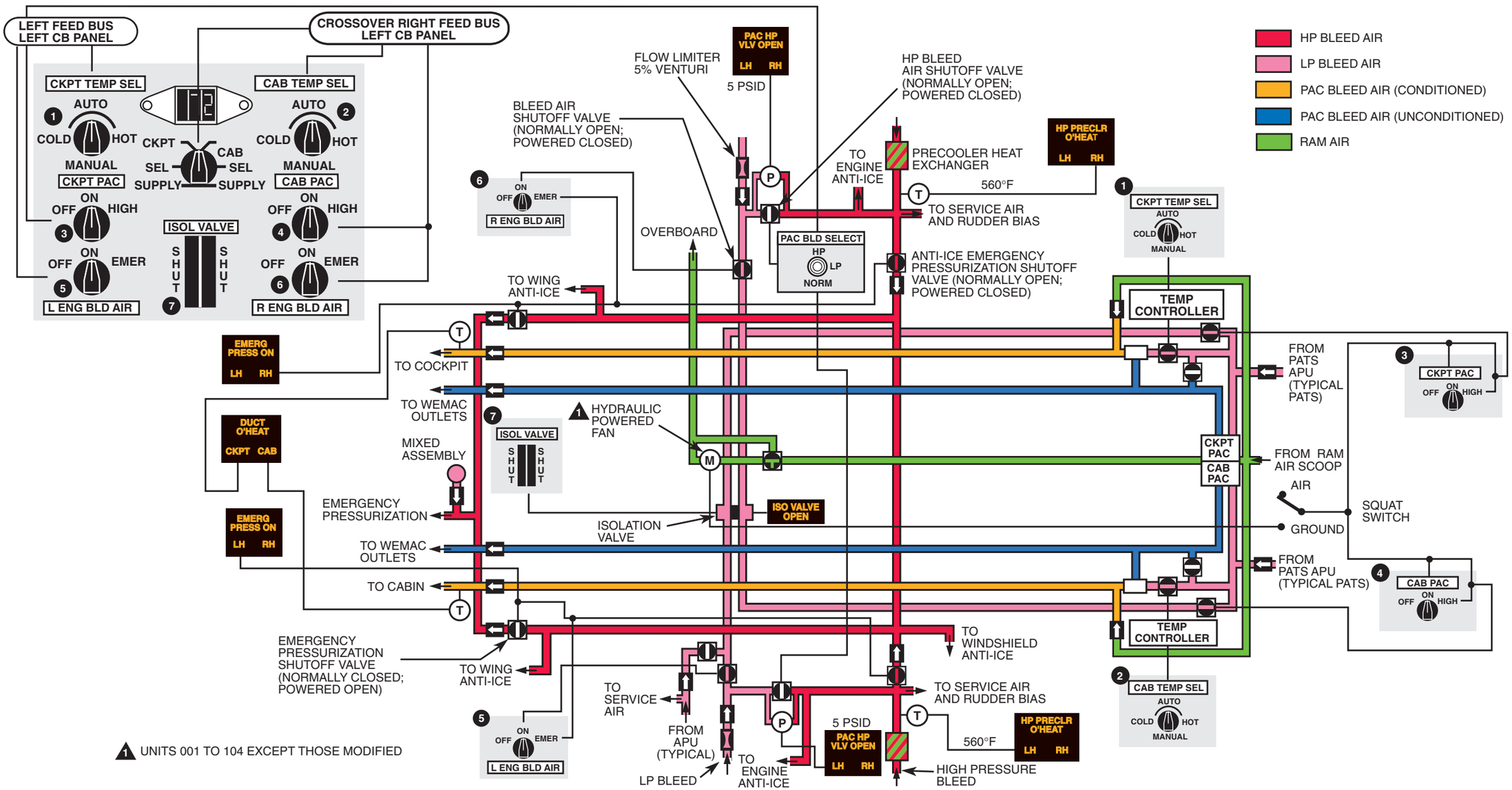
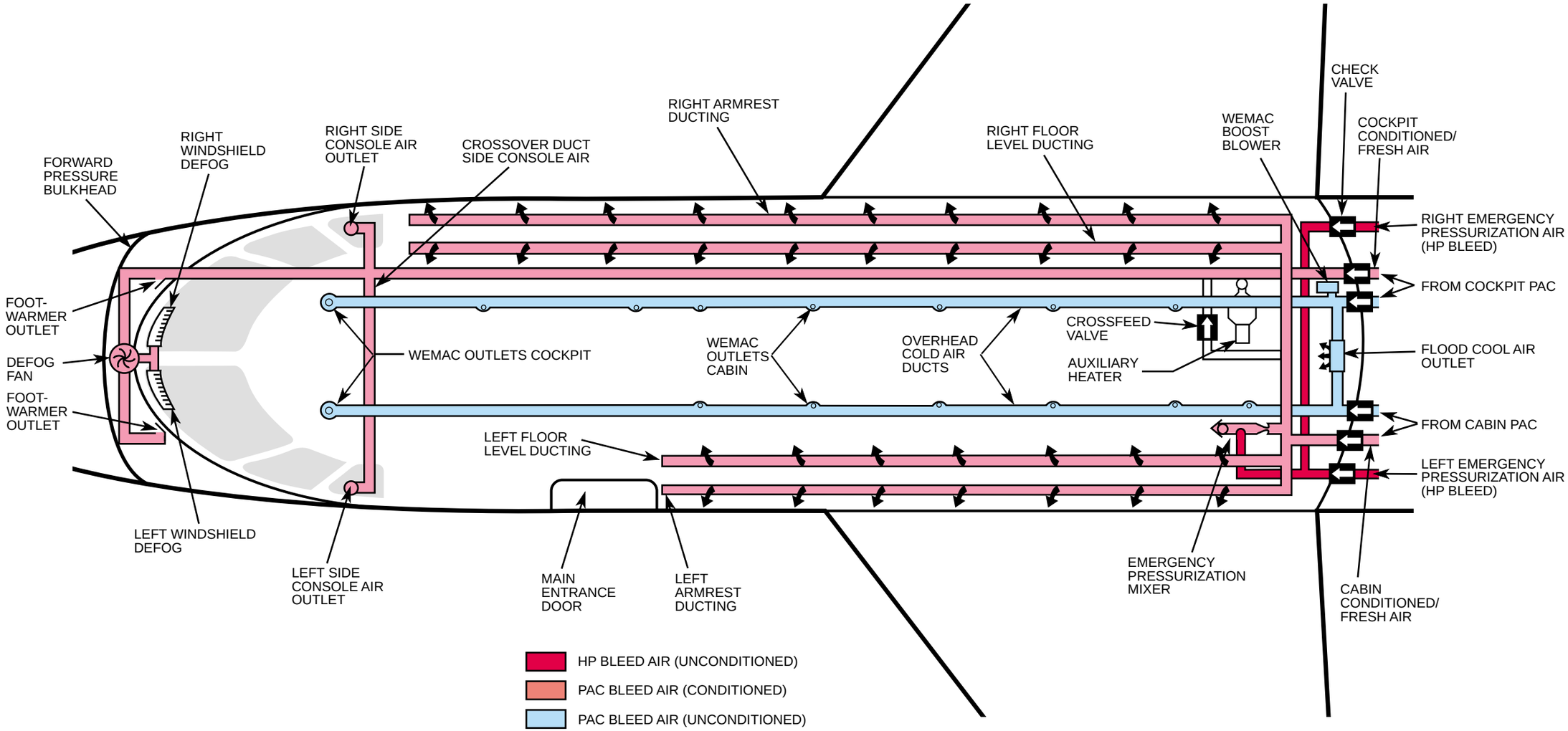
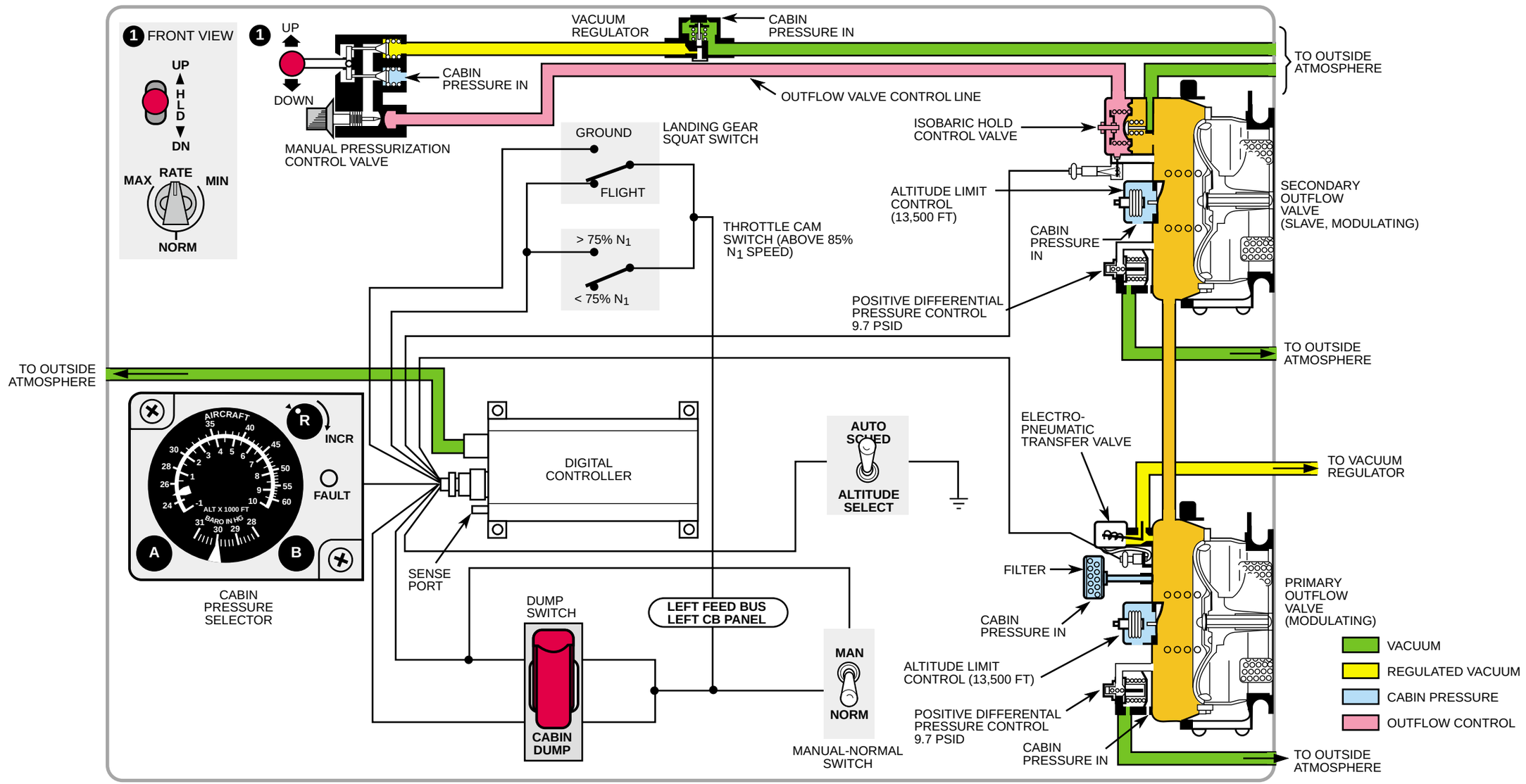
Bleed Air System



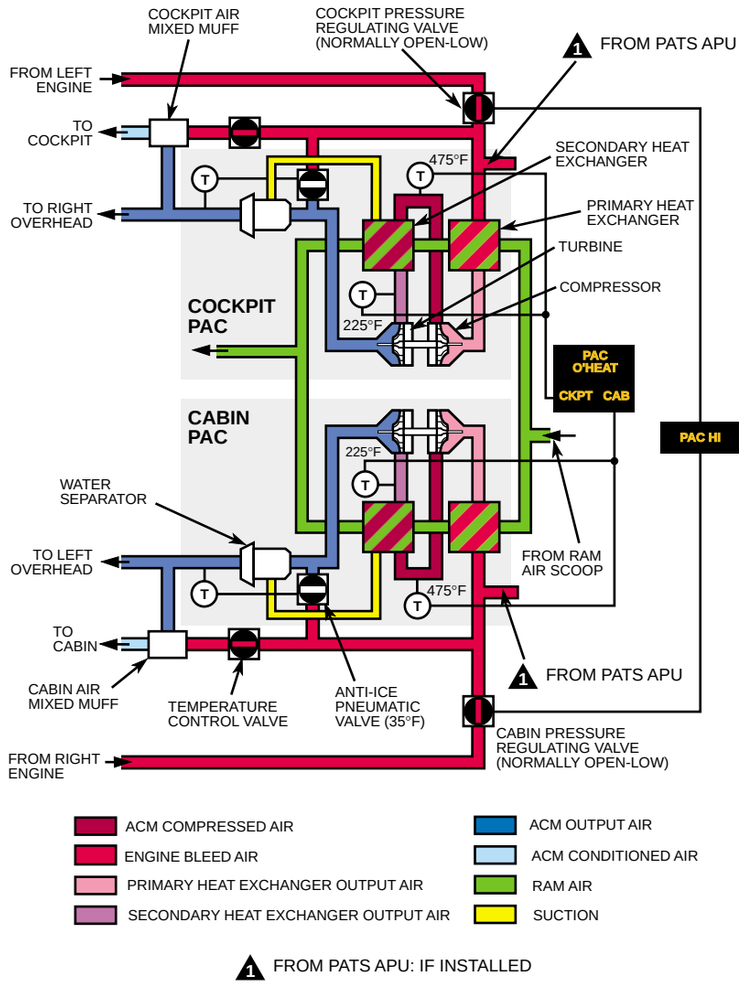
Air Distribution System



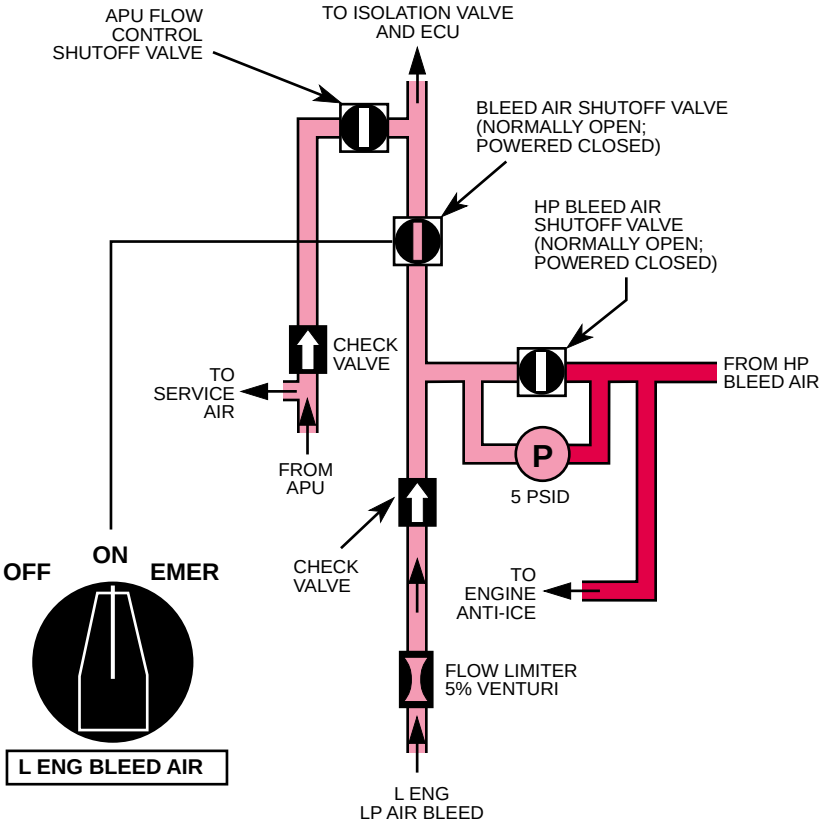
Pressurization System



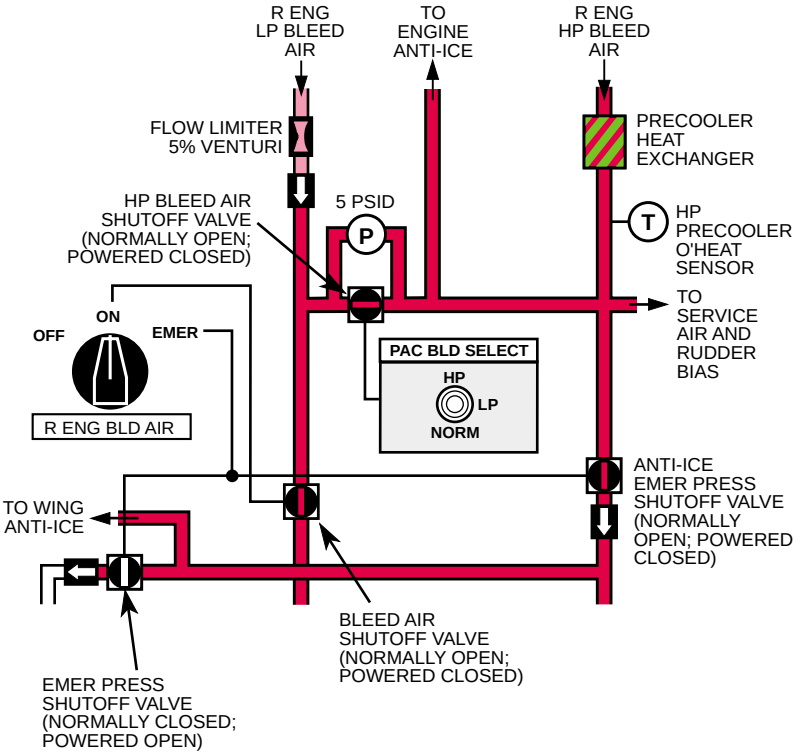
Air Cycle Machine



LP Bleed Air Supply



HP Bleed Air Supply



Bleed Air Supplies

Low pressure (LP) and/or high pressure (HP) bleed air obtained from the engines supplies the:

- air conditioning system
- normal and emergency pressurization systems
- wing, windshield, and engine anti-icing systems
- rudder bias system
- service air system (door seal and pressurization system air ejector).

If installed, the auxiliary power unit (APU) also supplies bleed air for the air conditioning and service air systems.

LP Air

LP bleed air from each engine's axial compressor flows through a flow-limiting venturi before it enters the collector manifolds. The venturis limit total LP bleed air extraction to 5% of that produced by the engine. In the collector manifolds, bleed air flows through a check valve and shutoff/pressure regulating valve before it reaches the environmental control unit packages (PACs). The check valves prevent reverse airflow from an operating engine to an inoperative engine.

When operating with the APU bleed air switch in OPEN, the APU supplies bleed air through a check valve and open bleed air shut-off valve into the collector duct that supplies the PACs. At low engine power settings on the ground, supplying the environmental control system with APU bleed air is more efficient.

HP Air

HP bleed air from each engine's HP compressor flows through a precooler and slave valve before it passes through the engine pylon into the tee duct. The slave valve, controlled by a pilot valve, regulates the air bypassing the precooler to maintain it at a temperature between 500 and 550°F (260 and 288°C). If the bleed air temperature downstream of the precooler exceeds 560 ±12°F (293 ±7°C), an overtemperature switch illuminates the associated HP PRECLR O'HEAT annunciator.

In the tee duct, the HP air supply splits to supply the:

- emergency pressurization system through the anti-ice/emergency pressurization shutoff valve and emergency pressurization shutoff valve
- wing and windshield anti-ice systems through the anti-ice/emergency pressurization shutoff valve, wing anti-ice shutoff valve, and windshield pressure regulating shutoff valve
- collector ducts through the open HP bleed air shutoff valve
- service air and rudder bias systems
- engine nacelle anti-icing system.

Air Conditioning

On the ground with the throttle levers below the 55% N_1 position and the PAC BLD SELECT switch in NORM, the HP bleed air shutoff valves open to supplement LP bleed air. Advancing the throttles above the 55% N_1 position, closes the HP bleed air shutoff valves; LP bleed air is then the sole source for the PACs.

Opening and closing of the HP bleed air shutoff valve can also be controlled by placing the PAC BLD SELECT switch in LP (shutoff valve closed) or HP (shutoff valve open).

Normally, left and right bleed air separately supply the cabin and cockpit PACs. Placing the ISOL VALVE switch in OPEN supplies 28V DC to open the isolation valve and connect the two bleed air supplies. This allows one engine to supply both systems during an engine failure. Check valves prevent reverse bleed air flow to the inoperative engine.

On **unit 200 and subsequent**, an optional Freon air conditioning system supplements the PACs for ground and low altitude operations.

ECU PACs

On **units 001 to 104**, the ECU PACs consist of a dual core primary and secondary heat exchanger, air cycle machine (ACM), pressure regulator and shutoff valve, temperature sensor and thermal switches, anti-ice pneumatic valve assembly, water separator, and flow-limiting venturi.

On **unit 105 and subsequent**, the ECU PACs consist of a heat exchanger, air cycle machine, fan housing, water separator, bypass valve, and overtemperature switch.

A PACs bleed air flows through a pressure regulator and shutoff valve before it enters the primary heat exchanger. The shutoff valve, controlled by a high/low solenoid, regulates bleed air pressure to 28.5 PSIG in the high setting and to 15 PSIG in the low setting.

After the flow-limiting venturi, bleed air then moves through a ram air cooled primary heat exchanger that provides initial air cooling before it reaches the ACM's compressor. As air flows through the compressor, it is compressed and heated before it passes through the secondary heat exchanger for cooling.

After passing through the secondary heat exchanger, air flows to the ACM's turbine where it rapidly expands and cools as it expends energy to drive the turbine. The rapidly spinning turbine, in turn, drives the ACM's compressor.

If installed, a hydraulically operated fan draws air through the PAC heat exchangers to supplement ground cooling. The fan deactivates on takeoff.

On **units 001 to 104**, there is a thermal switch at the compressor outlet and turbine inlet. If temperature of the air exiting the compressor exceeds 475°F (246°C) or the air temperature entering the turbine exceeds 225°F (107°C), the thermal switches illuminate the associated PAC O'HEAT CKPT/CAB annunciator and perform an automatic PAC shutdown.

On **unit 105 and subsequent**, if the temperature of the air exiting the ACM compressor exceeds 435 ±15°F (224 ±8°C), the compressor outlet thermal switch illuminates the associated PAC O'HEAT CKPT/CAB annunciator and performs an automatic PAC shutdown.

After exiting the ACM, conditioned air combines with air bypassed around the primary heat exchanger. In the water separator, a coalescer removes water from the moisture-laden conditioned air. An ejector collects water and supplies it to the secondary heat exchanger to assist cooling.

A temperature switch downstream of the water separator monitors water separator outlet air temperature. At temperatures below 35°F (1.6°C), the switch opens an anti-ice pneumatic valve that heats the air entering the water separator to prevent icing.

Distribution and Control

Conditioned air mixed with hot bleed air heats and pressurizes the cockpit and cabin. Cold conditioned air directly from the PACs cools and ventilates the cockpit and cabin through overhead Wemac ducts.

On the ground, forced air from a ram air scoop at the vertical stabilizer base ventilates the cockpit and cabin.

Temperature Control

With the CKPT TEMP SEL and CAB TEMP SEL knobs in the AUTO range, cockpit and cabin temperature controllers regulate air temperature based on temperature signals provided by zone and duct temperature sensors. In response to these inputs and the desired air temperature selected through the control panel, each controller opens or closes its temperature control valve to increase or decrease the amount of hot bleed air supplied to the mixer muffs.

Placing a CKPT or CAB TEMP SEL knob in the MANUAL range allows the crew to manually control cockpit and cabin air temperature by directly controlling the opening and closing of the temperature control valves.

Through the source selectable digital temperature indicator, the crew monitors zone and supply temperature and the setting selected for temperature control.

If the cockpit and cabin supply duct temperature exceeds 300°F (149°C), a duct overheat switch illuminates the associated DUCT O'HEAT CKPT/CAB annunciator. If a duct overheats, selecting a lower temperature with the environmental control closes the temperature control valve to cool the air supply.

If a cockpit PAC malfunctions or its CKPT PAC knob is in OFF, a crossflow check valve between the cabin and cockpit ducting opens to admit cabin PAC conditioned air into the cockpit.

Boost and Flood Cooling

On **unit 105 and subsequent; prior aircraft with SB650-21-22**, with the WEMAC BOOST switch in ON, an electric fan in the aft vanity mixes cabin air with conditioned air to increase air flow through the overhead distribution ducts and prevent fogging from the Wemac outlets.

On **unit 105 and subsequent**, an optional flood cooling system allows rapid cooling by directing most of the cold conditioned air from the PACs through an aft bulkhead mounted plenum into the cabin. With the control switch in FLOOD COOL, a motor-driven door partially closes off the overhead distribution ducts to route most of the air through the flood cooling outlet. With the control switch in OFF, the door closes the outlet and cold air flows normally through the overhead distribution ducts.

Freon Air Conditioning

With the aircraft electrical system powered by the engine-driven generators or external power, placing the A/C switch in ON energizes the air conditioner compressor and evaporator fans. The air conditioner compressor then cycles on and off in response to the setting made with the A/C TEMP selector. The system provides cold conditioned air through the forward evaporator and fan in the forward end of the dropped aisle and the rear evaporator and fan in the right vanity area. With the A/C switch in FAN, the compressor does not operate but the fans continue to circulate air through the cabin.

Depending on the position of the FWD EVAP and AFT EVAP switches, the evaporator fans operate at high (HI), medium (MED), or slow (LOW) speeds.

Auxiliary Heating

An auxiliary electric heater in the cockpit air distribution ducts supplements normal heating and assists in window defogging. Through the CKPT AUX FAN and CKPT AUX FAN/HEAT switches, the flight crew can select:

- fan low/heat low
- fan high/heat high
- fan high/heat low.

To prevent overheating, the system will not operate with the FAN switch in LOW and the FAN/HEAT switch in HIGH. After placing both switches in OFF, a cooldown circuit runs the fan until output temperature is below 130°F (54°C).

Baggage Compartment Heating

With DC power available and the BAT HTR switch in ON, an electric blower, heating elements, and ambient temperature switch maintain baggage compartment temperature between 70 and 90°F (21 and 32°C). If the baggage compartment temperature reaches 180°F (82°C), an overheat temperature switch illuminates the BAG HTR O'HEAT annunciator. If the temperature continues to rise, thermal fuse(s) melt at 280°F (138°C) to cut power to the heating elements.

Instrument Panel Cooling

With the W/S DEFOG switch in LOW or HIGH, a 28V DC fan underneath the defog deck circulates air behind the instrument panel for cooling. The fan also operates if a thermal switch senses a temperature above 98°F (37°C) behind the instrument panel. On **aircraft with EFIS**, the fan operates continuously.

Avionics Cooling

With the battery switch in BATT, cooling fans circulate air through the avionics equipment to prevent overheating. On **units 001 to 178**, a thermal switch with a 98°F (37°C) set-point controls power to the fans. On **unit 179 and subsequent**, the fans operate whenever the battery switch is in BATT.

Pressurization

With a constant supply of conditioned air flowing into the cabin, the pressurization system automatically maintains a selected cabin altitude, climb rate, and descent rate with two outlow valves that control the rate of cabin air escape to atmosphere. At the aircraft's maximum operating altitude of 51,000 ft, the system's 9.3 PSID maximum cabin pressure differential maintains a comfortable 8,000 ft cabin altitude.

The system's primary and secondary outflow valves respond to electrical commands from the pressurization controller during automatic operation and pneumatic commands from the manual pressurization control valve during manual operation. If a system failure occurs, the outflow valves prevent cabin altitude from exceeding 13,500 ±1,500 ft and pressure differential from exceeding 9.7 PSID.

If the pressurization system completely fails, the cabin or cockpit PACs provide sufficient airflow to maintain cabin pressure.

At power-up, the pressurization system automatically performs a self test of the controller, outflow valves, squat switches, and system components. If a component fails the self-test, pressurization can be controlled through the manual pressurization control valve.

Automatic Operation

There are two automatic operating modes: auto-schedule and cabin altitude select. In either mode, the digital cabin pressurization controller electrically controls the primary and secondary outflow valves through their electro-pneumatic transfer valves.

Auto-Schedule

With pressurization system switches in NORM and AUTO SCHED, the crew sets cabin climb rate and landing field elevation and makes barometric pressure corrections.

On the ground with the throttles above the 75% N_1 position, the pressurization controller pre-pressurizes the cabin to eliminate cabin altitude bumps at liftoff. As the aircraft leaves the ground, the squat switches signal the controller to enter its flight mode. The controller, using the landing field barometric pressure entered, uses its auto schedule to provide a cabin altitude based on aircraft altitude.

During climb to altitude and descent, the crew manually selects the cabin rate-of-climb while the controller provides climb and descent rate limiting. If the crew selects an excessive climb or descent rate as compared to the auto schedule, the controller limits the rate to match the schedule. The controller, however, does not limit climb and descent rates less that the auto schedule requires.

The crew sets the required barometric pressure during the approach. At aircraft touchdown, the squat switches signal the controller to enter its landing mode thus preventing a lower cabin altitude than field elevation. After one minute, the system enters ground mode: it opens both outflow valves to dump cabin pressurization.

Cabin Altitude Select

With the pressurization control switches in NORM and ALTITUDE SELECT, the crew sets desired cabin rate-of-change, cabin altitude, and barometric pressure correction. The controller then automatically controls primary and secondary outflow valve opening and closing to achieve the desired settings.

In altitude select mode, the crew can select cabin rate-of-change from 150 to 2,500 FPM up or 90 to 2,500 FPM down.

Manual Operation

If the system loses power, it automatically enters manual mode. Placing the MAN/NORM switch in MAN also places the system in manual mode. The crew then selects cabin altitude and rate-of-change on the cabin altitude and differential pressure indicator and the rate-of-climb indicator.

With the system in manual mode, the crew directly controls cabin altitude through the UP/HLD/DN switch and cabin rate-of-change through the RATE knob.

Holding the switch in UP raises cabin altitude by connecting the control valve to atmosphere. The outflow valve opens and cabin altitude climbs. Holding the switch in DOWN connects the control valve to cabin pressure. The outflow valve closes and cabin altitude descends.

Emergency Pressurization

If cabin altitude climbs above 8,500 ±350 ft, the cabin altitude switch closes to illuminate the CABIN ALT 8500 FT annunciator. If cabin altitude continues to climb and reaches 10,000 ±350 ft, two barometric switches close to sound an aural warning. Pressing the CAB ALT WARN button silences the warning.

If cabin altitude continues to climb and reaches 13,500 ±500 ft, a second set of two barometric switches close to automatically initiate emergency pressurization. The emergency pressurization shutoff valves energize to bypass the PACs and supply bleed air directly into the cabin and cockpit. Placing the L/R ENG BLD AIR switches in EMER also initiates emergency pressurization. The primary and secondary outflow valves also close to limit cabin altitude to 13,500 ±500 ft.

Finally, a sixth barometric pressure switch connected to the autopilot system closes at 13,500 ±500 ft to provide a signal to the autopilot computer. With this switch closed, a ground provided by the air data computer (aircraft at approximately 35,000 ft), and the autopilot engaged, the autopilot system enters the emergency descent mode.

Bleed Air Manifold

Power Source	Engines (L/R – HP and LP air) APU air
Distribution	Normal air conditioning/pressurization Left engine to cockpit PAC Right engine to cabin PAC When open, isolation valve connects 2 sides Emergency pressurization Engine anti-ice system Wing anti-ice system Windshield anti-ice system Rudder bias Entry door seal Cabin pressure control air ejector
Control	Switches CKPT/CAB AIR ENG BLD AIR L/R (EMER) ISOL VALVE APU BLEED AIR OPEN Anti-ice systems
Monitor	Annunciators HP PRECLR O'HEAT PAC O'HEAT CKPT/CAB EMERG PRESS ON ISO VALVE OPEN Anti-ice systems
Protection	ENG BLD AIR CBs (5A) Bleed air shutoff valve

Pressurization Systems

Power Source	Bleed air manifold APU air Left Feed bus
Distribution	Aircraft pressure vessel
Control	MAN/NORM controller switch AUTO SCHED/ALTITUDE SELECT switch Cabin DUMP/PRESSURIZE switch Digital controller Throttle switches CAB ALT WARN MUTE/TEST button
Monitor	Cabin altitude/differential pressure indicator Cabin rate-of-climb indicator CABIN ALT 8500 FT annunciator Cabin altitude warning horn – 10,000 ft Amber FAULT light
Protection	PRESSURIZATION CB (5A) Outflow valves Altitude limit control – 13,500 ft Positive differential pressure control – 9.7 PSID Cabin pressurization failure warning system Emergency pressurization system ENG BLD AIR selector on EMER Squat switches

Air Conditioning System

Power Source	Left Feed bus Crossover Right Feed bus Bleed air manifold Fresh air (**units 001 to 104**) Freon system (**optional on unit 200 and subsequent**)
Distribution	Cockpit Cabin
Control	Switches PAC BLD SELECT (HP/LP/NORM) CKPT/CAB PAC ENG BLD AIR CKPT/CAB TEMP SEL Temperature display selector Optional Freon system A/C switch FWD/AFT EVAP switches A/C TEMP controls
Monitor	Annunciators DUCT O'HEAT CKPT/CAB PAC O'HEAT CKPT/CAB PAC HI PAC HP VLV OPEN EMERG PRESS ON
Protection	Circuit breakers FWD/AFT EVAP FAN – **with optional Freon system** (10A) COCKPIT TEMP (5A) CABIN TEMP (5A) MAN CABIN TEMP (5A) DEFOG FAN (5A) Overtemperature shutdown for PACs