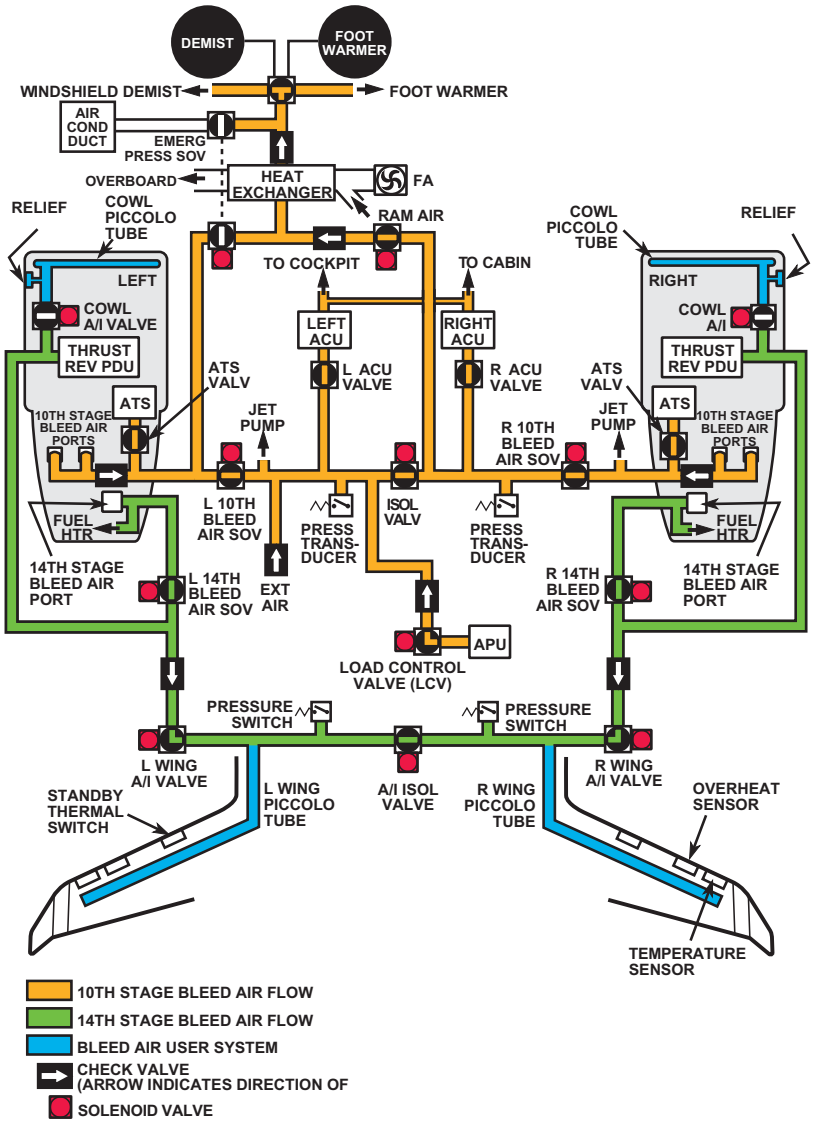
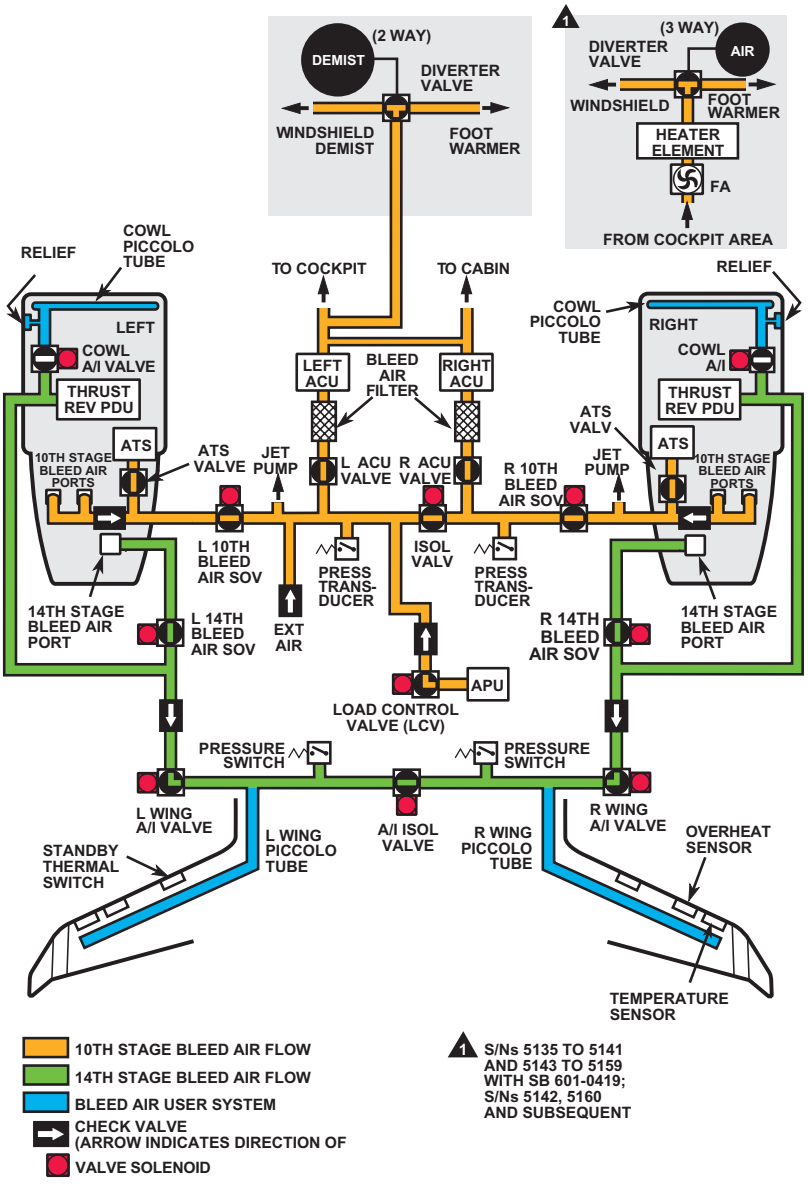
Environmental System

S/Ns 3001 to 3066 and 5001 to 5134

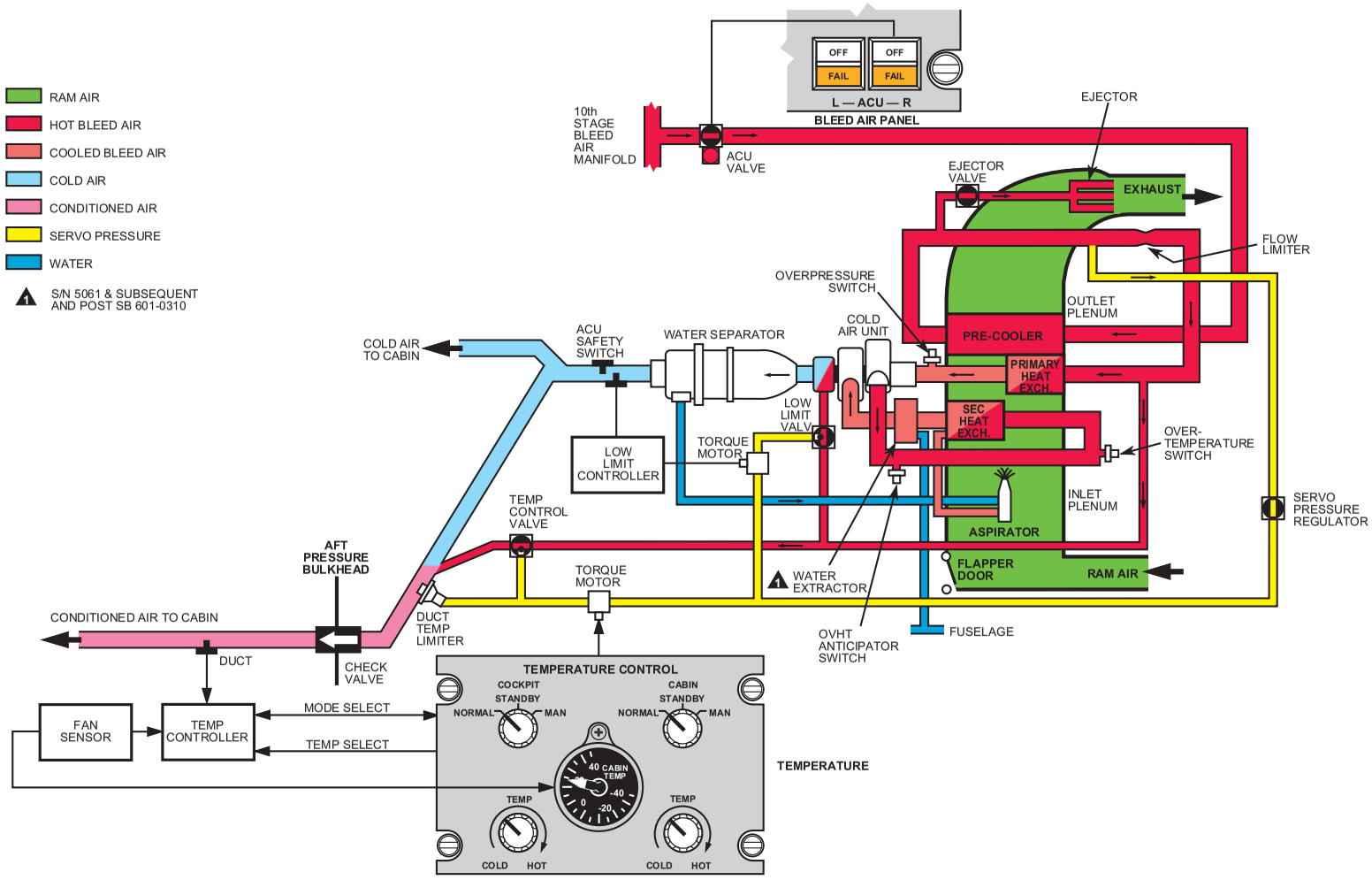


Environmental System

S/Ns 5135 to 5141 and 5143 to 5159
Without SB 601-0419



Air Conditioning System



Environmental Systems

Bleed air sources, air conditioning, and pressurization comprise the environmental systems.

An external air source or the APU provides bleed air for engine starting and air conditioning. The engines then supply bleed air for cross-engine starts, air conditioning, pressurization, and anti-icing.

Pneumatic System

Bleed air from the engine's 10th stage compressor, auxiliary power unit (APU), or an external air source supplies the:

- engine air turbine starters
- air conditioning system
- normal and emergency pressurization systems
- window demisting and footwarmers.

Bleed air from the engine's 14th stage compressor supplies the:

- wing leading edge anti-icing system
- engine anti-icing system
- thrust reverser system
- fuel heaters (**S/Ns 3001 to 3066 and 5001 to 5134**).

10th Stage Bleed Air

Connecting an external air source to the ground air adapter opens the ground air supply valve to supply pressurized air for engine starting.

With APU RPM above 95%, the APU electronic control unit illuminates the APU RDY light as it supplies power to the BLEED AIR switchlight. Pressing the BLEED AIR switchlight energizes the load control valve solenoid and illuminates the OPEN caption so that when the load control valve opens, the OPEN light illuminates. Bleed air then flows through a check valve into the aircraft's 10th stage bleed air manifold.

Opening the left or right bleed air shutoff valve and the isolation valve closes the load control valve. This prevents bleed air flow into the APU.

From two ports on each engine's compressor casing, 10th stage bleed air flows through ducting and a check valve before reaching the bleed air shutoff valve. Pressing the 10th STAGE switchlights supplies 28V DC from DC Bus 1 and DC Bus 2 (**S/Ns 3001 to 3066 and 5001 and subsequent without SB 601-0437**). **On S/Ns 5135 and subsequent with SB 601-0437**, the power source for both the left 10th stage bleed and the left ACU are moved from DC1 to DC Essential. The valves open and the associated BLEED CLOSED lights extinguish. If a bleed air shutoff valve loses power, the valve fails to the closed position.

Bleed air then flows through the open bleed air shutoff valves and enters the 10th stage bleed air manifold. When the 10th stage bleed air manifold pressurizes, transducers downstream of the shutoff valve drive the BLEED AIR gage.

Pressing the ENG FIRE PUSH switchlight closes the associated bleed air shutoff valve.

During engine cross-starts or when only one engine is supplying bleed air, pressing the ISOL switchlight opens the isolation valve. The ISOL switchlight illuminates; bleed air from either engine pressurizes both sides of the 10th stage bleed air manifold.

14th Stage Bleed Air

Pressing the 14th STAGE switchlights supplies 28V DC from DC Bus 1 and 2 to the left and right bleed air shutoff valves, respectively. The BLEED CLOSED lights then extinguish, and the shutoff valves open. Bleed air from each engine's 14th stage flows toward the thrust reverser system, cowl anti-ice valves, and the wing anti-ice valves. If a shutoff valve loses power or there is a loss of bleed air pressure, the shutoff valve fails to the spring loaded open position.

Pressing the ENG FIRE PUSH switchlight closes the associated bleed air shutoff valve.

During thrust reverser operation, the wing and engine anti-icing shutoff valves close to provide dedicated 14th stage bleed air flow for the thrust reverser system.

Footwarmer/Demist System

On S/Ns 3001 to 3066 and 5001 to 5134, placing the CKPT HEAT switch in the NORM or STBY position opens the right (NORM) or left (STBY) pressure regulator and shutoff valve connected to the 10th stage bleed air manifold. When STBY is selected, hot bleed air flows through a heat exchanger where it cools to approximately 66 to 77°C (150 to 170°F) before travelling forward through ducts to the footwarmer and demist diverter valve assembly.

On S/Ns 5135 and subsequent, the air conditioning system directly supplies the footwarmer and demist diverter valve assembly.

On S/Ns 5142, 5160 and subsequent; 5135 to 5141 and 5143 to 5159 with SB 601-0419, a fan pulls cockpit air from the flight compartment and sends it through a heater and the footwarmer demist duct.

Air Conditioning

From the 10th stage bleed air manifold, bleed air flows to the air conditioning unit (ACU) pressure regulating and shutoff valves. Pressing both ACU switchlights opens the ACU shutoff valves and extinguishes the OFF lights.

Bleed air flows through a ram air-cooled precooler that reduces bleed air temperature to approximately 287°C (500°F). Downstream of the precooler, an ejector valve uses bleed air to induce air flow through the precooler and heat exchangers when the aircraft is on the ground.

After passing through the precooler, the air flow splits. One flow supplies the temperature control modulating valve while the other continues past a flow limiting venturi to the primary heat exchanger. After additional cooling by the primary heat exchanger, bleed air enters the cooling turbine compressor inlet where it is compressed and heated. Bleed air then continues to the secondary heat exchanger for additional cooling. **On S/N 5061 and subsequent and prior S/Ns with SB 601-0310**, a water extractor removes moisture from air leaving the secondary heat exchanger and vents it overboard.

From the secondary heat exchanger, air flows to the cooling turbine's inlet. As the air flow expends energy to rotate the turbine, the air rapidly expands, loses pressure, and cools. This rapid pressure and temperature drop also condenses any water vapor present.

Cold, moisture-laden air leaving the turbine then enters the water separator. A swirling motion imparted to the air flow in the water separator throws off the heavier water droplets. The water collects in a sump that is then sprayed across the heat exchangers to assist cooling.

A low-limit temperature controller maintains air leaving the water separator at approximately 2° (35°F) by introducing hot bleed air into the turbine outlet through the low limit valve.

The cold air finally flows forward to the cabin and cockpit through distribution ducts for cooling and mixing with hot air. Approximately 40% of ACU No. 1 output and all of ACU No. 2 output flows to the cabin. The remaining 60% of ACU No. 1 output supplies the cockpit.

Cold air from both ACUs directly supplies the cockpit and cabin cold air “eyeball” outlets.

After mixing with hot bleed air supplied by the temperature control modulating valve, temperature-controlled air passes through the aft pressure bulkhead and check valves into the cabin and cockpit distribution ducts.

Temperature Control

With the COCKPIT and CABIN selectors in the NORMAL position, the temperature controller compares fan and duct temperature sensor signals to TEMP knob setting. A difference between the sensed temperature and the knob setting produces an error signal. The controller then uses this error signal to drive the electromagnetic control valve torque motor.

The torque motor positions the temperature control modulating valve to increase or decrease the amount of hot bleed air mixed with conditioned air to increase or decrease the air temperature entering the cockpit and cabin.

Placing the COCKPIT and CABIN selectors in the STANDBY position provides an alternate means of controlling cabin and cockpit temperature by removing the fan sensor from the control circuit. The controller then regulates air temperature based on the difference between the duct temperature sensor and the TEMP knob setting.

Placing the COCKPIT and CABIN selectors in the MAN position removes the temperature sensors from the temperature control circuit. Moving a TEMP knob toward COLD closes the temperature control modulating valve to decrease hot bleed air mixing and lower air temperature. Moving the TEMP knob toward HOT opens the modulating valve to increase hot bleed air mixing and raise air temperature. The low-limit temperature sensor will override the temperature knob in all three modes of operation.

If the temperature control system malfunctions and the distribution ducts begin overheating, the duct temperature limiter vents modulating valve operating pressure to ambient. The modulating valve closes to produce a drop of duct temperature.

Pressurization

The air conditioning system supplies a constant flow of air into the passenger cabin and cockpit for the pressurization system which:

- automatically maintains selected cabin altitude through isobaric pressurized operation
- automatically limits maximum cabin pressure differential
- provides crew selected cabin altitude rate-of-change
- allows barometric correction for preprogrammed landing field altitude
- permits manual cabin altitude control through manual outflow valve operation
- automatically limits cabin altitude rate-of-change during pressurization and depressurization
- regulates and smooths cabin pressurization to prevent pressurization surges
- permits emergency pressurization if normal system fails
- furnishes emergency ventilation to provide rapid smoke removal.

The primary outflow valve automatically limits cabin pressure differential to 9.1 ±0.10 PSID. If the primary outflow valve fails to limit cabin pressure differential, the secondary outflow valve limits it to 9.3 ±0.10 PSID.

If cabin altitude reaches 10,400 ±300 or 10,000 ±300 ft (**CAA certified aircraft**), a cabin altitude sensing switch illuminates the CABIN PRESS LOW light. Descending below 9,000 or 8,700 ft (**CAA aircraft**) resets the switch and the CABIN PRESS LOW light extinguishes.

Automatic Operation

Placing the cabin pressurization controller mode selector in the AUTO position enables automatic pressurization control based on landing field altitude, landing field barometric pressure, and cabin altitude rate-of-change settings.

With the aircraft on the ground and throttles set below the 36.5° position, applying power to the system initiates a system self-test. When the system completes the test with no faults detected, the pressurization controller commands the outflow valves to fully open.

Advancing the throttles above approximately 35° power lever angle (PLA) and 85% power setting signals the controller to begin closing the outflow valves. The valves slowly close and the system maintains cabin altitude approximately 200 ft below field elevation. This prevents sudden cabin altitude bumps as the aircraft takes off.

Once airborne, the controller determines the proper pressurization schedule to follow as the aircraft climbs to its cruising altitude. During climb, the controller compares its auto schedule to landing field altitude and selects the higher value as its control value. Finally, the system maintains the desired cabin altitude rate-of-change set through the controller by regulating outflow valve opening and closing.

As the aircraft descends to a landing, the controller sets cabin altitude descent to provide a smooth transition between aircraft altitude and field elevation. On touchdown, the controller opens the outflow valves to equalize cabin pressure.

Manual Operation

Placing the mode selector switch in the MAN position allows the crew to manually control outflow valve operation. Holding the MAN REG toggle in the UP position opens the outflow valves so the cabin climbs; holding the toggle in the DN position closes the valves, and the cabin descends.

Emergency Pressurization

If both air conditioning units fail or the aircraft loses normal electrical power and cabin altitude begins climbing, pressing the EMER PRESSN switchlight opens the emergency pressurization and footwarmer/demist shutoff valves. Pressurized bleed air supplied from the 10th stage bleed air manifold then pressurizes the cabin.

On S/N 5135 and subsequent, the emergency pressurization system was removed for weight reduction in combination with other changes in the footwarmer/demist system. **SB 601-0437**, installed at the operators option, provides limited emergency pressurization capability. The left 10th stage bleed and left ACU power sources are changed to the DC Essential bus. During emergency pressurization operation, the shutoff valve remains open and the left air conditioning unit operates to provide the emergency pressurization air source. There are no separate controls or monitors for this modification.

Pneumatic Systems

Power Source	Engines 10th stage bleed air 14th stage bleed air APU 10th stage bleed air manifold supply External air source 10th stage bleed air manifold supply DC Bus 1 and DC Bus 2 DC Essential bus
Distribution	10th stage bleed air Air conditioning Engine starting (air turbine starters) Pressurization Window demisting 14th stage bleed air Wing anti-icing Engine anti-icing Thrust reversers
Control	14TH STAGE switchlights 10TH STAGE switchlights ENG FIRE PUSH (14th stage shutoff valves) BLEED AIR switchlight (APU) Bleed air shutoff valves (10th and 14th stage) Isolation valve (10th stage) Load control valve (APU)

Pneumatic System (continued)

Monitor	10th stage BLEED AIR pressure gage BLEED CLOSED lights DUCT FAIL lights ISOL OPEN light Bleed air FAILED (APU) light Bleed air OPEN (APU) light
Protection	Bleed air leak detection system Air conditioning units overpressure switches

Air Conditioning System

Power Source	10th stage bleed air manifold Air conditioning units (ACUs) Ram air DC Bus 1 and DC Bus 2 DC Essential bus AC Bus 2
Distribution	Cabin air distribution ducts Cockpit air distribution ducts Avionics cooling
Control	COCKPIT selector CABIN selector Cabin and cockpit TEMP controls DEMIST and FOOT WARMER controls L/R ACU switches ACU valves Temperature controller Temperature control valves FOOTWARMER and DEMIST valves
Monitor	CABIN TEMP gage FAIL light (overpressure/overtemperature) COOL AIR FAIL lights (avionics cooling)
Protection	Low limit system (2°C/35°F) Duct temperature limiter (205°C/400°F) Overpressure switch (53 PSI)

Pressurization System

Power Source	Air conditioning system Air jet pump Battery bus
Distribution	Cockpit/cabin pressure vessel
Control	ControlCabin pressurization control panel R (rate) knob B (barometric pressure) knob A (field altitude) knob MODE switch (MAN/AUTO) RATE knob MAN REG switch (UP/DN) Cabin pressure controller Primary and secondary outflow valves Throttle switches (>35 ±1°) EMER PRESS N switchlight EMER DEPRESS switchlight
Monitor	CABIN altitude indicator FAULT light AUTO FAULT light CABIN PRESS LOW light 10,400 ±300 ft cabin altitude 10,000 ±300 ft cabin altitude (CAA)
Protection	Pressurization controller (self testing) Primary outflow valve (9.1 ±0.10 PSID) Secondary outflow valve (9.3 ±0.10 PSID) Decompression vents