Section - III
SYSTEMS DESCRIPTION

Sub-section 10
ENVIRONMENTAL

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GENERAL

Bleed air is tapped from both engines and conditioned to acceptable temperature levels by an air conditioning pack incorporating a three-wheel air cycle machine. Conditioned air is ducted to the flight compartment and passenger cabin to provide ventilation, heating and pressurization. Temperature levels, set manually, are automatically controlled.

Pneumatic controls automatically maintain required pressurization (cabin altitude) while manual controls provide emergency selections of air conditioning and pressurization. On the ground, conditioned air is supplied by the APU (if installed) and the air cycle machine when the main engines are not running.

BLEED AIR SYSTEM

ENGINE AIR BLEED

Bleed air from each engine enters the rear equipment bay via two ducts in each pylon. Low Pressure (LP) air is ducted from a flow limiting venturi to a mixing valve. When both Main Air Valves (MAV) are selected open, High Pressure (HP) air is ducted from a flow limiting venturi to a solenoid-operated shut-off valve then to the mixing valve.

MIXING VALVE

The mixing valve regulates HP air (when it is demanded by LP air low pressure) and mixes the HP and LP air supplies to maintain at the outlet of the valve a minimum pressure of 20 psi and limits the temperature to approximately 270° C.

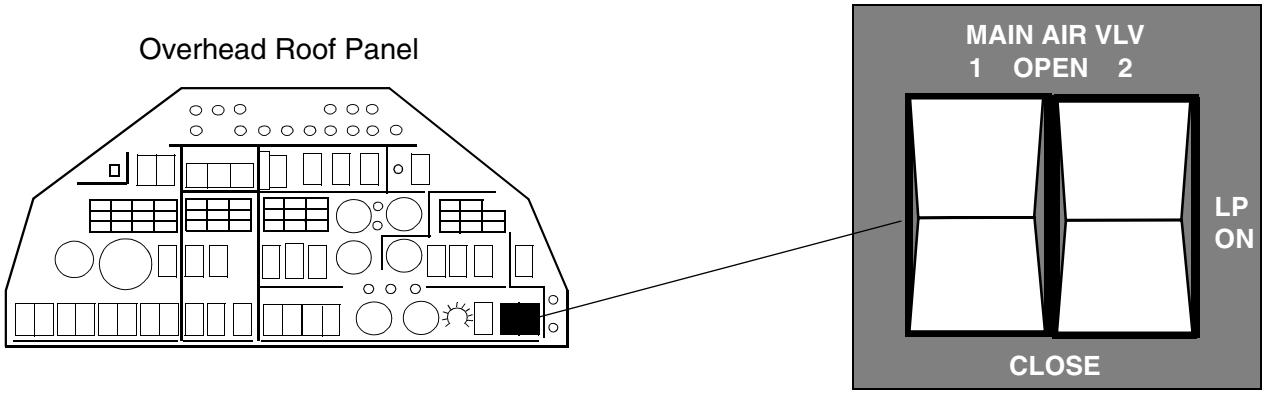
The amount of HP air used is dependent on the LP air pressure available. When the LP air pressure falls to 30 psi, the HP valve is opened but the mixing valve does not mix any HP air into the system until the LP air pressure falls to 22 psi and below.

MAIN AIR VALVE

Air from each mixing valve is fed through an electrically actuated main air valve (MAV) and a non return valve (NRV) into a common supply duct. The MAV and HP valve selections are made by means of two switches, MAIN AIR VLV 1 and MAIN AIR VLV 2, on the overhead roof panel.

The switch selections of CLOSE, LP and OPEN affect the system as follows:

- CLOSE - MAV and HP valve are both selected closed.
- LP ON - MAV selected open and HP valve selected closed.
- OPEN - MAV selected open.
  HP valve ‘armed’ but the valve position is controlled by the LP duct pressure switch.



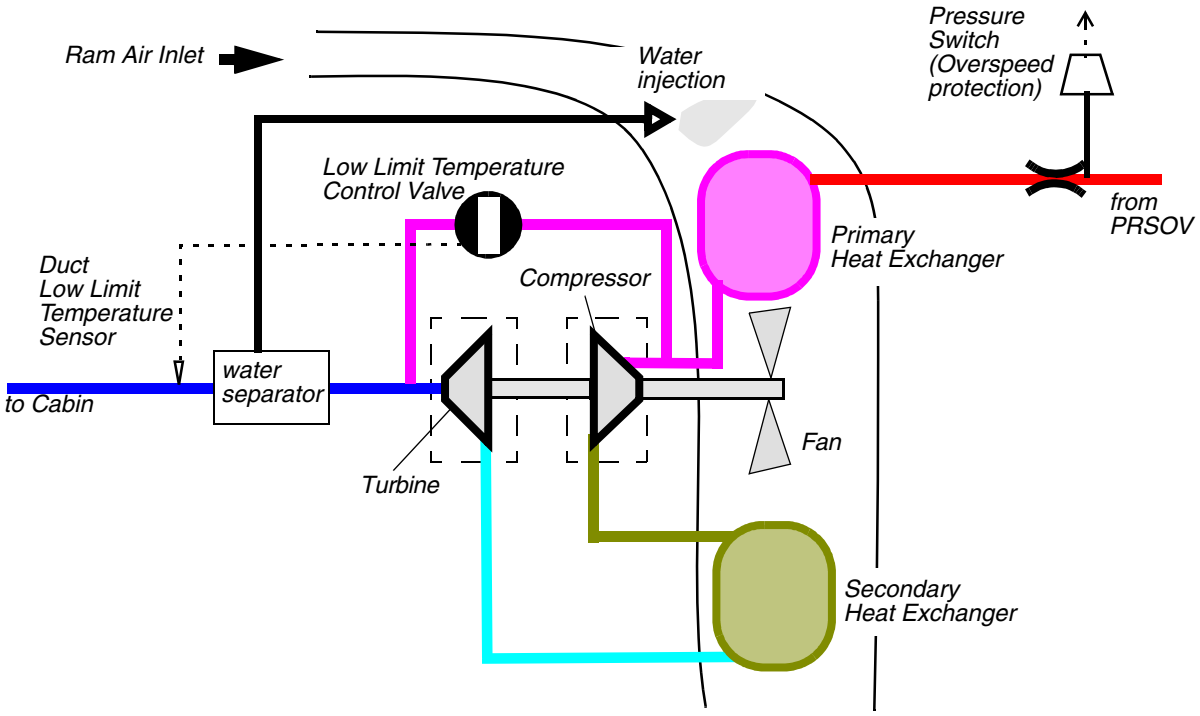
Time delay units are incorporated in the *open* circuit of the MAVs to prevent an initial surge of air to the cabin. The No. 1 MAV has a staggered open/delay logic control, and takes approximately 20 seconds to reach the fully open position. The No. 2 MAV is fast acting but is delayed by 30 seconds before running fully open in approximately one second.

PRESSURE REGULATOR and SHUT-OFF VALVE

From each main air valve the air is ducted via a non-return valve, and then via a common duct to a pressure regulator and shut-off valve unit, (PRSOV) and a pressure reducing and flow restricting venturi to an air cycle machine.

AIR CYCLE MACHINE

The air cycle machine (ACM) consists of a three-wheel cold air unit (CAU), and primary and secondary heat exchangers which are cooled by ram air. Excess water is removed by a water separator at the exit from the ACM. To enhance the cooling performance this water is ejected back into the ram air flow above the primary heat exchanger.



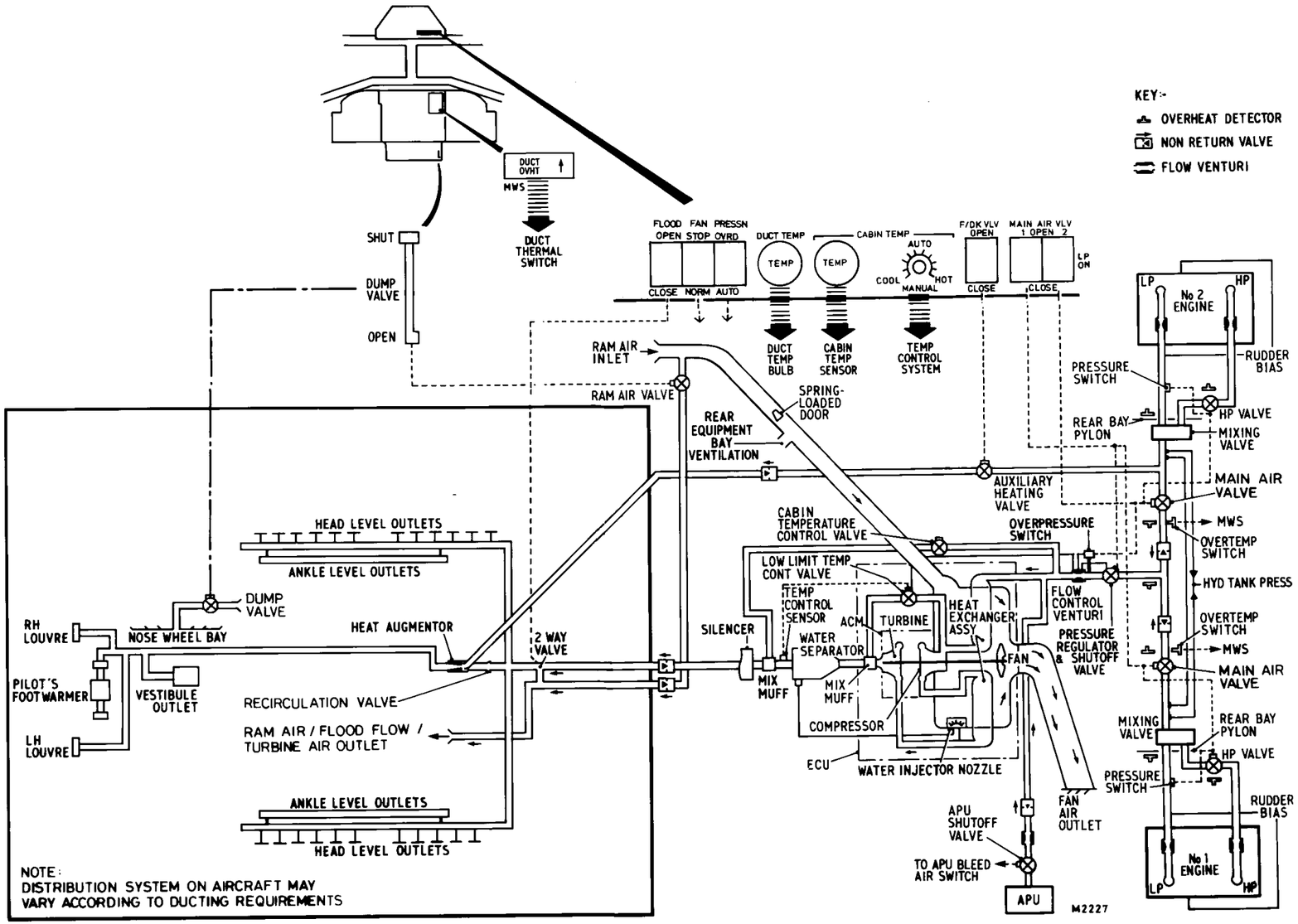


Figure 1
Air Supply and Distrubution

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OVERSPEED PROTECTION

A pressure switch downstream of the PRSOV, protects the ACM from overspeed should the PRSOV fail. The pressure switch operates on a rising pressure of 40 psi to signal the No. 2 MAV to close.

The No. 1 MAV remains open and the maximum flow to the CAU is restricted by the venturi in the No. 1 LP bleed duct.

Closure of the No. 2 MAV will be indicated by the MWS panel annunciator, MAIN AIR VLV 2 illumination.

NOTE: The illuminated MAIN AIR VLV 2 annunciator indicates that the position of the main air valve No. 2 does not agree with the selection made on the MAIN AIR VLV 2 switch.

The closure of No. 2 MAV results in a decrease in system pressure. To avoid cycling of the valve, a latch circuit maintains the closed signal. The system can be reset by selecting the MAIN AIR VLV 2 switch to CLOSE, this action causes the MAIN AIR VLV 2 annunciator to extinguish. If the system pressure has fallen, No. 2 MAV will subsequently open when the switch is selected OPEN.

COLD AIR UNIT (CAU)

The CAU consists of a fan, a compressor and a turbine mounted on a common shaft. Bleed Air from the venturi enters the ACM via the primary heat exchanger, which cools the air to an acceptable level for the CAU.

The primary exchanger is cooled by ram air from an intake at the base of the fin. The cooled air from the primary heat exchanger enters the CAU compressor, which raises its pressure and temperature before it is cooled by the secondary heat exchanger. The secondary heat exchanger uses ram air as the cooling medium.

From the secondary heat exchanger, the air is expanded and cooled through the turbine. The energy extracted in this process is used to drive the compressor and the fan. The fan is used to draw cooling air through the ram air system.

At the exit from the turbine, the air temperature is below dewpoint and water is condensed out in the form of fog. To prevent the formation of ice, the temperature of the air before entry into the water separator is controlled by the low limit temperature control system. The water separator extracts approximately 2/3 of the water from the airflow.

The drained water is injected back into the heat exchanger cooling air to enhance the cooling capacity. The temperature of the air down stream of the water separator is controlled by the cabin temperature control valve.

LOW LIMIT TEMPERATURE CONTROL SYSTEM

The air temperature at the inlet to the water separator is limited by a control circuit to a minimum temperature of about 2°C to prevent freezing and subsequent blockage of the water separator. Warm air is routed from the primary heat exchanger outlet via the Low Limit Temperature Control Valve (LLTCV) to the inlet of the water separator.

NOTE: In extremely cold conditions the temperature at the inlet may drop as low as -8°C *when cabin temp is set to max cool (auto or manual).*

In the unlikely event that freezing would occur at the water separator due to high humidity at these cold temperatures, the bypass valve in the water separator would open and allow continued flow.

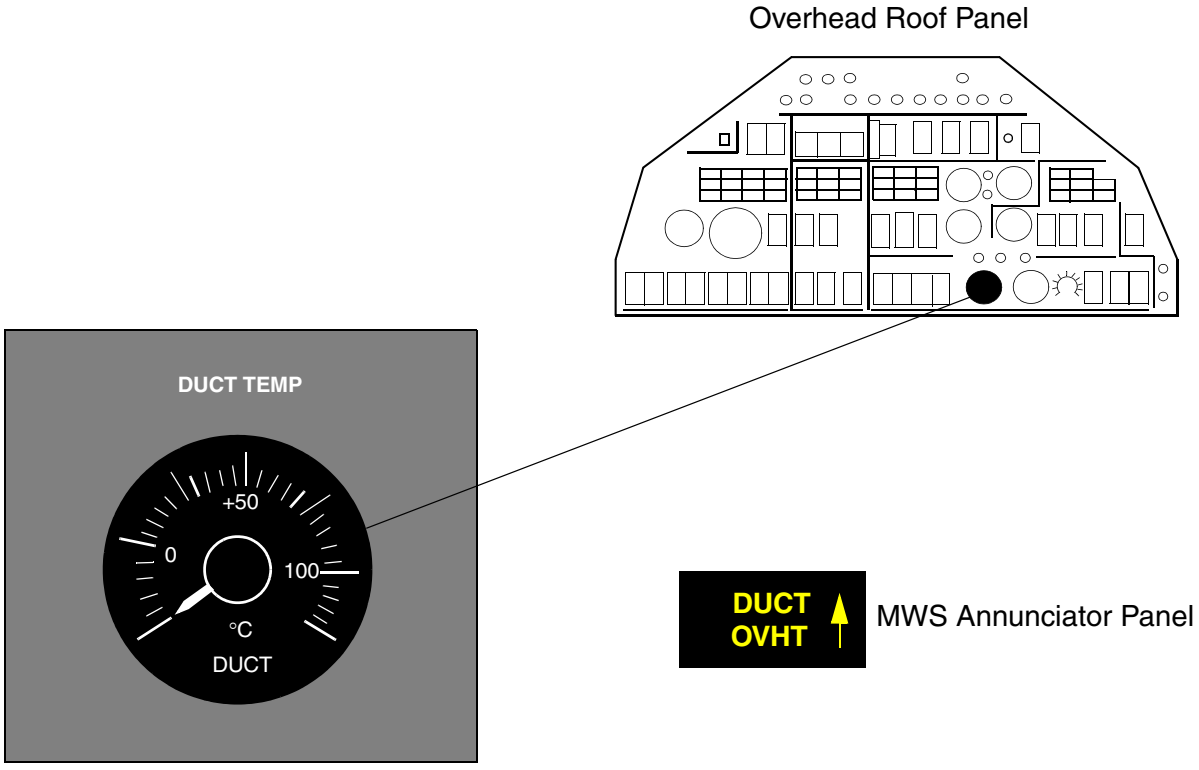
The operation of the LLTCV is controlled by a low limit control sensor in the duct downstream of the water separator. The low limit temperature control system operates independently of any other system and can override cold selections made by the flight crew.

DUCT TEMPERATURE

A DUCT TEMP indicator is connected to a temperature sensor located in the duct downstream of the silencer. This temperature may be considered as the cabin air inlet temperature.

Should the temperature be exceeded, a duct over temperature sensor, set at 115°C, will cause a DUCT OVHT amber repeater annunciator to illuminate on the MWS panel, which draws attention to the DUCT TEMP indicator located on the overhead roof panel.

The over temperature signal will also cause the cabin temperature control valve to be motored fully closed. When the temperature in the duct falls, normal automatic control is restored and the DUCT OVHT repeater annunciator extinguishes.



CABIN TEMPERATURE CONTROL SYSTEM

Temperature of the air delivered to the cabin may be varied by the flight crew via selections on the CABIN TEMP AUTO-MANUAL/COOL-HOT temperature selector. AUTO or MANUAL are the two modes of operation for the cabin temperature system.

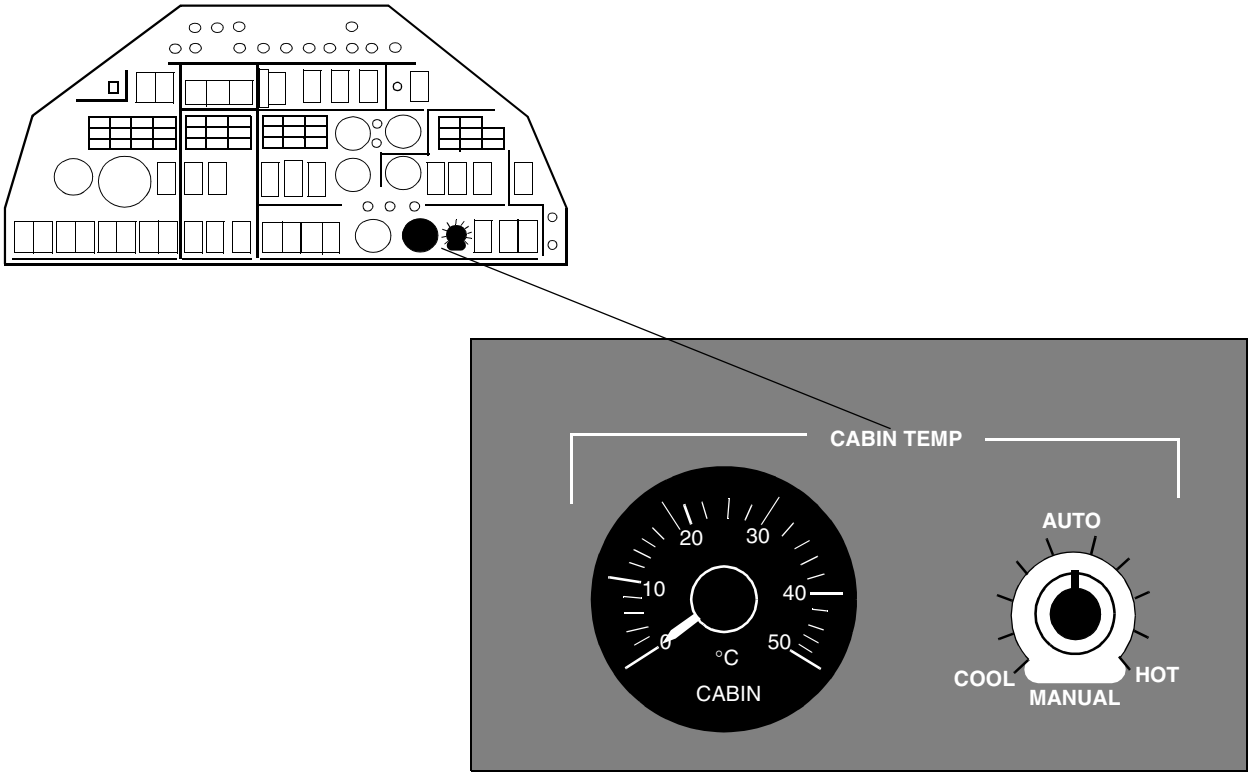
AUTO MODE

In the AUTO mode, the required temperature in the cabin is selected by positioning the selector between COOL and HOT. Temperature is not indicated on the temperature selector, however a full COOL selection corresponds to 18.32° C (65° F), and a full HOT selection corresponds to 31.1° C (88° F).

A temperature controller using signals from the selector switch, a duct temperature sensor, and a cabin temperature sensor unit, determines whether an increase or decrease of temperature is required.

Resulting signals from the controller cause the cabin temperature control valve to open or close accordingly. A CABIN TEMP indicator, on the overhead roof panel, is connected to a temperature bulb at the right forward cabin bulkhead position. An electrically operated fan draws air through a grill in the cabin and across the temperature bulb and the cabin temperature sensor. The duct over temperature limiting sensor and the low limit control system both remain operative in the MANUAL mode.

Overhead Roof Panel



MANUAL MODE

The MANUAL mode is selected by moving the CABIN TEMP selector through a detent to the MANUAL spring-loaded center-off position. Holding the selector to either COOL or HOT (as required) directly controls the position of the cabin temperature control valve. Releasing the CABIN TEMP selector to the center-off position, stops the cabin temperature control valve in the attained position. The duct over temperature limiting sensor and the low limit control system both remain operative in the MANUAL mode.

CAUTION: THE FAN FOR THE TEMPERATURE INDICATOR BULB AND THE CABIN TEMPERATURE SENSOR IS INOPERATIVE WHEN *MANUAL* IS SELECTED.

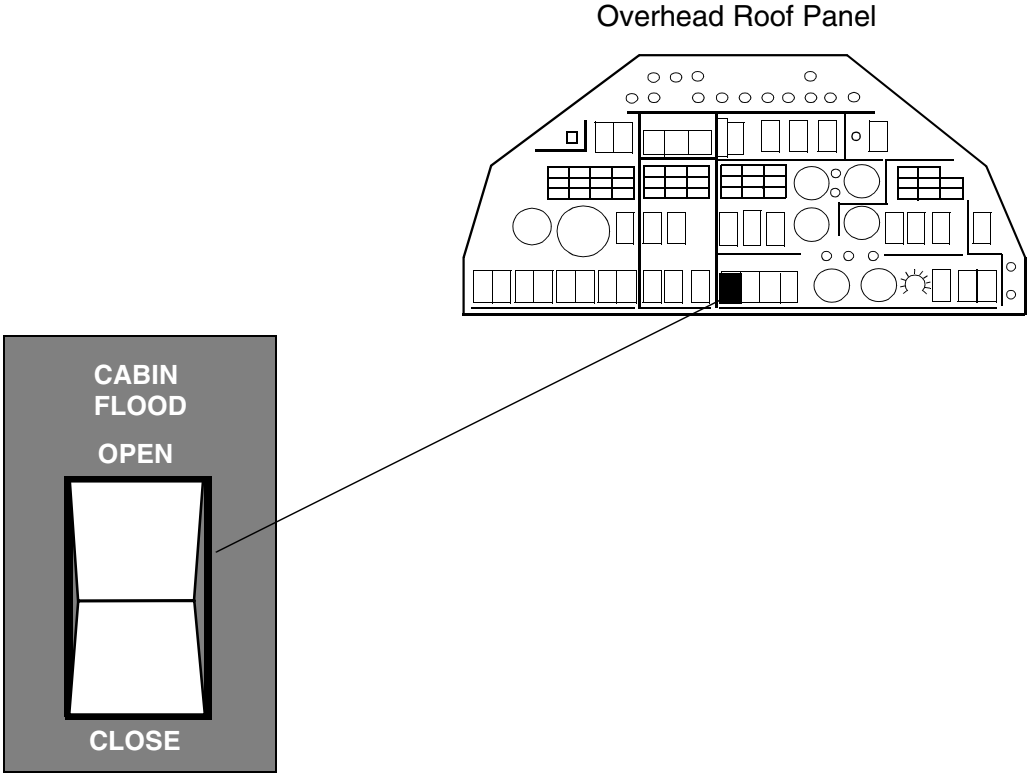
THE DUCT TEMPERATURE SHOULD BE MONITORED TO CHECK THE CABIN AIR INLET TEMPERATURE IS NOT ALLOWED TO EXCEED FLIGHT CREW AND PASSENGER COMFORT LEVELS, NOR SHOULD *HOT* SELECTIONS ACTIVATE DUCT OVERTEMP LIMITS.

NOTE: In extremely cold conditions the temperature at the inlet may drop as low as -8 C when cabin temp is set to max cool (auto or manual).

In the unlikely event that freezing would occur at the water separator due to high humidity at these cold temperatures, the bypass valve in the water separator would open and allow continued flow.

FLOOD AIR CONTROL

Temperature controlled air enters the pressure cabin through a silencer, a non return valve and an electrically operated two-way flood open/close valve, which is controlled by a CABIN FLOOD switch on the overhead roof panel.

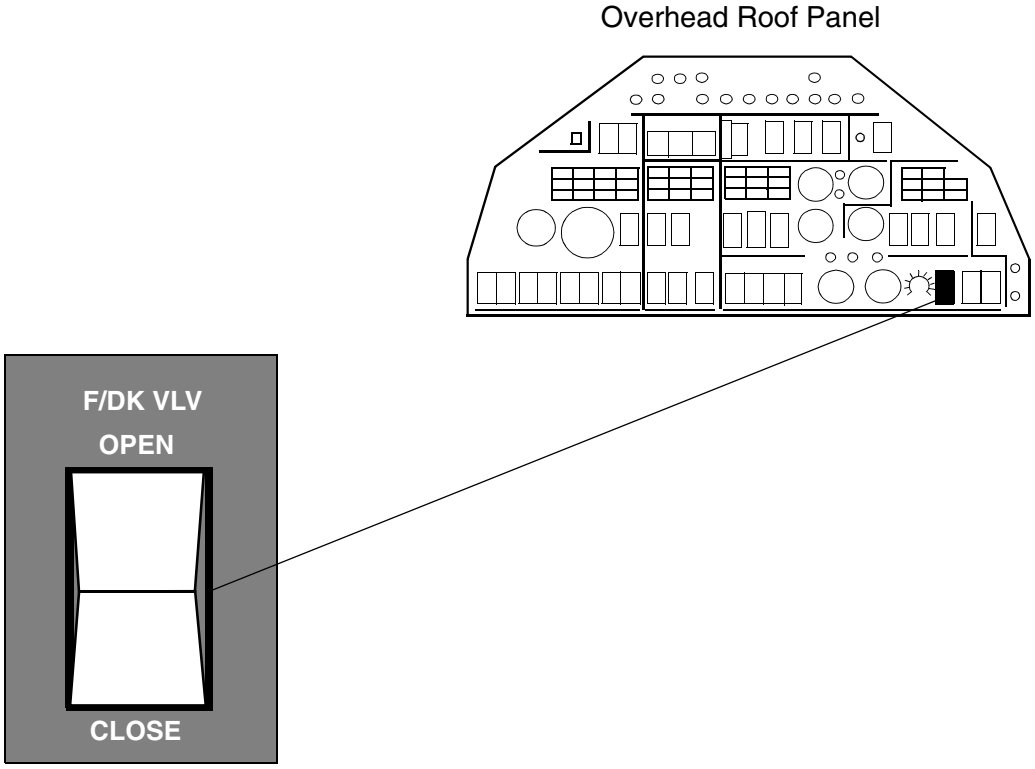


With FLOOD OPEN selected, all the conditioned air is supplied to a cabin flood flow outlet, at roof level at the right rear of the passenger cabin.

With FLOOD CLOSE selected, the air supply to the cabin flood flow outlet is cut-off and temperature controlled air is supplied to the cabin high level outlets and the flight compartment duct.

AUXILIARY HEATING SYSTEM

The auxiliary heating system supplies the flight compartment with a variable supply of hot air via a heat augmentor in the main supply system. Control of the auxiliary system valve is by the F/DK VLV switch on the overhead roof panel.



The supply is tapped from upstream of the main air valve of No. 2 engine via a non return valve. If, while the flight compartment auxiliary heating valve is open, an overheat of 115° C is detected in the outlet duct, then the flight compartment auxiliary heating valve is closed, and remains closed until selected manually open.

RAM AIR

Ram air from the dorsal air intake is used primarily as a cooling medium for the heat exchanger but it can also be introduced into an unpressurized cabin for ventilation purposes. The cabin supply is ducted from the ram air intake and fed into the cabin through an electrically operated ram air valve and a non return valve, and into the flood flow duct.

The ram air valve is controlled by a micro-switch which operates when the DUMP VALVE lever is selected fully OPEN.

The ram air passes through the CAU heat exchanger assisted by a fan driven by the CAU turbine, and is ducted to atmosphere through a grille in the airplane skin. If the intake becomes obstructed, a spring loaded door in the intake duct opens inwards to permit air from the rear equipment bay to enter the intake and supply the CAU heat exchanger.

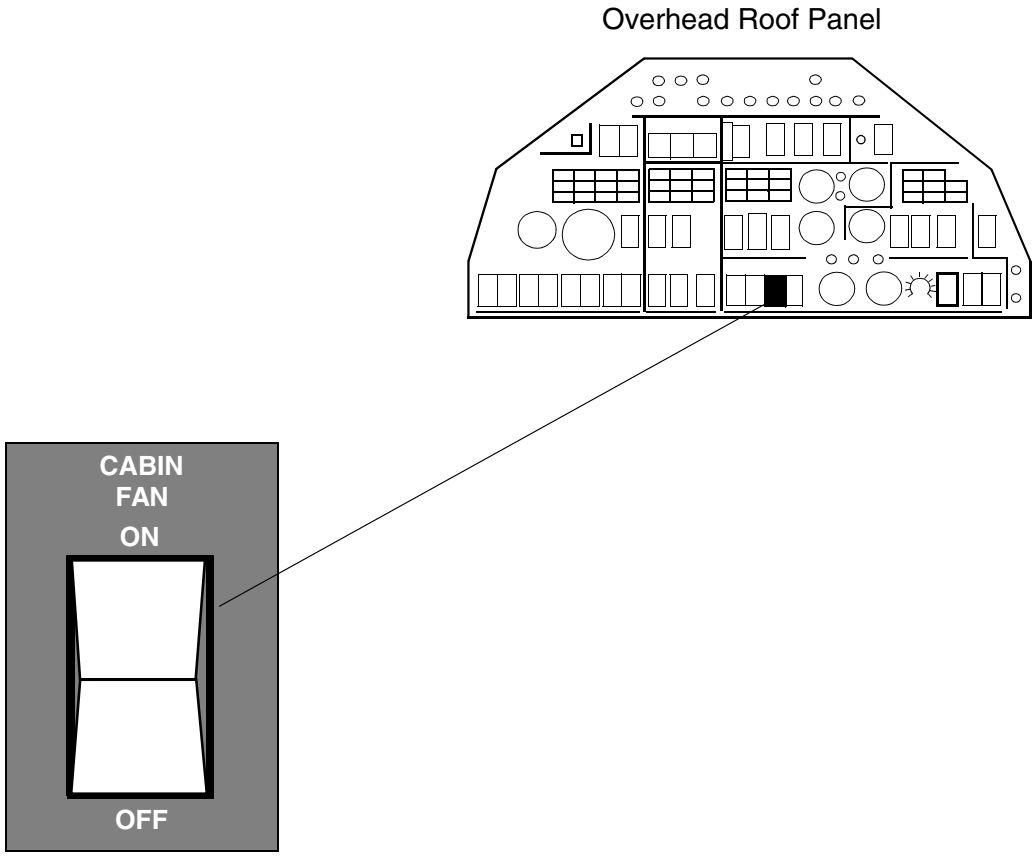
REAR EQUIPMENT BAY VENTILATION

A tapping is taken from the dorsal fin air intake to provide an air supply for rear equipment bay ventilation. There are no controls or indications for this supply.

CABIN RECIRCULATED AIR SUPPLY

An electrically operated fan draws air from the rear of the cabin and recirculates it via individual controllable outlets on each passenger service unit (one outlet per passenger seat position).

The recirculated air is also supplied to two further outlets in the flight compartment. The fan is controlled from a CABIN FAN switch in the ENVIRONMENTAL section of the flight compartment overhead roof panel.

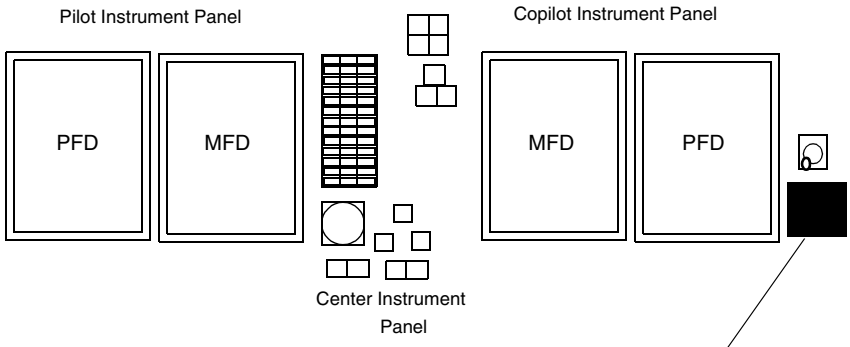


PRESSURIZATION CONTROL SYSTEM

INDICATOR

A triple pointer CABIN pressure indicator is located on the copilot's instrument panel at the lower right of the PFD. The three pointers are:

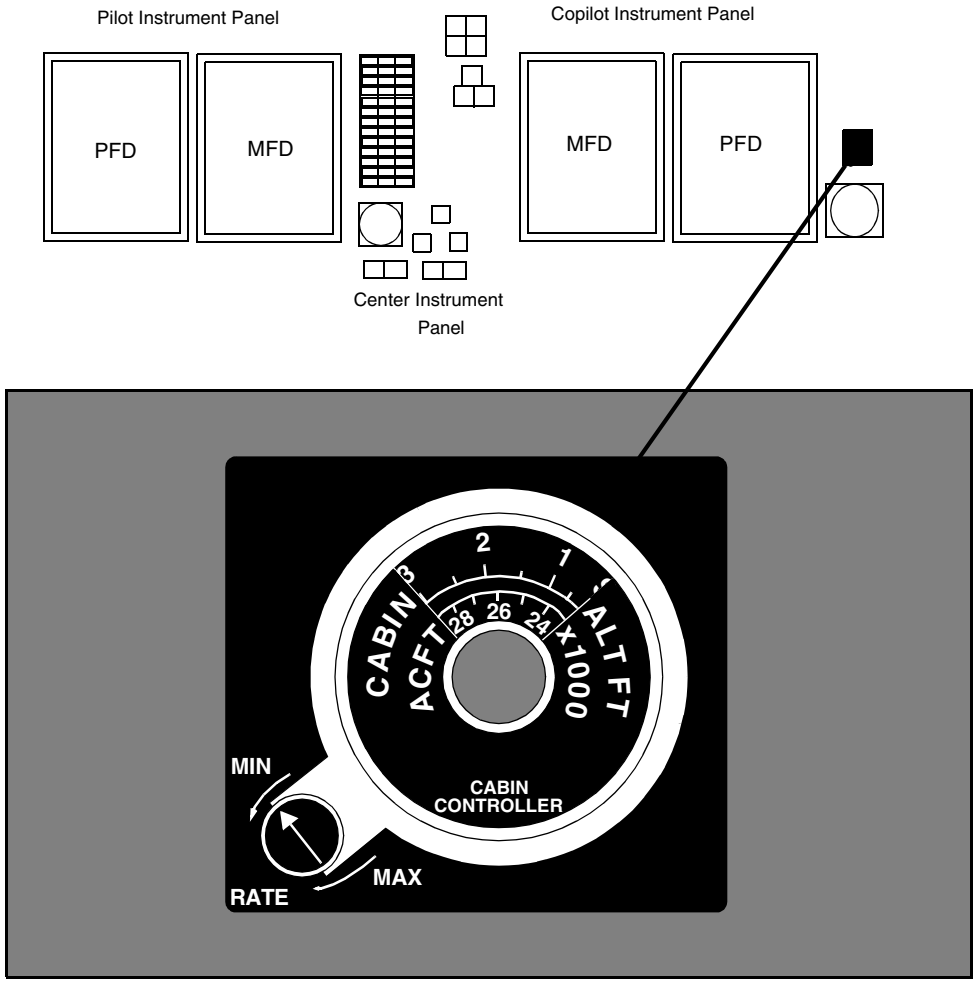
- An "A" pointer which displays cabin altitude.
- A plain white pointer which indicates cabin altitude rate of change.
- A pointer with red and white diagonal hash marks which displays cabin differential pressure.



AUTOMATIC CONTROL

Cabin pressure is controlled by two outflow/safety valves on the rear pressure bulkhead. During normal operation both valves are automatically controlled, but in the event of system malfunction, manual control of one outflow/safety valve is available.

Each outflow valve is operated by the differential between the cabin pressure and a reference pressure, sensed from a CABIN CONTROLLER via a pneumatic relay.



The CABIN CONTROLLER is located on the copilot's instrument panel, right of the PFD. The controller has two rotary selector knobs, one at the center and one offset at the bottom left.

The center knob controls the rotation of a dial with an outer and an inner scale. Both scales show ALTitude graduated in FT x 1000. The outer displays the selected CABIN altitude. With a CABIN altitude set, the inner scale shows the associated airplane altitude at a nominal cabin differential pressure of 8.55 psi. This will provide a 7500 feet cabin altitude at an airplane altitude of 41,000 feet.

The offset knob labelled RATE and marked with an arrow, is used to adjust cabin altitude rate of change. The range is from approximately 2000 ft/min, with the knob set at MAX, to 50 ft/min with the knob set at MIN. Setting the arrow vertically provides a rate of change of approximately 500 ft/min.

During automatic operation, cabin air passes through a filter into the pressure controller. The controller is connected to ambient via two pneumatic relays and a venturi.

Pneumatic Relay

Each pneumatic relay senses cabin pressure changes as referenced by the pressure controller. These pressure changes cause the associated outflow valve to operate via an absolute pressure regulator.

The pneumatic relays are connected to a single air jet pump. This pump, operated by engine bleed air, ensures that the desired differential between the outflow valve reference pressure and cabin pressure is maintained.

Absolute Pressure Regulators

The absolute pressure regulators are safety devices, set to maintain cabin altitude at 13,500 ±1500 feet in the event of system malfunction. In this condition, the regulators operate to prevent further reduction of the reference pressures. This causes the outflow valves to shut in an attempt to restore cabin pressure.

MANUAL CONTROL

Manual control of pressurization is achieved by operation of a shut-off valve and a needle valve. The shut-off valve, labelled PRESSURIZATION CONTROL has two positions, NORMAL and GROUND TEST. This valve is connected into the ambient bleed to the pressure controller. With NORMAL selected, the bleed is open and automatic pressurization control is available.

Selecting GROUND TEST closes the controller ambient bleed; this causes the outflow valves to shut. Subsequently, cabin pressure can be controlled by the needle valve labelled MANUAL CABIN ALTITUDE CONTROL. This valve connects one of the outflow valves to ambient via a venturi in the forward luggage bay.

Rotating the MANUAL CABIN ALTITUDE CONTROL valve between INCREASE and DECREASE, adjusts the pressure differential required to operate the outflow valve and allows a desired cabin altitude and rate of change to be attained.

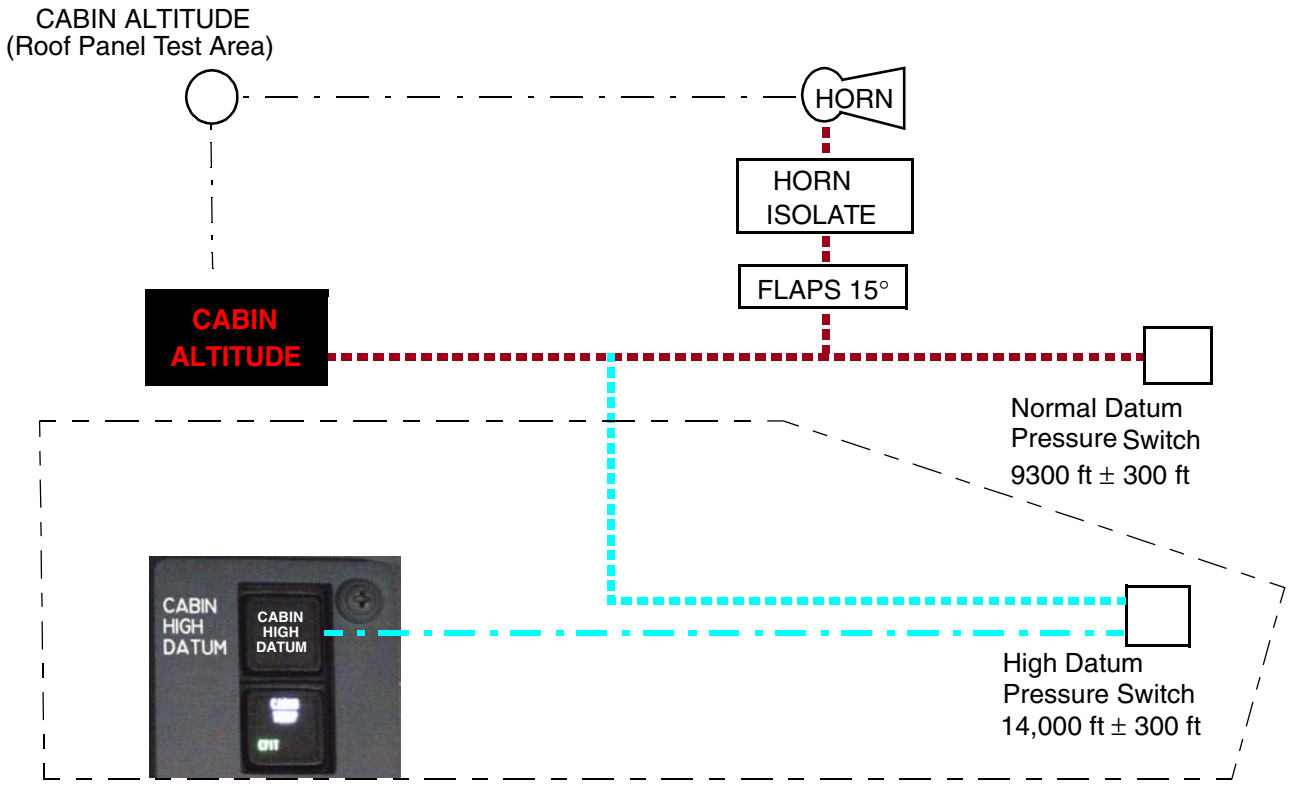
GROUND AIR CONDITIONING

With main engine(s) running and MAIN AIR VALVE(S) OPEN or with APU (if installed) running and APU AIR OPEN, air conditioning is available on the ground by means of a fan-operated venturi. The fan is electrically-operated and controlled by a PRESSN OVRD - AUTO switch via the landing gear lever lock circuit.

With the airplane on the ground and AUTO set, the fan operates so the venturi reduces the reference pressures and causes the outflow valves to open. Air circulates through the cabin with normal temperature control available. On takeoff, the venturi fan switches off automatically; pressurization control then operates from the normal pressure differentials. The OVRD position is used to switch off the venturi fan in the event of auto mode failure, or to achieve cabin pressurization on the ground for maintenance purposes.

Each outflow valve incorporates an inward relief facility. At a negative pressure differential of 0.5 psi the outflow valves open to allow reverse flow, at ambient, to enter the cabin. In this condition, the cabin altitude changes at airplane altitude rate of change irrespective of control settings. Also incorporated in each outflow valve is a pressure relief valve.

The relief valve cracks open when cabin differential pressure exceeds 8.6 psi, to exhaust outflow valve reference pressure. This causes the outflow valve to open and restrict the maximum cabin differential pressure to 8.8 psi In this condition, normal pressurization control is inoperative.



CABIN DEPRESSURIZATION WARNING

A normal datum pressure switch operates and illuminates the CABIN ALTITUDE red annunciator on the MWS panel. A warning horn sounds when the cabin altitude reaches 9300 ± 300 ft. The horn may be silenced by pushing a HORN ISOLATE button on the left thrust lever knob. A CABIN ALT button, on the TEST section of the overhead roof panel, is provided for checking the warning system.

NOTE: With flaps lowered beyond 15°, the depressurization warning horn is electrically isolated.

A second pressure switch is installed to permit take-off and landing at airfields above 9000 ft elevation.

The high altitude datum pressure switch is controlled by an illuminated push button switch labelled CABIN HIGH DATUM on the copilot's instrument panel.

When the button is pushed and illuminated, the high altitude datum pressure switch controls the set-point of the depressurization warning at 14,000 ± 300 ft.

When the push button is not operated and not illuminated, the normal datum pressure switch 9300 ± 300 ft controls the set-point.

DUMP VALVE

A butterfly type dump valve on the right sidewall of the nose gear bay can be set between OPEN and SHUT, by movement of a DUMP VALVE operating lever. The operating lever is located to the right of FMS No. 2 display screen.

The dump valve is used in conjunction with the ram air supply, (DUMP VALVE lever fully OPEN), to provide ventilation when the cabin is unpressurized in flight.

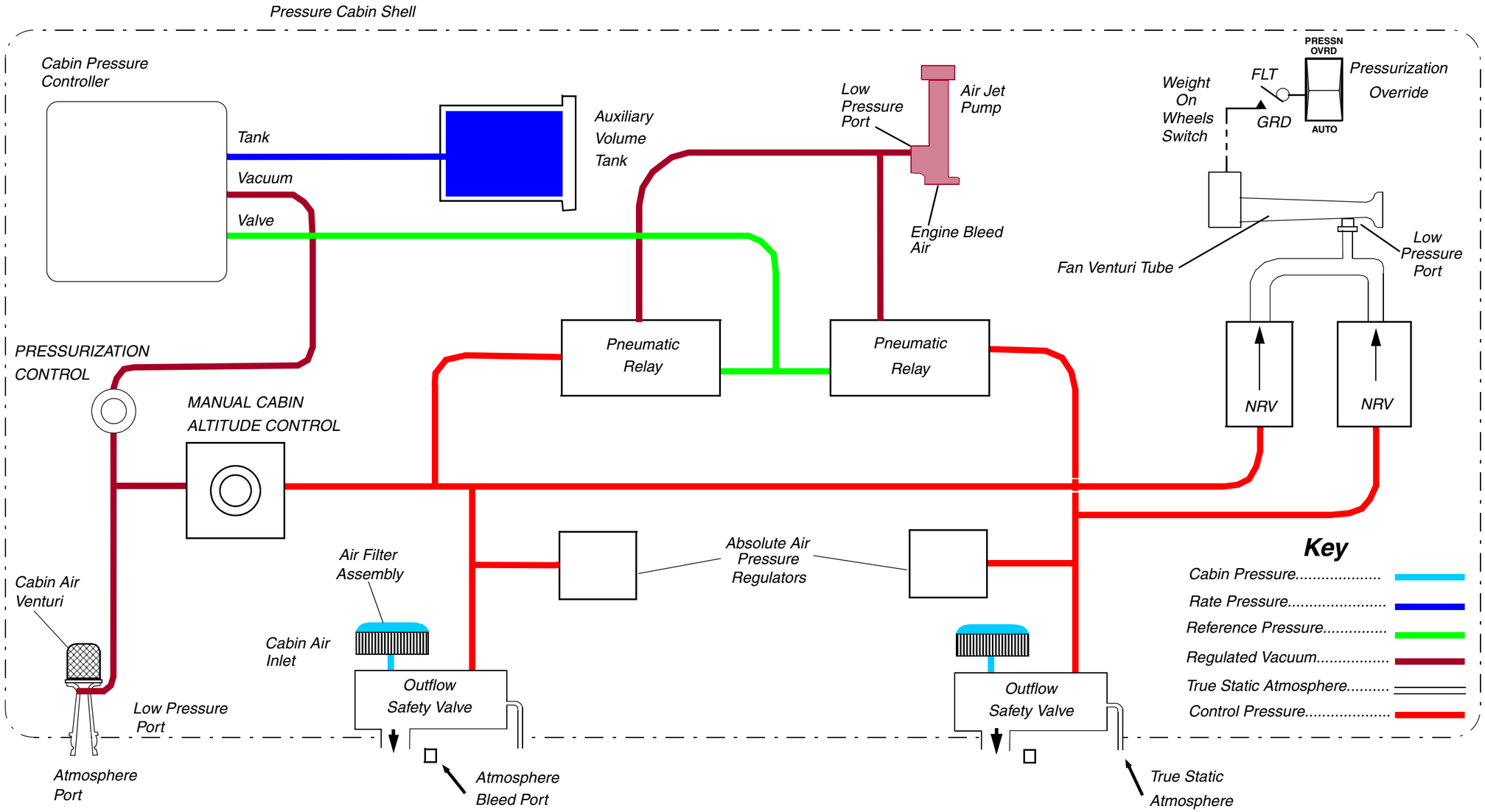


Figure 2
Pressurization System

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