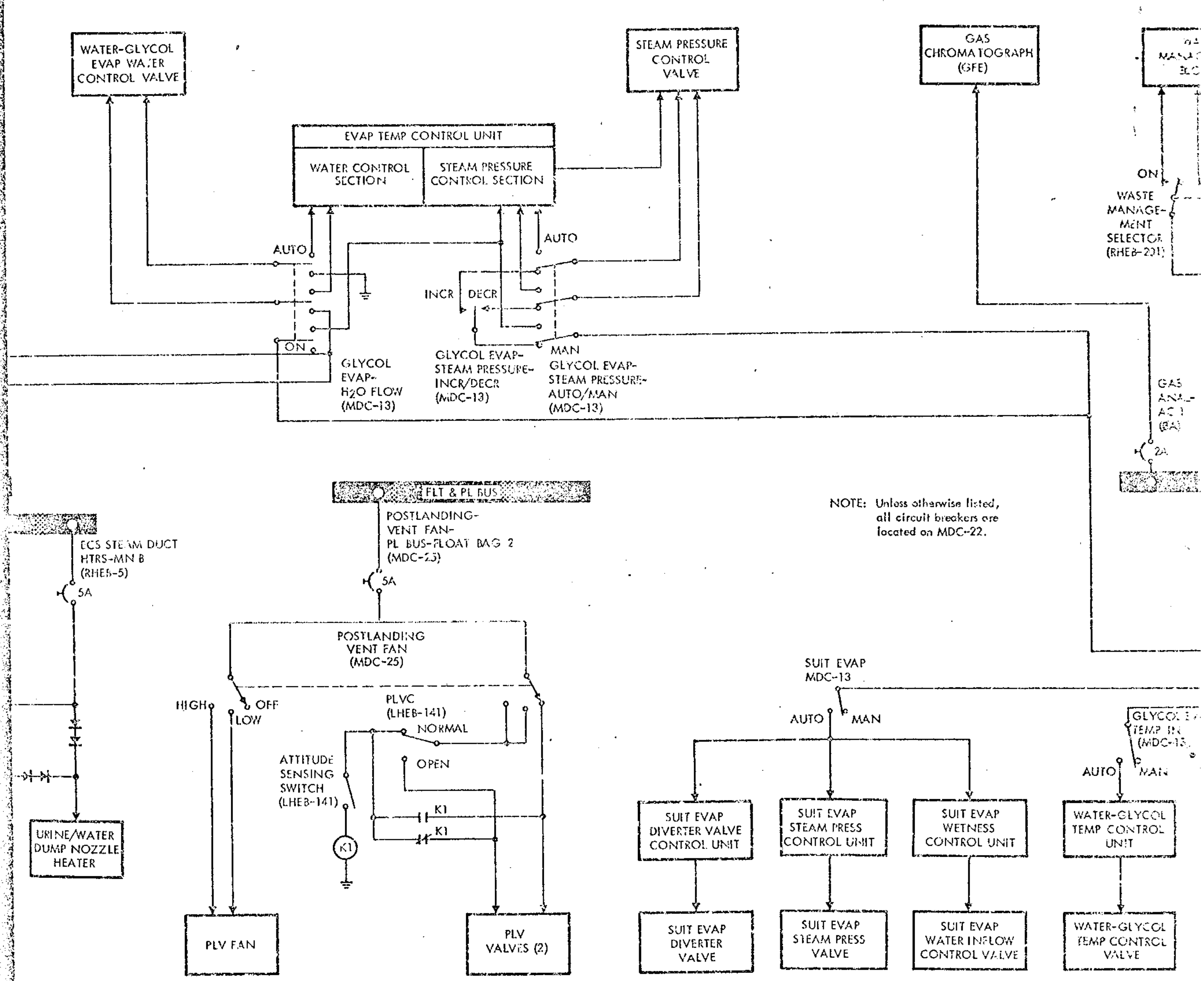
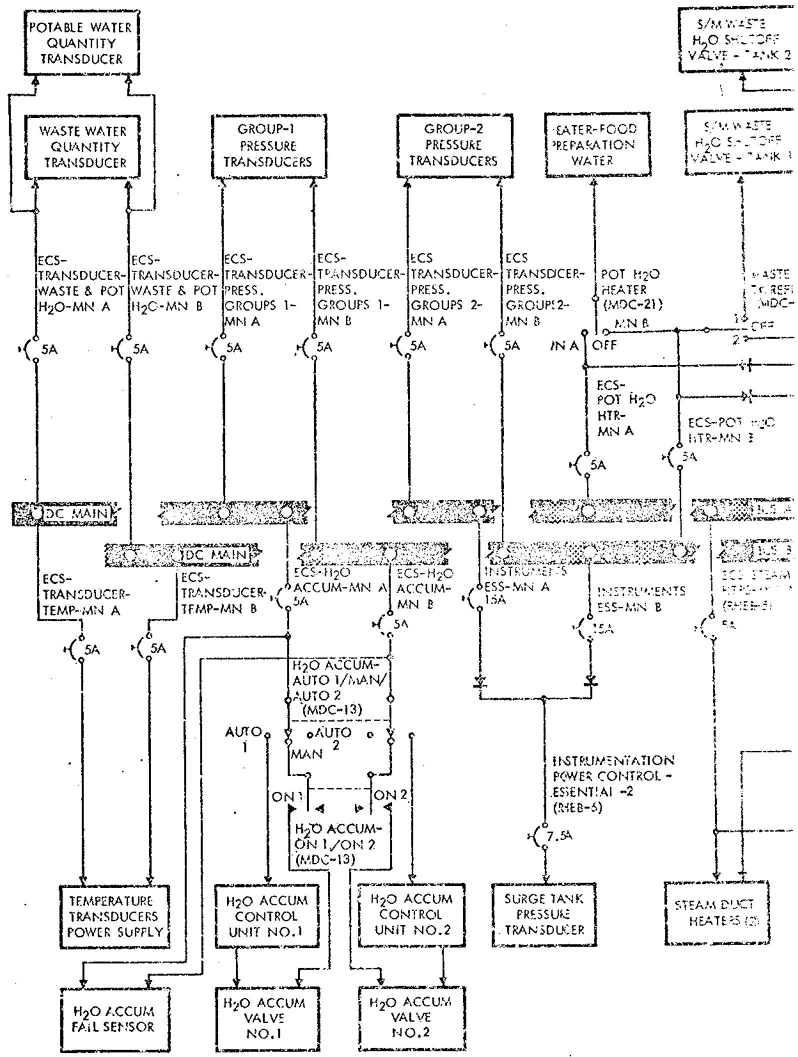


Figure 2.7-10. ECS Power Distribution Diagram



NOTE: Unless otherwise listed, all circuit breakers are located on MDC-22.


POTABLE WATER QUANTITY TRANSDUCER
WASTE WATER QUANTITY TRANSDUCER
GROUP-1 PRESSURE TRANSDUCERS
GROUP-2 PRESSURE TRANSDUCERS
S/M WASTE H2O SHUTOFF VALVE - TANK 2
ECS-TRANSDUCER-WASTE & POT H2O-MN A
ECS-TRANSDUCER-WASTE & POT H2O-MN B
ECS-TRANSDUCER-PRESS. GROUPS 1-MN A
ECS-TRANSDUCER-PRESS. GROUPS 1-MN B
ECS TRANSDUCER-PRESS. GROUPS 2-MN A
ECS TRANSDUCER-PRESS. GROUPS 2-MN B
POT H2O HEATER (MDC-21)
OFF
ECS-POT H2O HTR-MN A
5A
DC MAIN
ECS-TRANSDUCER-TEMP-MN A
ECS-TRANSDUCER-TEMP-MN B
ECS-H2O ACCUM-MN A
ECS-H2O ACCUM-MN B
INSTRUMENTS ESS-MN A
INSTRUMENTS ESS-MN B
15A
H2O ACCUM-AUTO 1/MAN/AUTO 2 (MDC-13)
AUTO 1
AUTO 2
MAN
ON 1
ON 2
H2O ACCUM-ON 1/ON 2 (MDC-13)
INSTRUMENTATION POWER CONTROL - ESSENTIAL -2 (MEB-5)
7.5A
TEMPERATURE TRANSDUCERS POWER SUPPLY
H2O ACCUM CONTROL UNIT NO.1
H2O ACCUM CONTROL UNIT NO.2
SURGE TANK PRESSURE TRANSDUCER
STEAM DUCT HEATERS (2)
H2O ACCUM FAIL SENSOR
H2O ACCUM VALVE NO.1
H2O ACCUM VALVE NO.2

2.7.4 PERFORMANCE AND DESIGN DATA.

2.7.4.1 Metabolic Data.

The following table contains the average metabolic rates, thermal balance, and water requirements for S/C crewmembers.

Parameter	Pressurized Cabin (Normal)	Depressurized Cabin (Emergency)
Total metabolic load BTU per man/day	11,200	12,000
Water production lb per man/day	4.0	9.8
CO_2 production lb per man/day	2.12	2.27
O_2 consumption lb per man/day	1.84	1.97
Water consumption lb per man/day	6.6	12.4
Urine production lb per man/day	2.6	2.6

2.7.4.2 Oxygen Supply Subsystem.

Performance and design data for the oxygen supply subsystem are as follows:

- Maximum oxygen flow rate to ECS from cryogenic storage tanks: 9.0 lb per hr
- Surge tank quantity: 3.7 lb (approx)
  Surge tank nominal pressure: 900±35 psig
  Surge tank pressure relief setting: 1045±25 psig
- Entry tank quantity: 1 lb (approx)
  Entry tank nominal pressure: 900±35 psig
  Entry tank pressure relief setting: None
- Regulated working oxygen pressure: 100±10 psig
  Pressure relief setting: 130±10 psig
  Flow rate: 0.7 lb per min max
- Regulated tank pressurization oxygen pressure: 20±2 psig
  Pressure relief setting: 25±2 psig
  Flow rate: 0.075 lb per min (one regulator) and 0.15 lb per min (two regulators)

2.7.4.3 Pressure Suit Circuit Subsystem.

Performance and design data for the pressure suit circuit subsystem are as follows:

- Heat exchanger cooling capacity: 2100 BTU per hr max (Gly or evap)
- Water evaporation rate: 1.97 lb per hr max
- Regulated demand pressure
  Normal: 2.5 to 3.5 in. H_2O below cabin pressure
  Emergency: 3.75 ±0.25 psia
  Flow rate: 0.67 lb per min max
- Suit compressor volumetric flow
  Normal flight: 35 cfm
  Emergency flight: 33.6 cfm
- Automatic temperature control: 45° to 55°F
- Max O_2 flow into suit circuit: 0.66 lb per min (regulator or manual valve)

2.7.4.4 Cabin Pressure and Temperature Control Subsystem.

Performance and design data for the cabin pressure and temperature control subsystem are as follows:

- Heat exchanger cooling capacity: 1250 BTU per hr max
- Regulated cabin pressure: 5.0±0.2 psig
  Flow rate: 0.65 lb per hr (one regulator) and 1.3 lb per hr (two regulators)
- Emergency inflow pressure (maximum of 0.5 in. diameter total leakage area): 3.5 psia for 5 minutes
  Flow rate: 0.67 lb per min max
- Cabin pressure relief
  Positive relief: 6.0 (+0.2, -0.4) psig
  Negative relief: 10 to 25 in. H_2O
- Differential pressure (C/M cabin-to-aft section)
  Normal ascent: 7.0 psig max.
  Abort ascent: 8.6 psig max.
- Automatic temperature control (flight): 70° to 80°F
- O_2 required for cabin repressurization, 0 to 5 psig at 70°F: 9.1 lb

2.7.4.5 Water-Glycol Coolant Subsystem.

Performance and design data for the water-glycol coolant subsystem are as follows:

- Reservoir quantity: 9 lb (approx)
- Total system quantity (less reservoir): 18 lb (approx)
- Evaporator cooling capacity: 7620 BTU per hr max

- Water evaporation rate: 7.5 lb per hr max
- Accumulator quantity: 1.36 lb (approx)
- Pump flow: 200 lb per hr
- Pump pressure
  Inlet: 7.5±1.5 psig
  Outlet (flight): 38(+8, -12) psia
- Automatic temperature control: 40° to 50.5°F

2.7.4.6 Water Supply Subsystem.

Performance and design data for the water supply subsystem are as follows:

- Potable tank quantity: 36 lb
- Waste tank quantity: 56 lb
- S/M water tank quantity: 112 lb (2 tanks)
- S/M nitrogen tank quantity (pressurant): capacity of 3.7 lb, filled to 1.5 lb (approx)
- Nitrogen tank fill pressure: 900 psig
- Nitrogen tank pressure relief setting: 1045±25 psig
- Nitrogen system regulated pressure: 40±2 psig
- Nitrogen system pressure relief setting: 44 to 48 psig
- Overboard dump pressure: approx 32 psi above outside ambient
  Flow rate: 2.5 lb per min max
- Food preparation water supply unit
  Capacity: 1.9 lb
  Hot water: 154°±4°F
  Cold water: 50°F (at water chiller)

2.7.4.7 Waste Management System.

Performance and design data for the waste management system is as follows:

- Urine/water dump nozzle orifice: 0.055 in.

2.7.4.8 ECS Power Consumption Data.

The following list contains the latest available data on electrical power consumed by components of the ECS. The wattage figures are for the earth orbit phase only, and apply to operations during the normal mode (pressurized cabin).

SYSTEMS DATA

Subsystem and Component	Control	No. of Units	Watts per Unit AC	Watts per Unit DC	Total Watts AC	Total Watts DC
OXYGEN SUPPLY						
O_2 flow transducer	ECS-TRANSDUCER-PRESS GROUPS-2 cb (2)	1		2.4		2.4
O_2 press transducer	ECS-TRANSDUCER-PRESS GROUPS-2 cb (2)	1		0.8		0.8
PRESSURE SUIT CIRCUIT						
Suit compressor	SUIT COMPRESSORS sw	2	85.0		†85.0 170.0	
ΔP sensor	ECS-TRANSDUCER-PRESS GROUPS-1 cb (2)	1		1.28		1.28
CO_2 sensor	ECS-TRANSDUCER-PRESS GROUPS-2 cb (2)	1		1.0		1.0
Diverter valve control unit	SUIT EVAP sw	1	2.5		2.5	
Diverter control valve	SUIT EVAP sw	1	*7.2		*7.2	
Steam press control unit	SUIT EVAP sw	1	2.5		2.5	
Steam press cont valve	SUIT EVAP sw	1	*7.2		*7.2	
Steam duct abs press sensor	SUIT EVAP sw	1		1.28		1.28
Wetness control unit	SUIT EVAP sw	1	5.0		5.0	
Water inflow control valve	SUIT EVAP sw	1		*3.0		*3.0
Wetness sensor	SUIT EVAP sw	1		0.2		0.2
Water-gly temp sensor	SUIT EVAP sw	1		0.001		0.001
Evap outlet air temp sensor	SUIT EVAP sw	1		0.001		0.001

*Intermittent operating components
†Only one component operates at a time

SYSTEMS DATA

Subsystem and Component	Control	No. of Units	Watts per Unit AC	Watts per Unit DC	Total Watts AC	Total Watts DC
Suit press transducer	ECS-TRANSDUCER-PRESS GROUPS-1 cb (2)	1		0.8		0.8
Suit temp sensor	ECS-TRANSDUCER-TEMP GROUP cb (2)	1	0.04		0.04	
CABIN PRESSURE & TEMP CONTROL						
Cabin air fan	CABIN AIR FAN-1&2 sw (2)	2	19.0		38.0	
Cabin temp control unit	CABIN TEMP-AUTO/MAN sw	1	2.5		2.5	
Cabin temp cont valve	CABIN TEMP-AUTO/MAN sw	1	*7.2		*7.2	
Cabin temp sensor	ECS-TRANSDUCER-TEMP GROUP cb (2)	1		0.001		0.001
Cabin temp anticipator	ECS-TRANSDUCER-TEMP GROUP cb (2)	1		0.001		0.001
Cabin press transducer	ECS-TRANSDUCER-PRESS GROUPS-2 cb (2)	1		0.8		0.8
WATER-GLYCOL COOLANT						
Water-glycol pump	ECS GLYCOL sw	2	36.0		†36.0	
Pump outlet press transducer	ECS-TRANSDUCER-PRESS GROUPS-1 cb (2)	1		0.8		0.8
Water-gly accum qty sensor	ECS-TRANSDUCER-PRESS GROUPS-1 cb (2)	1		0.8		0.8

*Intermittent operating components
†Only one component operates at a time

SYSTEMS DATA

Subsystem and Component	Control	No. of Units	Watts per Unit AC	Watts per Unit DC	Total Watts AC	Total Watts DC
Water-gly temp control unit	GLYCOL EVAP-TEMP IN sw	1	2.5		2.5	
Water-gly temp control valve	GLYCOL EVAP-TEMP IN sw	1	*7.2		*7.2	
Water-gly temp sensor	GLYCOL EVAP-TEMP IN sw; GLY EVAP-STEAM PRESS-AUTO/MAN sw; GLYCOL EVAP-H_2O FLOW sw	5		0.001		0.005
Steam press control unit	GLY EVAP-STEAM PRESS-AUTO/MAN sw	1	2.5		2.5	
Steam press cont valve	GLY EVAP-STEAM PRESS-INCR/DECR sw	1	*7.2		*7.2	
Steam duct press switch	ECS-TRANSDUCER-PRESS GROUPS-1 cb (2)	1	TBD	TBD	TBD	TBD
Water control unit	GLYCOL EVAP-H_2O FLOW sw	1	5.0		5.0	
Water control valve	GLYCOL EVAP-H_2O FLOW sw	1		*3.0		*3.0
Wick temp sensor	GLYCOL EVAP-H_2O FLOW sw	1		0.28		0.28
Rad outlet temp sensor	ECS-TRANSDUCER-TEMP GROUP cb (2)	1	0.04		0.04	
Rad isolation valve	ECS RADIATOR sw (4)	4	*14.4		*57.6	

*Intermittent operating components

SYSTEMS DATA

Subsystem and Component	Control	No. of Units	Watts per Unit AC	Watts per Unit DC	Total Watts AC	Total Watts DC
WATER SUPPLY						
Pot water qty transducer	ECS-TRANSDUCER-WASTE & POT H_2O-MN A&B cb (2)	1		1.28		1.28
Waste water qty transducer	ECS-TRANSDUCER-WASTE & POT H_2O MN A&B cb (2)	1		1.28		1.28
Food prep water supply unit	POT H_2O HEATER sw	1		*45.0		*45.0
H_2O accum control unit	H_2O ACCUM-AUTO/MAN sw	1		3.0		3.0
H_2O accum valve	H_2O ACCUM-ON/OFF sw	2		*3.0		*3.0
H_2O accum fail sensor	ECS-H_2O ACCUM-MN A&B cb (2)	1		1.5		1.5
S/M water tank shut-off valve	WASTE H_2O TK REFILL sw	2		*160.0		*160.0
MISCELLANEOUS						
WMS blower	WASTE MANAGEMENT SELECTOR valve	1	*20.0			*20.0
Urine/water dump nozzle heater	ECS-STEAM DUCT HTR-MN A&B cb (2)	1		5.7		5.7
Steam duct heater	ECS-STEAM DUCT HTR-MN A&B cb (2)	2		3.0		6.0
Temp xducer pwr supply	ECS-TRANSDUCER-TEMP GROUP cb (2)	1		10.5		10.5

*Intermittent operating components

Subsystem and Component	Control	No. of Units	Watts per Unit AC	Watts per Unit DC	Total Watts AC	Total Watts DC
Temp sensor amplifier	ECS-TRANSDUCER-TEMP GROUP cb (2)	5	0.04		0.2	
Steam duct temp sensor signal conditioner	ECS-TRANSDUCER-TEMP GROUP cb (2)	1		1.5		1.5
Gas chromatograph	GAS ANAL—AC 1 cb	1	9		9	

*Intermittent operating components

2.7.5 OPERATIONAL LIMITATIONS AND RESTRICTIONS

2.7.5.1 ECS Caution Placards.

Caution notes bordered by yellow and black stripes appear adjacent to the postlanding vent valves in the forward tunnel area. The notes read, "POST LANDING VENT VALVE—PULL PIN BEFORE OPERATING VENT FAN." If the pins were not in place during flight, inadvertent opening of the cabin vent valves would immediately dump all cabin pressure, with possible catastrophic results.

A placard on each CO_2-odor absorber canister cover cautions the crewman to "PUSH BUTTON BEFORE OPENING," and includes an arrow to indicate direction button should be pushed. This instruction must be followed any time a canister cover is to be opened. By pressing the push-button, the differential pressure is equalized and the cover may then be removed.

The caution note on LHEB-314 pertains to filling the PLSS oxygen tanks and, therefore, is not applicable to earth orbital (Block 1) missions. It reads, "CAUTION 900 PSI CLOSE VALVE BEFORE REMOVING CAP."

2.7.5.2 ECS Caution Notes.

Design restrictions require that certain procedures be followed when positioning the inlet and outlet selector valves of the tank pressure regulator and relief valve assembly. If the inlet selector valve is placed to position 1 (or 2), the outlet selector valve must also be placed to position 1 (or 2) or to NORMAL position. This prevents shutting off the supply of oxygen for pressurizing the potable and waste water tanks and the water-glycol reservoir. Conversely, if the outlet selector valve is placed to position 1 (or 2), the inlet selector valve must be placed to position 1 (or 2) or to NORMAL position.

2.7.5.3 ECS General Data.

Several ECS controls are inaccessible during the mission. Those affected are located behind the two removable Y-axis attenuator panels in the LHEB. They include all controls mounted on LHEB-311, the suit circuit return air manual valve, and the diverter valve handle for the CO_2-odor absorber canisters. The attenuator panels are in place during the entire mission, but are removed to gain access to these ECS controls, and then immediately reinstalled. They provide an adequate bearing surface for the Y-axis attenuator shock strut pad for the landing impact.

The circuit breaker for the postlanding ventilation system is not engaged until after landing impact. This precaution, in conjunction with the lockpins previously inserted in the postlanding vent valves, assures that the cabin pressure will not be inadvertently dumped during flight.

High-oxygen flow during cabin repressurization, or when filling an empty (150 psia min) surge tank, may cause water-glycol freezing. This will occur when there is less than full flow through the warm water-glycol line upon which the flow restrictors are wound. Full coolant flow at this location, therefore, may be assured in the following manner. Between 15 and 30 minutes prior to anticipated high oxygen flow, set the GLYCOL EVAP-TEMP IN switch (MDC-13) to MAN, and override the GLYCOL EVAP TEMP IN valve (LHEB-311) to the full cool position.

Radiator heat rejection (as freezing) is a function of radiator inlet temperature and radiator orientation. Thus, if the radiator inlet temperature decreases to 75°F, the S/C must be placed in a 2 to 5 RPH (0.2 to 0.5 degree per second) roll rate. During this time radiator inlet temperature must not decrease below 70°F, or the individual radiator outlet temperature below 30°F.

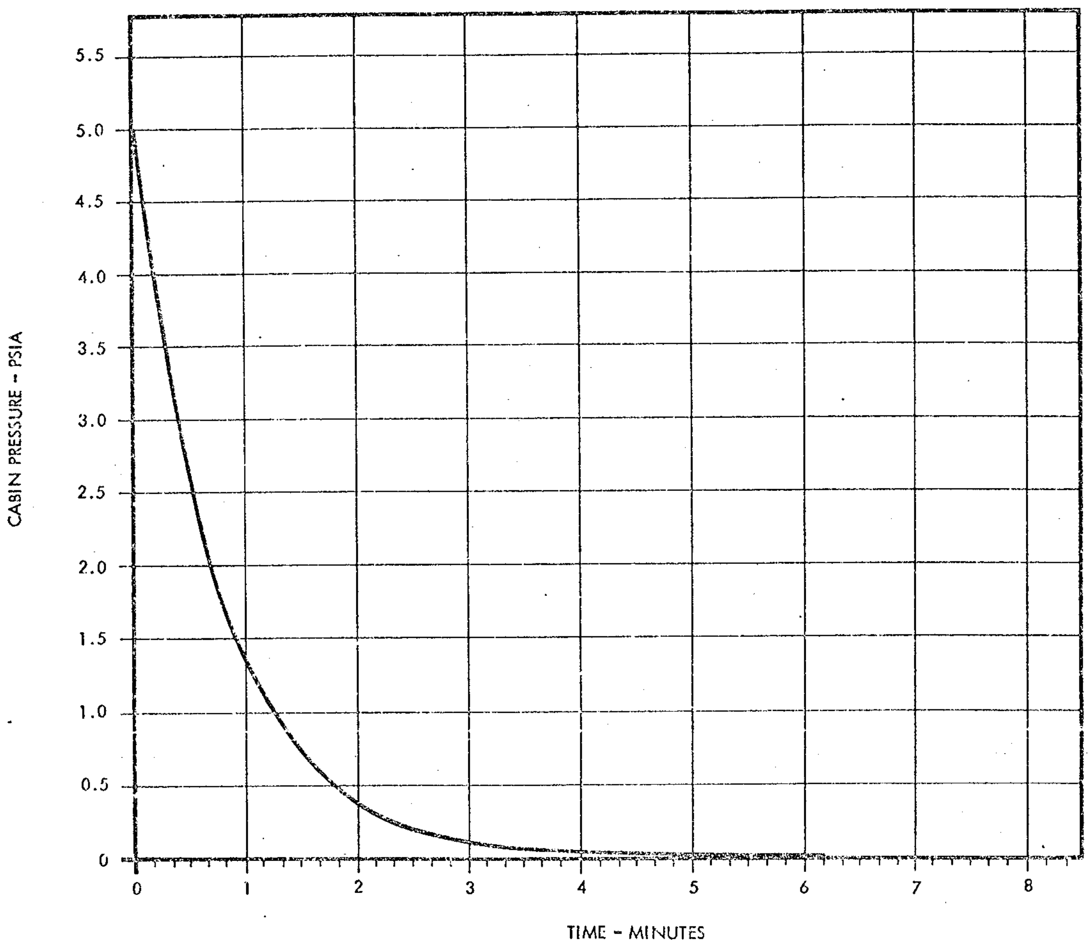
2.7.5.4 Cabin Depressurization Rates.

The time required for the C/M cabin to become depressurized is contingent upon how pressure is released. If the cabin is intentionally dumped, the time it takes to reach zero pressure will be as shown in figure 2.7-11, sheet 1 of 2. However, if the pressure is lost as the result of meteoroid punctures, the time will vary according to the size and number of holes. Figure 2.7-11, sheet 2 of 2, only reflects flow rate data for meteoroid holes that do not exceed a total equivalent area of 0.5 in. in diameter. The same chart also applies to the flow rate of one cabin pressure relief valve that has failed open while in the NORMAL position.

2.7.5.5 Cabin Repressurization Rates.

The C/M cabin may be repressurized by using either of two flow rates. To return the cabin pressure to normal in the shortest possible time, the conditions as set forth in figure 2.7-12, sheet 1 of 2, must be complied with. The flow rate, however, is dependent upon a full supply of oxygen in the

CABIN DEPRESSURIZATION - 5 TO 0 PSIA
INTENTIONAL DUMP TIME - 6 MIN, 11 SEC

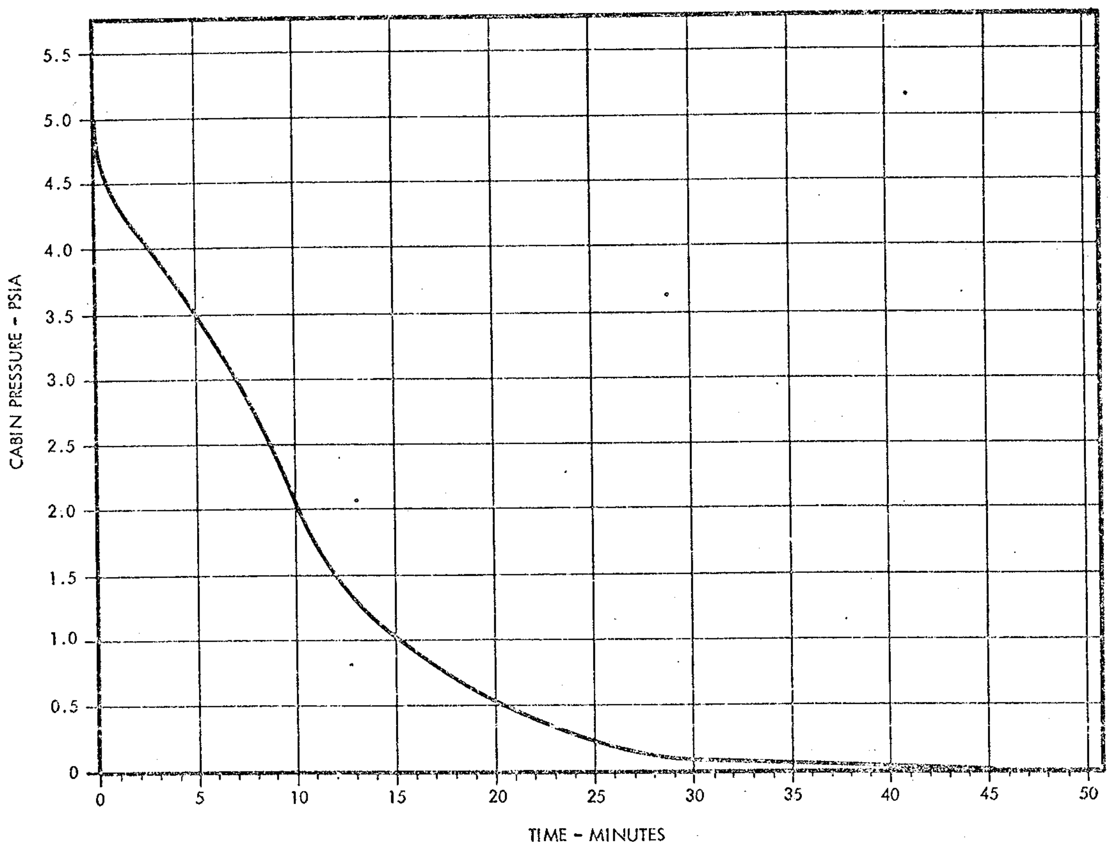


CONDITIONS:
1. EMERGENCY CABIN PRESSURE selector valve set to OFF.
2. CABIN REPRESS manual valve set to close.
3. CABIN PRESSURE RELIEF valve set to DUMP.
4. Normal cabin pressure regulators automatically close at 3.5 psia.

SM-2A-890

Figure 2.7-11. Cabin Depressurization Rates (Sheet 1 of 2)

CABIN DEPRESSURIZATION - 5 TO 0 PSIA
UNINTENTIONAL DUMP TIME - 45 MIN, 40 SEC*



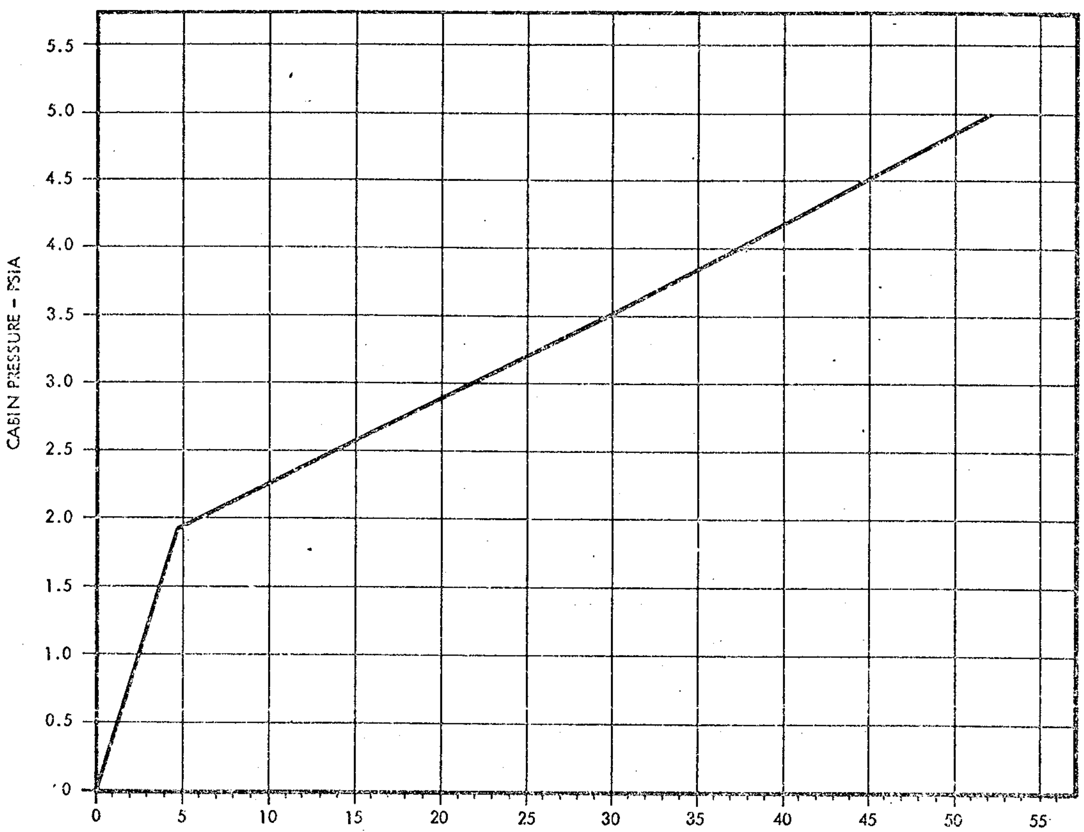
CONDITIONS:
1. EMERGENCY CABIN PRESSURE selector valve set to NORMAL.
2. CABIN REPRESS manual valve set to close.
3. CABIN PRESSURE RELIEF valves set to NORMAL.
4. Normal cabin pressure regulators automatically closed at 3.5 psia.
5. EMERGENCY CABIN PRESSURE selector valve set to OFF position when pressure reaches 3.5 psia (5 minutes).

*Depressurization is through a 0.5-inch-diameter (or equivalent) meteoroid puncture, or the maximum flow through one CABIN PRESSURE RELIEF valve that fails open while in the NORMAL position.

SM-2A-883

Figure 2.7-11. Cabin Depressurization Rates (Sheet 2 of 2)

CABIN REPRESSURIZATION - 0 TO 5 PSIA *
MINIMUM TIME ~ 52 MIN, 22 SEC



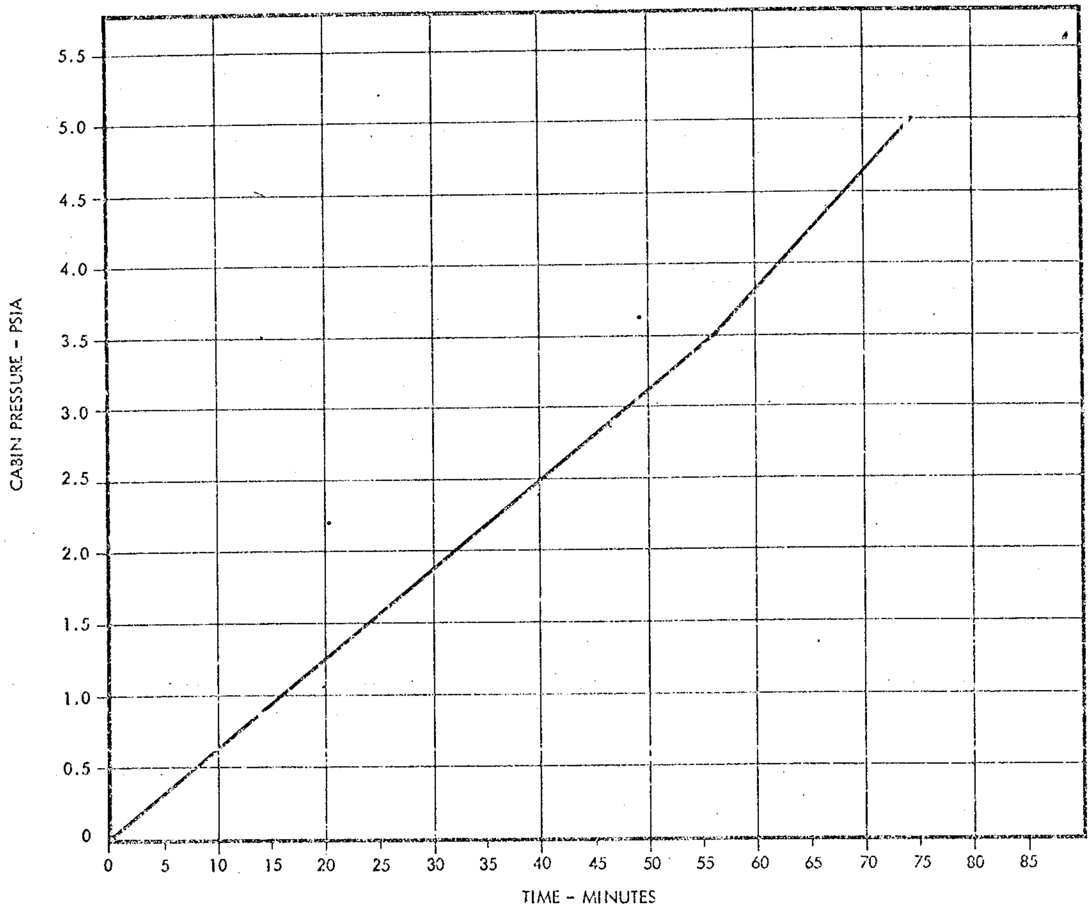
CONDITIONS:
1. EMERGENCY CABIN PRESSURE selector valve set to NORMAL.
2. CABIN REPRESS manual valve set to OPEN.
3. When surge tank pressure indicator decreases to 150 psia, EMERGENCY CABIN PRESSURE selector valve set to OFF; surge tank minimum pressure (150 psia) maintained by regulating CABIN REPRESS manual valve until valve is full open and surge tank pressure starts to increase.
4. Normal cabin pressure regulators automatically open at 3.5 psia.
5. When surge tank pressure again decreases to 150 psia, CABIN REPRESS manual valve regulated to maintain this minimum surge tank pressure.
6. When cabin pressure indicator reaches 5.0 psia, normal cabin pressure regulators automatically close and CABIN REPRESS manual valve set to close.

* Requires 9.1lb oxygen at 70°F cabin temperature

SM-2A-889A

Figure 2.7-12. Cabin Repressurization Rates (Sheet 1 of 2)

CABIN REPRESSURIZATION - 0 TO 5 PSIA *
NORMAL TIME - 74 MIN, 25 SEC



CONDITIONS:
1. EMERGENCY CABIN PRESSURE selector valve set to OFF.
2. CABIN REPRESS manual valve set to OPEN.
3. Normal cabin pressure regulators automatically open at 3.5 psia.
4. When cabin pressure indicator reaches 5.0 psia, normal cabin pressure regulators automatically close and CABIN REPRESS manual valve set to close.

* Requires 9.1lb oxygen at 70°F cabin temperature

SM-2A-887A

Figure 2.7-12. Cabin Repressurization Rates (Sheet 2 of 2) surge tank. When the surge tank is not full, or the repressurization time is not critical, the conditions for the flow rate as shown in figure 2.7-12, sheet 2 of 2, are used.

2.7.6 TELEMETRY MEASUREMENTS.

The following is a complete list of all ECS telemetry data that is monitored by flight controllers and ground support personnel. The last column contains the name and type of S/C crew display. The display utilizes the same pickoff or signal source as telemetry, unless a separate measurement number is included in the display column.

An asterisk (*) by the measurement number denotes information which is not available for recording or telemetry transmission during PCM low-bit rate operation.

Measurement Number	Description	Sensor Range	Normal Operating Range	Crew Display
CF 0001 P	Pressure cabin	0/17 psia	5.0±0.2 psia	PRESS - CABIN indicator
CF 0002 T	Temp cabin	40/125°F	70° to 80°F	TEMP - CABIN indicator
CF 0005 P	Press CO_2 partial	0/30 mm Hg	<7.6 mm Hg	PART PRESS CO_2 indicator and CO_2 PP HI C&W light
*CF 0006 P	Press surge tank	50/1050 psia	900±35 psia	TANK PRESS - 1 - O_2 indicator
*CF 0008 T	Temp suit supply manf	20/95°F	55°F	TEMP - SUIT indicator
CF 0009 Q	Quantity waste water tank	0/100%	Variable	WATER - QUANTITY indicator
CF 0010 Q	Quantity potable H_2O tank	0/100%	Variable	WATER - QUANTITY indicator
CF 0012 P	Press suit demand reg sense	0/17 psia	3.75±0.25 psia	PRESS - SUIT indicator
CF 0015 P	Press suit compressor diff	0/1 psid	Min 0.3 to 0.4 psid	ΔP SUIT COMPR indicator
CF 0016 P	Press glycol pump outlet	0/60 psia	37 to 45 psia	PRESS GLY DISCH indicator

SYSTEMS DATA

Measurement Number	Description	Sensor Range	Normal Operating Range	Crew Display
*CF 0017 T	Temp glycol evap outlet steam	20/95°F	>45°F	None
CF 0018 T	Temp glycol evap outlet liquid	25/75°F	40° to 50.5°F	GLY EVAP - OUTLET TEMP indicator
CF 0019 Q	Quantity glycol accum	0/100%	40 to 60%	GLY ACCUM - QUANTITY indicator
CF 0020 T	Temp space radiator outlet	-50/+100°F	Variable	ECS RAD - OUTLET TEMP indicator and GLYCOL TEMP LOW C&W light
*CF 0025 P	Press pump package inlet	0/60 psia	7 psi min	None
CF 0034 P	Back press glycol evaporator	0.05/0.25 psia	0.098 to 0.154 psia	GLY EVAP STEAM PRESS indicator
CF 0035 R	Flow rate ECS O_2	0.2/1.0 lb/hr	0.425 lb/hr	FLOW O_2 indicator
*CF 0036 P	Press outlet O_2 reg supply	0/150 psia	100±10 psia	None
*CF 0120 P	Press H_2O and glycol tanks	0/50 psia	18 to 35 psid	None
*CF 0135 R	Flow rate manifold inlet to suit 1	0/0.2 lb/hr	TBD	None
*CF 0136 R	Flow rate manifold inlet to suit 2	0/0.2 lb/hr	TBD	None
*CF 0137 R	Flow rate manifold inlet to suit 3	0/0.2 lb/hr	TBD	None
*CF 0148 P	DP supply and return manifold	0/0.8 psid	0.25 to 0.5 psid	None
*CF 0153 T	Temp compressor inlet	50/125°F	TBD	None
*CF 0184 T	Temp CO_2 absorber outlet	90/200°F	TBD	None

SYSTEMS DATA

Measurement Number	Description	Sensor Range	Normal Operating Range	Crew Display
*CF 0245 T	Temp O_2 reg inlet	-50/+150°F	TBD	None
*CF 0326 P	Press potable H_2O tank drain	0/50 psia	18 to 35 psid	None
*CF 0327 P	Press waste H_2O tank drain	0/50 psia	18 to 35 psid	None
*CF 0481 T	Temp CP branch 1 inlet	40/150°F	TBD	None
*CF 0482 T	Temp CP branch 1 outlet	40/150°F	TBD	None
*CF 0483 T	Temp CP branch 2 inlet	40/150°F	TBD	None
*CF 0484 T	Temp CP branch 2 outlet	40/150°F	TBD	None
*CF 0549 P	Diff press coldplate branch 1	0/2.0 psid	TBD	None
*CF 0550 P	Diff press coldplate branch 2	0/10 psid	TBD	None
CT 0108 K	Gas analysis - suit and cabin	N/A	N/A	None
SF 0665 T	Temp space radiator inlet	60/150°F	Variable	None
SF 0671 T	Temp ECS radiator outlet 1	0/50°F	Variable	ECS RAD OUT TEMP-1 indicator
SF 0672 T	Temp ECS radiator outlet 2	0/50°F	Variable	ECS RAD OUT TEMP-2 indicator

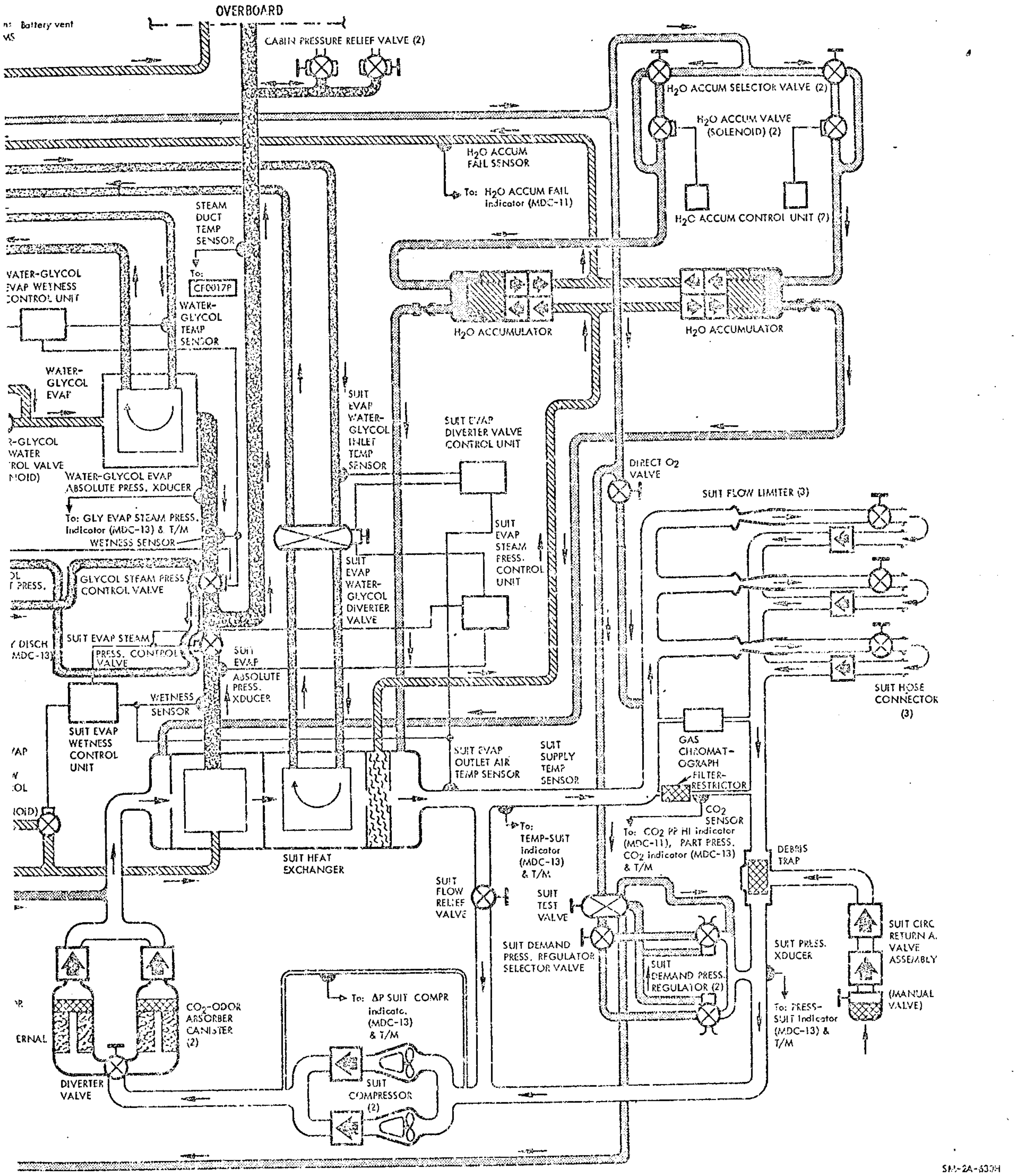
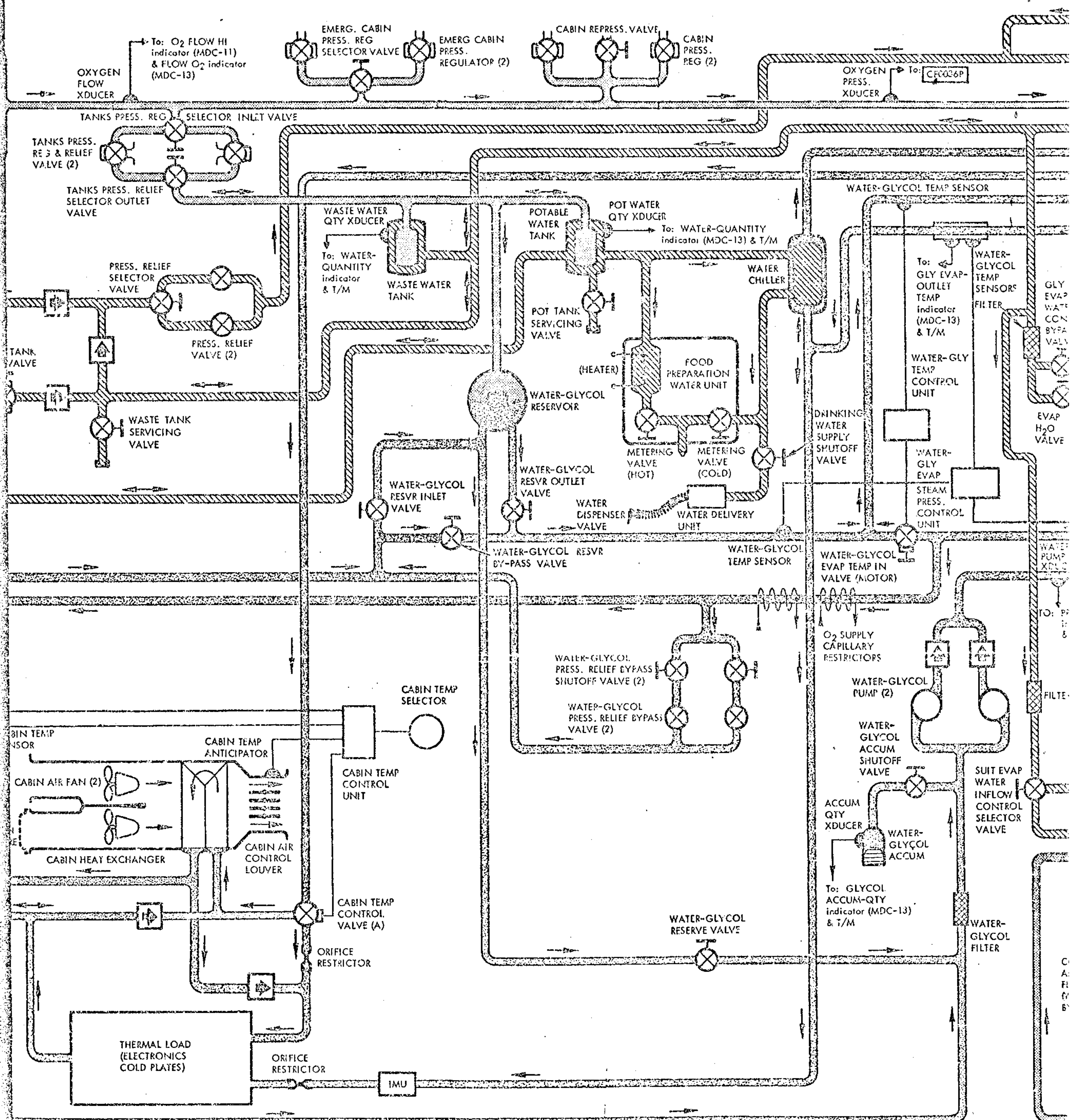
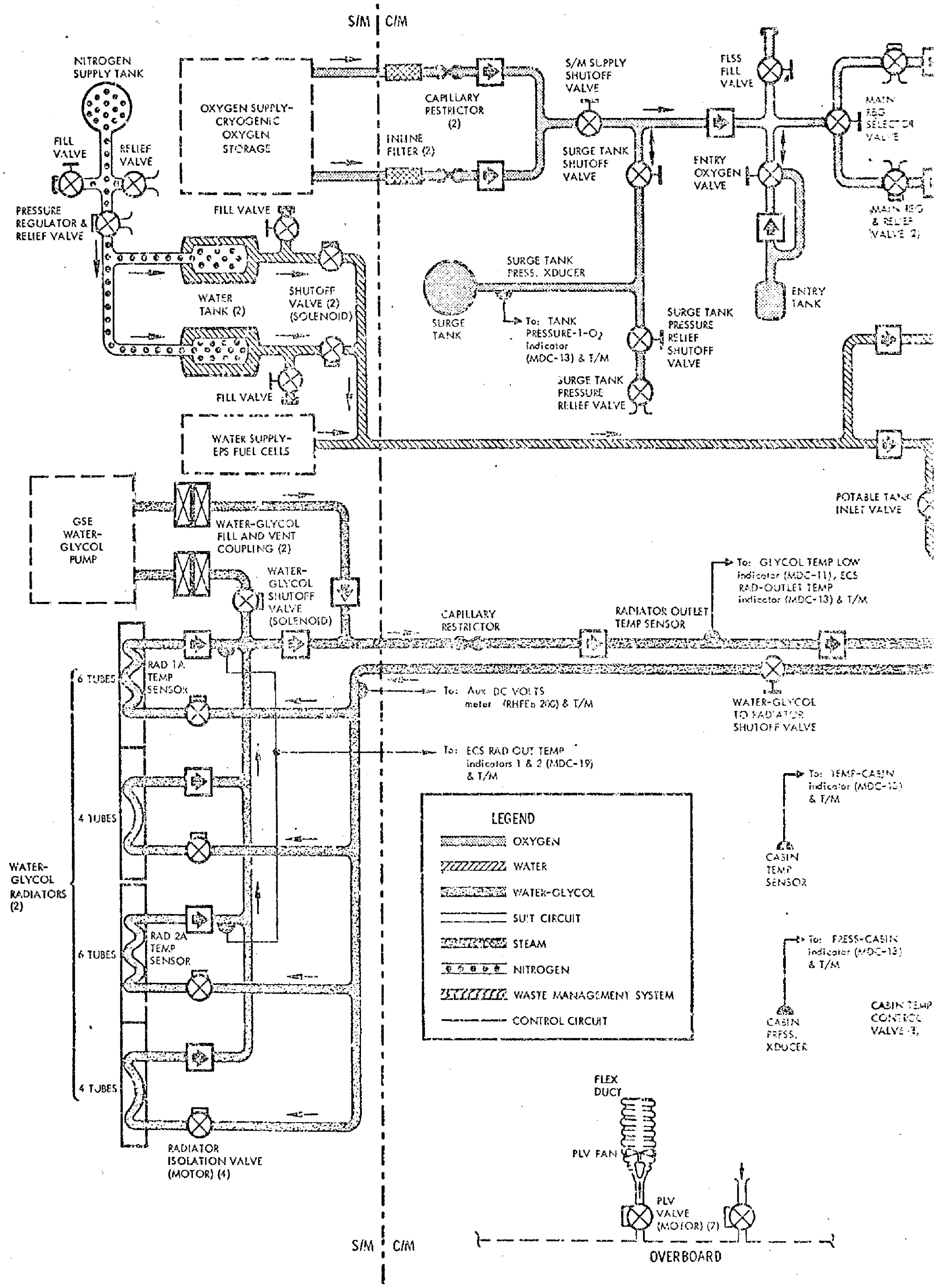


Figure 2.7-13. ECS Schematic Diagram


OXYGEN FLOW XDUCER
To: O2 FLOW HI indicator (MDC-11) & FLOW O2 indicator (MDC-13)
EMERG. CABIN PRESS. REG SELECTOR VALVE
EMERG CABIN PRESS. REGULATOR (2)
CABIN REPRESS. VALVE
CABIN PRESS. REG (2)
OXYGEN PRESS. XDUCER
To: CF0036P
TANKS PRESS. REG
SELECTOR INLET VALVE
TANKS PRESS. REG & RELIEF VALVE (2)
TANKS PRESS. RELIEF SELECTOR OUTLET VALVE
WASTE WATER QTY XDUCER
To: WATER-QUANTITY indicator & T/M
WASTE WATER TANK
POTABLE WATER TANK
POT WATER QTY XDUCER
To: WATER-QUANTITY indicator (MDC-13) & T/M
WATER CHILLER
WATER-GLYCOL TEMP SENSOR
To: GLY EVAP-OUTLET TEMP indicator (MDC-13) & T/M
WATER-GLYCOL TEMP SENSORS
FILTER
PRESS. RELIEF SELECTOR VALVE
PRESS. RELIEF VALVE (2)
POT TANK SERVICING VALVE
TANK VALVE
WASTE TANK SERVICING VALVE
(HEATER)
FOOD PREPARATION WATER UNIT
WATER-GLYCOL RESERVOIR
METERING VALVE (HOT)
METERING VALVE (COLD)
DRINKING WATER SUPPLY SHUTOFF VALVE
WATER-GLY TEMP CONTROL UNIT
WATER-GLY EVAP STEAM PRESS. CONTROL UNIT
EVAP H2O VALVE
WATER-GLYCOL RESVR INLET VALVE
WATER-GLYCOL RESVR OUTLET VALVE
WATER DISPENSER VALVE
WATER DELIVERY UNIT
WATER-GLYCOL RESVR BY-PASS VALVE
WATER-GLYCOL TEMP SENSOR
WATER-GLYCOL EVAP TEMP IN VALVE (MOTOR)
O2 SUPPLY CAPILLARY RESTRICTORS
WATER-GLYCOL PRESS. RELIEF BYPASS SHUTOFF VALVE (2)
WATER-GLYCOL PRESS. RELIEF BYPASS VALVE (2)
WATER-GLYCOL PUMP (2)
CABIN TEMP SELECTOR
CABIN TEMP ANTICIPATOR
CABIN TEMP CONTROL UNIT
CABIN AIR FAN (2)
CABIN HEAT EXCHANGER
CABIN AIR CONTROL LOUVER
CABIN TEMP CONTROL VALVE (A)
ORIFICE RESTRICTOR
WATER-GLYCOL ACCUM SHUTOFF VALVE
ACCUM QTY XDUCER
WATER-GLYCOL ACCUM
To: GLYCOL ACCUM-QTY indicator (MDC-13) & T/M
SUIT EVAP WATER INFLOW CONTROL SELECTOR VALVE
WATER-GLYCOL RESERVE VALVE
WATER-GLYCOL FILTER
THERMAL LOAD (ELECTRONICS COLD PLATES)
ORIFICE RESTRICTOR
IMU



S/M
C/M
NITROGEN SUPPLY TANK
FILL VALVE
RELIEF VALVE
PRESSURE REGULATOR & RELIEF VALVE
OXYGEN SUPPLY-CRYOGENIC OXYGEN STORAGE
CAPILLARY RESTRICTOR (2)
INLINE FILTER (2)
S/M SUPPLY SHUTOFF VALVE
SURGE TANK SHUTOFF VALVE
FLSS FILL VALVE
ENTRY OXYGEN VALVE
ENTRY TANK
FILL VALVE
WATER TANK (2)
SHUTOFF VALVE (2) (SOLENOID)
FILL VALVE
SURGE TANK PRESS. XDUCER
SURGE TANK
SURGE TANK PRESSURE RELIEF SHUTOFF VALVE
SURGE TANK PRESSURE RELIEF VALVE
WATER SUPPLY-EPS FUEL CELLS
POTABLE TANK INLET VALVE
GSE WATER-GLYCOL PUMP
WATER-GLYCOL FILL AND VENT COUPLING (2)
WATER-GLYCOL SHUTOFF VALVE (SOLENOID)
CAPILLARY RESTRICTOR
RADIATOR OUTLET TEMP SENSOR
WATER-GLYCOL TO RADIATOR SHUTOFF VALVE
RAD 1A TEMP SENSOR
6 TUBES
4 TUBES
6 TUBES
4 TUBES
RAD 2A TEMP SENSOR
WATER-GLYCOL RADIATORS (2)
RADIATOR ISOLATION VALVE (MOTOR) (4)
LEGEND
OXYGEN
WATER
WATER-GLYCOL
SUIT CIRCUIT
STEAM
NITROGEN
WASTE MANAGEMENT SYSTEM
CONTROL CIRCUIT
CABIN TEMP SENSOR
CABIN PRESS. XDUCER
FLEX DUCT
PLV FAN
PLV VALVE (MOTOR) (2)
OVERBOARD

SECTION 2

SUBSECTION 2.8

TELECOMMUNICATION SYSTEM

2.8.1 INTRODUCTION.

The telecommunication (T/C) system includes the spacecraft (S/C) communications and data equipment required for voice communications; acquisition, processing, storage and transmission of operational and flight qualification telemetry (TLM), television (TV), and biomedical data; reception of up-data; and transmission of appropriate tracking and ranging signals. At least part of the T/C system will be in operation during all phases of the mission—from prelaunch through recovery. The following list summarizes T/C capabilities as utilized on SC-012.

- S/C intercommunications between crewman
- Hardline voice communications and transmission of TV and TLM data to the Launch Control Center (LCC) via the service module umbilical (USM) during prelaunch
- In-flight voice communications with the manned spaceflight network (MSFN)
- Voice tape recording of comments, observations, opinions, etc., with time correlation
- Acquisition and processing of TLM, TV, and operational biomedical data from the S/C structure and systems, TV camera, and crewman biomedical sensors, respectively
- TLM data storage
- Transmission of real-time or stored TLM data
- Reception of up-data (guidance and navigation, and timing data and real-time commands) from the MSFN
- Transmission of C-band tracking pulses in response to received radar signals
- Limited capabilities for S-band operation, including transmission of voice and TLM data plus TV, stored analog, or pseudo-random noise (PRN), ranging codes, and reception of voice and up-data
- Postlanding recovery aids including voice communications and recovery beacon transmission

- Generation of timing signals for synchronization of the T/C and other S/C systems.

2.8.2 FUNCTIONAL DESCRIPTION.

The functional description of the T/C system is divided into four parts: voice communications, data operations, tracking and ranging, and S-band operations. The unified S-band subsystem (USBS), used for all S-band operations, provides back-up voice, data, tracking and ranging capabilities, and the sole means for transmission of TV or analog data.

2.8.2.1 Voice Communications.

2.8.2.1.1 General.

All S/C voice communications (figure 2.8-1) originate and terminate in the crewmen's personal communication assemblies (headsets). Each crewman has two headsets; one is located in the "bump-hat" for use while wearing the constant-wear garment; the other is located in the spacesuit helmet. Each headset is comprised of two independently operating earphones and two microphones with self-contained preamplifiers. The headsets are used for all voice transmission and reception.

Each crewman's headset is connected to the audio center (A/C) equipment by a separate electrical umbilical assembly, commonly referred to as a "cobra cable." In addition to the audio circuits, each of the three cobra cables contains wiring for the operational biomedical sensors in the constant wear garments and the push-to-talk (PTT) control circuitry. The PTT control circuitry consists of a pushbutton-type PTT key and a PTT/CW selector switch. With the PTT/CW selector switch in the PTT position, the PTT key permits manual control of voice transmission by the appropriate transmitter and mike amplifier circuit in the audio center module.

The PTT mode was designed to be used during the launch phase of the mission when high noise levels would preclude usage of the VOX circuitry. In this mode, the PTT key will enable the microphone amplifier, voice recorder, VHF-AM and S-Band transmitters if the latter three have their attendant control switches configured properly. The audio center power switch and the cobra cable mode switch would be in PTT position during this mode.

The CW mode was also designed to be used during the high-noise levels of the launch phase. In this mode, however, the VHF and S-band downvoice communications links are not enabled. This gives us a PTT controlled intercommunications. The voice recorder could also be enabled in this mode if needed. The audio center power switch would also be in the PTT position, but the mode switch on the cobra cable must be in the CW position. It should be noted that on older cobra cables, the CW position was used only for emergency key. Now, this position will be used for both

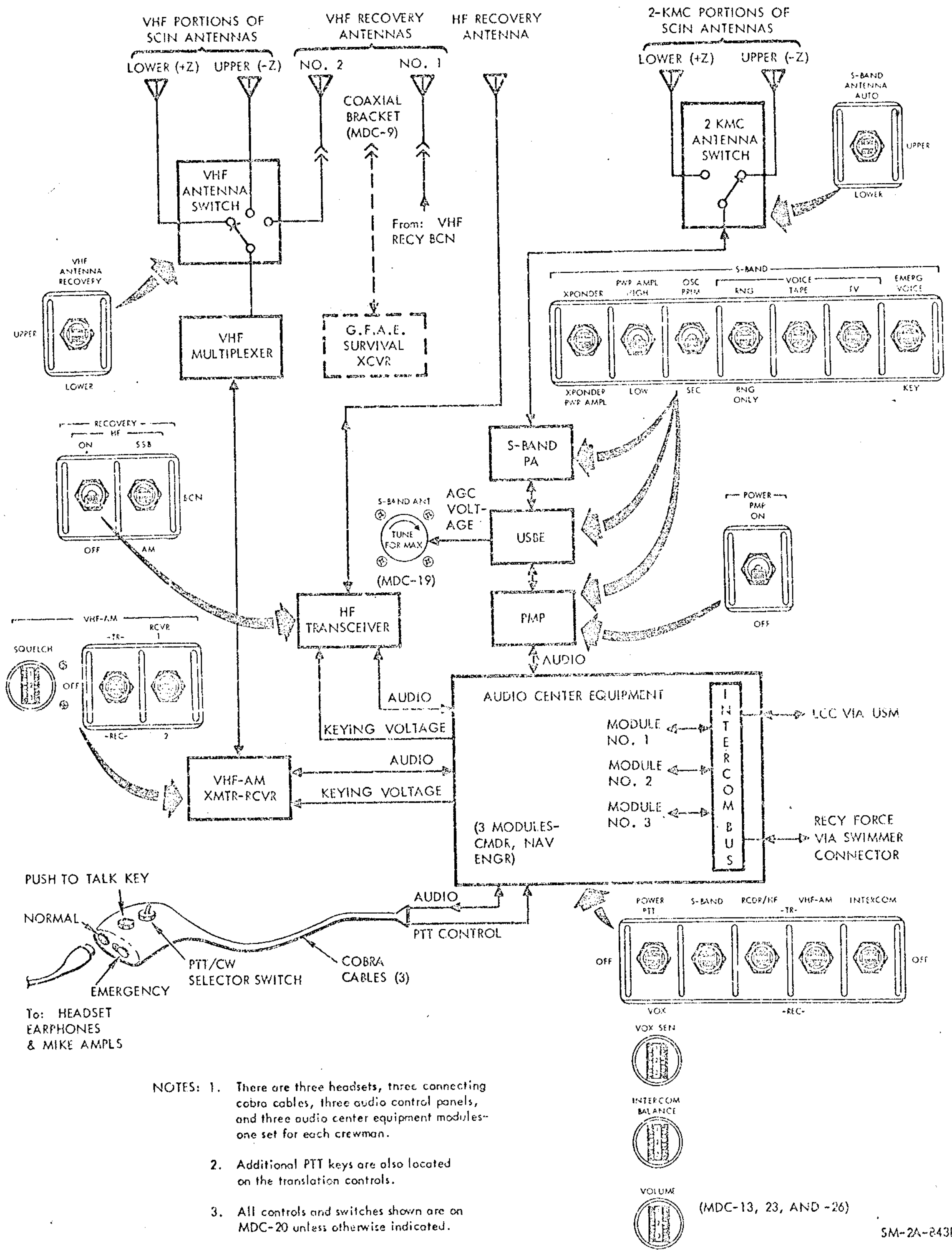


Figure 2.8-1. Voice Communications

emergency key and the PTT intercommunications functions. PTT keys are also located on the translation controls. Their function duplicates that of the PTT key with the PTT/CW selector in the PTT position on the cobra cable.

The head of each cobra cable has two electrical connectors, marked NORM and EMER. Normally, the connector marked NORM will be used; however, in the event of failure in one of the A/C modules, the affected crewman may connect the cable from his spacesuit to the connector marked EMER. This will connect his audio circuits to another A/C module and allow the same module to be shared by two crewmen.

A strap has been added to the cobra cable so the PTT button can be held in the ON position if desired. This would allow a continuous intercom if the Audio center POWER switch, (MDC 13, 23, 26) is in the PTT position.

The A/C equipment contains three separate but identical modules, one for each crewman, and a commonly connected intercom bus. This equipment serves as a control and distribution center for all S/C audio signals. Each of the three modules has a separate but identical set of controls located on MDC-26, -13, and -23 for the command pilot, senior pilot, and pilot, respectively. Thus each crewman is provided with independent control of all audio inputs and outputs to and from his own headset. A POWER switch on each panel controls application of power to its respective A/C module and selects the PTT or voice-operated relay (VOX mode) of operation. The PTT mode permits monitoring of incoming audio signals plus PTT activation of the microphone amplifier, voice recorder, and the enabling of any communications transmitters if their attendant control switches are properly configured.

The VOX mode permits the microphone amplifier to be activated by the voice-operated switching circuitry within the audio center. The audio output of the amplifier is then applied to isolation and switching diodes controlled in part by the audio center controls located on panels MDC-26, -13, and -23.

Voice transmission over, the activated unified S-band equipment is allowed by placing the S-BAND switch to REC (MDC-26, -13, -23), setting the cobra cable PTT/CW switch at PTT and closing the PTT pushbutton on either the cobra cable or the translation controls.

Voice transmission over, the HF transceiver is limited to the post-landing phase of the mission; however, the RCDR/HF switch (MDC-26, -13, -23) in the T/R position provides a ground for the power control relay in the voice recorder. The intercom switch (MDC-26, -13, -23) would also have to be in the T/R position so the audio signal would be available for recording.

Voice transmission over, the activated VHF-AM transmitter is allowed by placing the VHF-AM switch to T/R (MDC-26, -13, -23), setting the cobra cable PTT/CW switch to PTT, and closing the PTT pushbutton on either the cobra cable or the translation controls. Monitoring the VHF-AM is provided by placing the VHF-AM T/R/OFF/REC switch to REC.

Each audio control panel has three thumbwheel-type potentiometer controls: a VOX SENS control for adjusting the sensitivity of the VOX circuit, an INTERCOM BALANCE control for decreasing the level of the audio signals received from the RF equipment relative to that received from the intercom bus, and a VOLUME control for changing the overall level of all audio signals to the earphones. Each channel, in the A/C modules, also contains sidetone circuitry which enables a crewman to monitor his own transmission.

2.8.2.1.2 S/C Intercommunications.

S/C intercommunications and hardline voice communications are conducted via the intercom bus, which is commonly connected to each of the three A/C modules, to the LCC during prelaunch via the USM, and to recovery forces via the swimmer electrical connector during recovery operations. To communicate, a crewman must activate his A/C module by placing the POWER switch to VOX or PTT and setting the INTERCOM switch to T/R.

An A/C intercom transmission can only be initiated with the PTT key, if the PTT position of the power switch is selected. In the VOX position, either the VOX circuit or the PTT key will indicate an intercom transmission. If only an intercom transmission is desired, the PTT/CW switch on the cobra cable should be in the CW position. Normally, the A/C modules will remain activated throughout the entire mission.

2.8.2.1.3 In-Flight Voice Communications.

In-flight voice communications with the MSFN will be conducted over the USBS and the VHF-AM transmitter-receiver equipment. Controls for the S-band and the VHF-AM groups are located on MDC-20, and MDC-26, -13, and -23. The VHF-AM controls on MDC-20 consist of a T/R/OFF/REC switch that controls application of power, a RCVR switch to control which of two receiver modes 1 simplex, 2 duplex, are operational, a SQUELCH control to establish the level of RF signal required to pass audio signals to the audio center, and a VHF ANTENNA switch to manually select the upper (+Z), or lower (-Z), antenna. Voice transmission via VHF-AM is controlled by the placement of the VHF-AM switch (MDC-26, -13, or -23) to T/R, the cobra cable MODE switch to PTT, and depressing the PTT pushbutton on the cobra cable. Either T/R or REC permits voice reception from the MSFN.

Voice communication is possible in all operational modes of the USBS, with the exception of the emergency key mode, providing the S-BAND switch (MDC-26, -13, or -23) is placed at REC. Transmission is controlled by the PTT pushbutton on the cobra cable, providing the cobra cable MODE switch is in the PTT position. (Refer to paragraph 2.8.3.3.4 for additional information on the unified S-band operations.)

2.8.2.1.4 Recovery Voice Communications.

After touchdown, the HF transceiver equipment will be utilized for voice communications. It is controlled by the RECOVERY-HF switches on

MDC-20 which include an ON-OFF switch and a SSB/BCN/AM switch for selecting mode. Either the single sideband (SSB) or amplitude modulation (AM) modes may be used for voice communications. The beacon (BCN) mode is used to transmit a continuous wave beacon for tracking purposes.

Voice transmission in either the SSB or AM mode can be VOX- or PTT-controlled when the RCDR/HF switch (MDC-26, -13, -23) is placed to T/R.

The HF transceiver utilizes the HF recovery antenna. This antenna must be deployed after touchdown by setting the POSTLANDING—ANTENNA DEPLOY switches on MDC-25 to their upper positions, A and B, while the MASTER EVENT SEQ CONT switches 1 and 2 (MDC-24) are at arm and MASTER EVENT SEQ CONT ARM A and B circuit breakers (MDC-22) are closed.

The VHF/AM transmitter-receiver equipment can be used as backup by utilizing VHF recovery antenna No. 2 which can be selected by setting the VHF ANTENNA switch (MDC-20) to RECOVERY. Also, the GFAE survival transceiver can be used inside the S/C by connecting its coaxial cable to VHF recovery antenna No. 1 or No. 2 at the coaxial bracket, MDC-9. These coaxial connectors may be utilized, during the interval preceding the arrival of the recovery forces, in the most advantageous manner. Any combination of VHF recovery beacon, GFAE survival transceiver, and VHF-AM transmitter-receiver may be employed as warranted by the serviceability of the communications equipment.

2.8.2.2 Data Operations.

2.8.2.2.1 General.

T/C system data capabilities include the processing, storage, and transmission of TLM data to the MSFN; the reception and processing of up-telemetry data (up-data) received from the MSFN; and during USBE testing, the transmission of TV from the TV camera. In addition to transmitted data, verbal comments may be recorded on the voice recorder. (See figure 2.8-2.)

2.8.2.2.2 TLM Transmission and Storage.

TLM data may simultaneously be transmitted via VHF-FM and/or S-band and recorded in the DSE for delayed time transmission when requested by MSFN. The system configuration prohibits transmission or recording of real time data while transmitting stored data.

TLM data for transmission to the MSFN consists of analog and digital signals obtained from the guidance and navigation system, central timing equipment, instrumentation sensors and transducers located throughout the S/C structure and operational systems, and biomedical sensors worn by

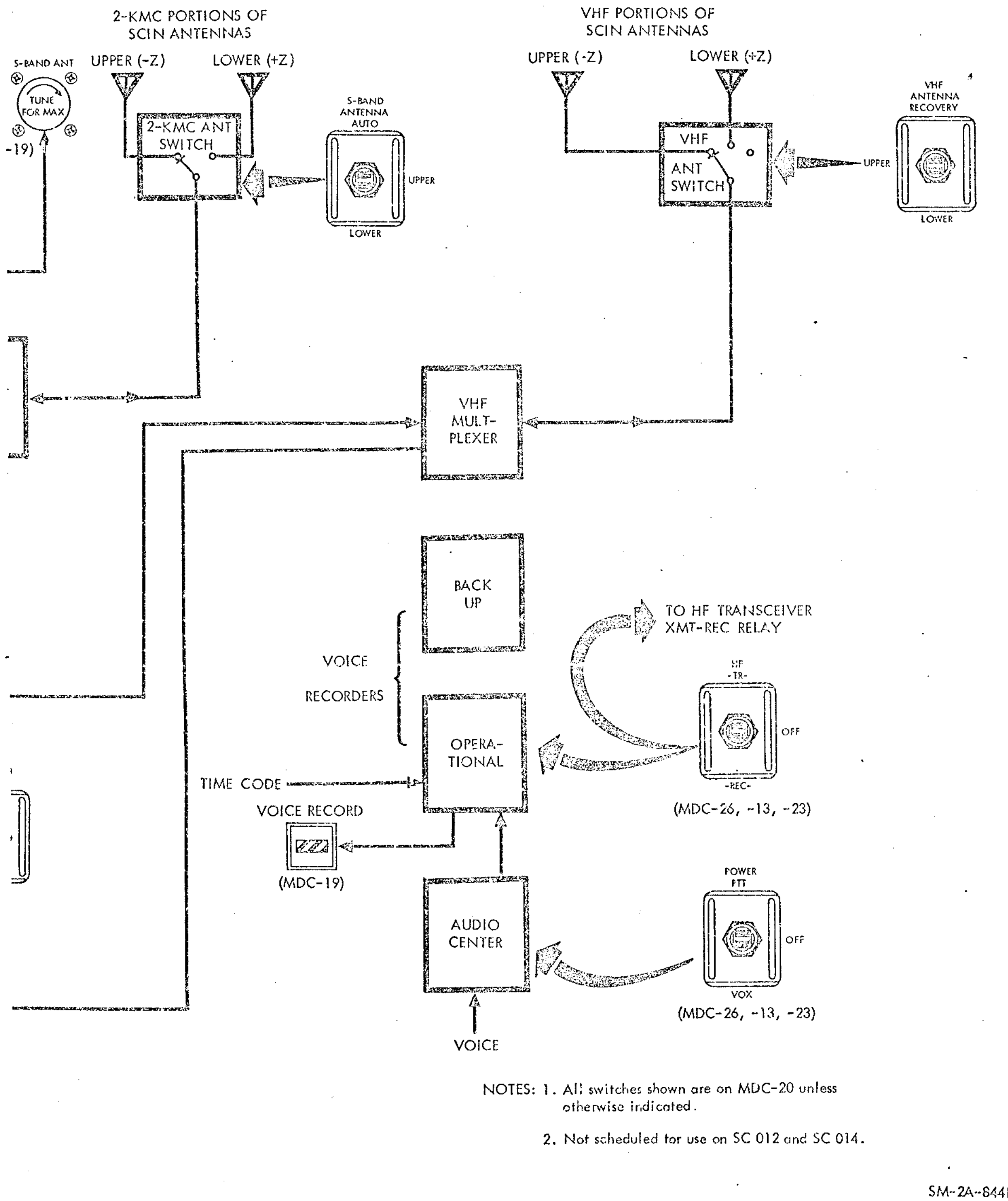
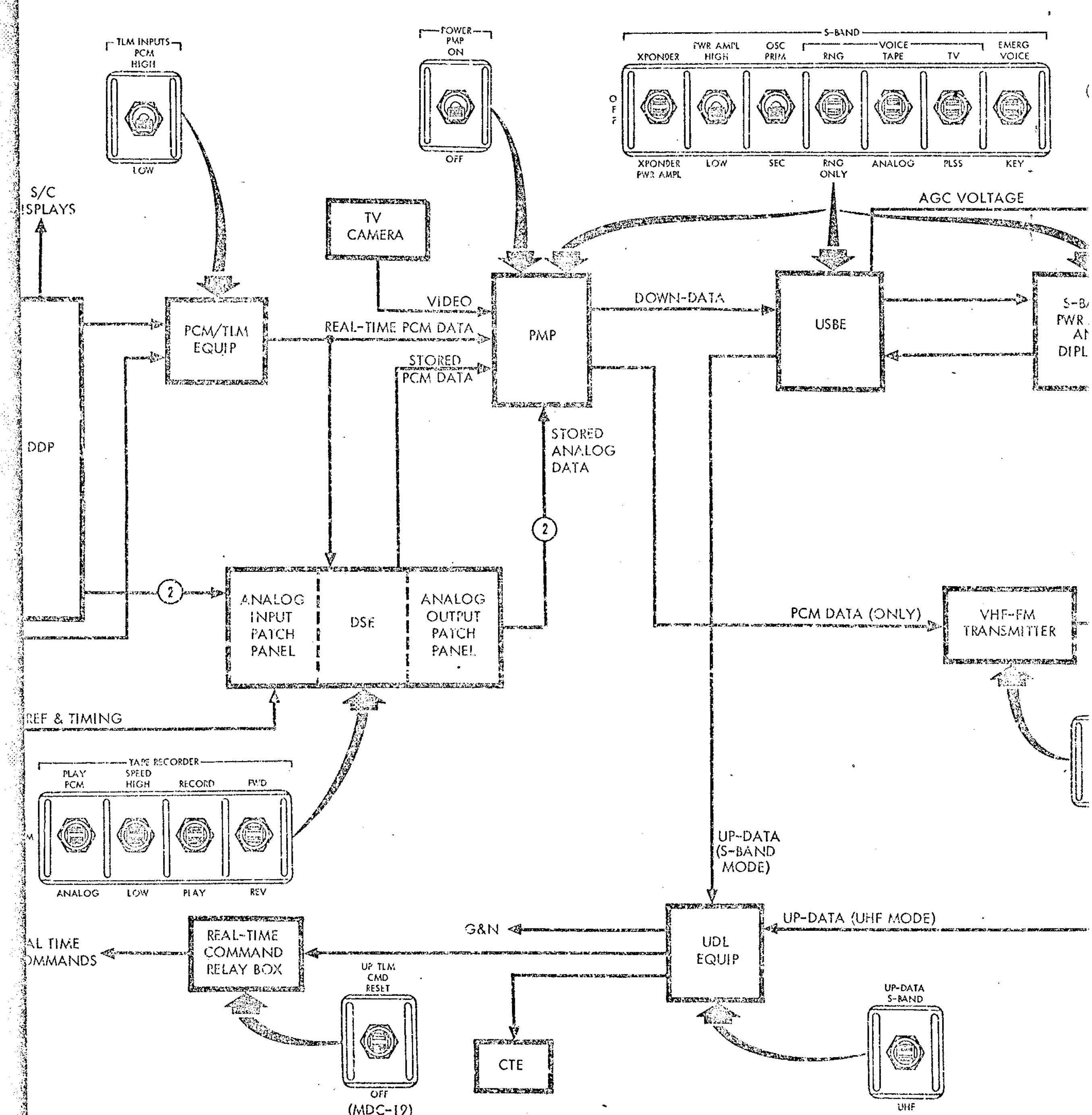
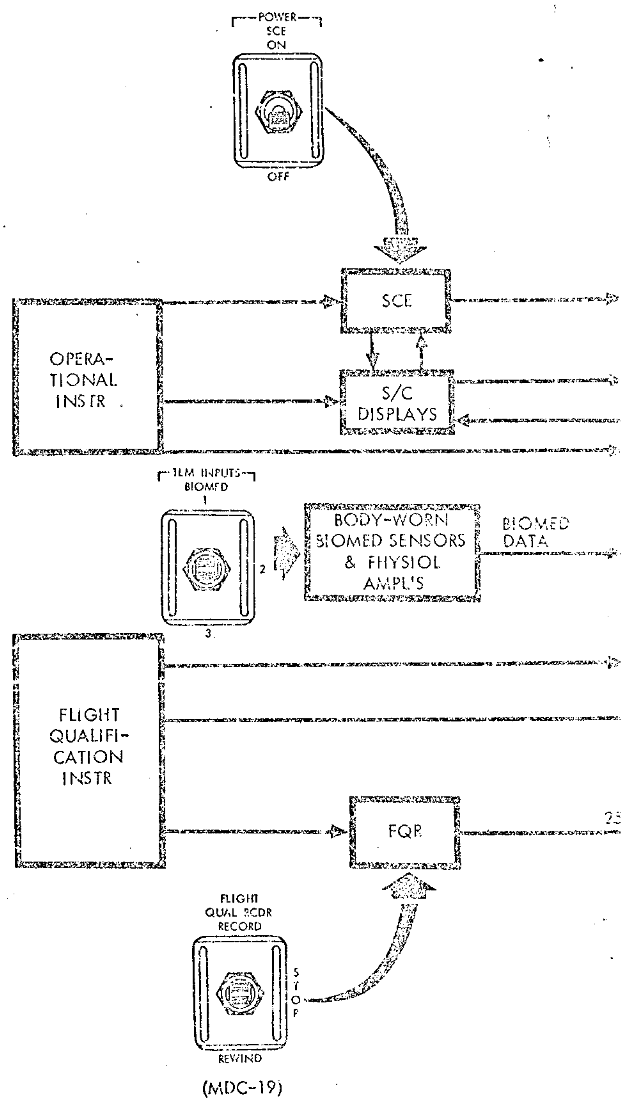


Figure 2.8-2. Data Operations



TLM INPUTS
PCM
HIGH
LOW
POWER
PMP
ON
OFF
S-BAND
XPONDER
PWR AMPL
HIGH
OSC
PRIM
VOICE
RNG
TAPE
TV
EMERG
VOICE
XPONDER
PWR AMPL
LOW
SEC
RNG
ONLY
ANALOG
PLSS
KEY
S/C
ISPLAYS
TV
CAMERA
AGC VOLTAGE
VIDEO
REAL-TIME PCM DATA
STORED
PCM DATA
PCM/TLM
EQUIP
PMP
DOWN-DATA
USBE
DDP
STORED
ANALOG
DATA
2
ANALOG
INPUT
PATCH
PANEL
DSE
ANALOG
OUTPUT
PATCH
PANEL
PCM DATA (ONLY)
VHF-FM
TRANSMITTER
REF & TIMING
TAPE RECORDER
PLAY
PCM
SPEED
HIGH
RECORD
FWD
ANALOG
LOW
PLAY
REV
UP-DATA
(S-BAND
MODE)
UP-DATA (UHF MODE)
G&N
AL TIME
OMMANDS
REAL-TIME
COMMAND
RELAY BOX
UP TLM
CMD
RESET
OFF
(MDC-19)
UDL
EQUIP
CTE
UP-DATA
S-BAND
UHF


POWER
SCE
ON
OFF
SCE
OPERA-
TIONAL
INSTR .
S/C
DISPLAYS
TLM INPUTS
BIOMED
1
2
3
BODY-WORN
BIOMED SENSORS
& PHYSIOL
AMPL'S
BIOMED
DATA
FLIGHT
QUALIFI-
CATION
INSTR
FQR
FLIGHT
QUAL RCDR
RECORD
STOP
REWIND
(MDC-19)

the crewman. Some of the instrumentation signals require conditioning before they can be utilized. This is accomplished by the signal conditioning equipment (SCE) activated by the POWER-SCE switch on MDC-20. The remaining TLM signals are either conditioned at their source by local signal conditioners, which requires no action on the part of crewmen, or do not need conditioning. The operational instrumentation signals are used for S/C displays and real time or delayed TLM transmission via VHF-FM and/or S-band. Those to be telemetered are routed to the pulse-code modulation-telemetry (PCM TLM) equipment. Most of the flight qualification signals are routed to the PCM TLM equipment along with the operational TLM signals. A few, however, are recorded as analog signals in the flight qualification recorder (FQR) for postflight analysis only. The FQR will be activated at brief intervals only during critical phases of the mission by the FLIGHT QUAL RCDR switch on MDC-19.

The PCM TLM equipment combines the signals to be telemetered and converts them to a single, digital, pulse train which is then fed to the premodulation processor equipment (PMP) and the data storage equipment (DSE). The PCM TLM equipment is activated at all times. Its only control is the TLM INPUTS – PCM switch on MDC-20. This switch is used to select the PCM bit-rate. In the HIGH (51.2 KBPS) position, all TLM inputs to the PCM TLM equipment are processed and combined into the output signal. The LOW (1.6 KBPS) position eliminates the less essential parameters and is used only when a PCM pulse train of reduced bandwidth is required. The reduced bandwidth allows PCM data to be recorded at a reduced (3.75 ips) speed when long periods of data recording are required.

The PCM signal is fed to the PMP and DSE simultaneously for real-time (R/T) transmission and/or storage. For R/T transmission, the signal is processed through the PMP to the VHF/FM and/or S-BAND transmitters. The PMP is controlled by the POWER – PMP switch, the S-BAND group of switches, and the TAPE RECORDER – PLAY switch. When R/T transmission is not possible, the PCM data can be stored in the DSE, which is controlled by the TAPE RECORDER group of switches and the TLM INPUTS – PCM switch discussed in the previous paragraph. When played back later, the stored PCM data is also processed through the PMP to the VHF/FM and/or S-BAND transmitters for transmission. The sole function of the VHF/FM transmitter is the transmission of R/T or stored PCM data. Its only control is the VHF-FM – ON/OFF switch on MDC-20. It utilizes the same antennas as the VHF/AM transmitter-receiver, namely, the upper or lower SCIN antenna as selected by the VHF antenna switch.

Backup capability for the transmission of PCM TLM data is provided by the USBS. (Refer to a subsequent discussion of unified S-band operations.)

2.8.2.2.3 Up-Data Reception.

Up-data which can be transmitted to the S/C by the MSFN consists of three types: G&N data for up-dating the Apollo guidance computer, timing data for up-dating the central timing equipment (CTE), and realtime commands (RTCs) for providing the MSFN with limited control of certain on-board functions.

During normal operations, up-data is received by the UHF/FM receiver contained in the up-data link (UDL) equipment. Once received, the signal is processed and decoded, and the information is routed to the G&N system, the CTE, or UDL-RTC relay box. For backup, up-data can also be transmitted by MSFN stations to the S/C via the S-band carrier. When this occurs, the up-data is received by the USBE receiver which extracts the up-data subcarrier and routes it to the PMP where the intelligence is removed from the signal and sent to UDL equipment for processing, decoding, and distribution. In this S-band mode, the UHF/FM receiver is bypassed. Selection of the UHF or S-BAND mode is made with the UP-DATA switch on MDC-20. The UP TLM CMD – RESET/OFF switch (MDC-19) enables the crew to nullify previous RTCs and return control to the S/C. An UP TLM – ACCEPT/BLOCK switch (MDC-14) is also provided so that G&N up-data can be prevented from effecting the computer and the attendant validity signal being sent to the PCM format.

2.8.2.3 Tracking and Ranging.

2.8.2.3.1 In-Flight Tracking and Ranging.

The function of the in-flight tracking and ranging equipment (figure 2.8-3) is to assist the MSFN in determining S/C position and velocity. The primary method employed is C-band tracking. The C-band transponder on-board the S/C is used for this purpose. It operates in conjunction with conventional, earth-based, radar equipment by transmitting response pulses to the MSFN when radar pulses from the earth are received. It operates in a "1-pulse" or a "2-pulse" mode, depending on the type of radar equipment being used at the nearest MSFN station. A single control, the C-BAND switch on MDC-20, is used to activate the C-band transponder in either mode.

Backup tracking and ranging capabilities are provided by the USBS.

2.8.2.3.2 Recovery Tracking.

Line-of-sight and beyond-line-of-sight beacon transmission capabilities are provided to assist recovery personnel in locating the S/C during parachute descent and after touchdown. Line-of-sight beacon transmission is accomplished using the VHF recovery beacon equipment. The beyond-line-of-sight capability is furnished by operating the HF transceiver in a beacon mode.

During parachute descent the VHF recovery beacon is activated by setting the RECOVERY – VHF-BCN switch (MDC-20) to ON. This causes a 2-second, modulated VHF pulse to be transmitted every 5 seconds from VHF recovery antenna No. 1, which is deployed automatically with VHF recovery antenna No. 2 when the main parachutes are deployed.