ENVIRONMENTAL CONTROL SYSTEM (ECS)

DESCRIPTION AND OPERATION

The ECS system comprises the following subsystems: bleed air management, environmental control unit (ECU) temperature control air distribution and pressurization.

Bleed Air Management

There are three bleed air sources: APU, engine low-pressure (LP) compressor stage and high-pressure (HP) compressor stage.
APU bleed air is selected by the bleed air selector. Bleed air is extracted from the engines by selecting either R ENG, L ENG or BOTH ENGINES on the ECS selector. APU bleed air is also selected with the ECS selector. LP bleed air is used during climb and cruise conditions, up to 40,000 ft. Selection of HP or LP bleed source is determined by the high pressure bleed air shut-off valve (HPSOV) either by a thrust lever position on ground, or by a low pressure pylon pressure switch in flight. HP bleed is utilized in flight during idle descent and high altitude flights.
Bleed air is extracted from engines or APU for airconditioning and pressurization. The bleed air management system performs the following functions: bleed air source selection, pressure regulation and precooling.

During ground operations, with the APU selected, the ECS provides maximum ground cooling capacity.

The engine bleed air is cooled by the precooling system, located downstream of the APU and consists of a precooler, a precooler bypass valve and a thermostat. The precooler provides additional bleed air cooling during low-pressure operations and enables the use of high pressure bleed air when the low pressure source does not provide minimum cabin ventilation and cooling.

Ram Air

The ram air subsystem has one inlet in the vertical stabilizer root that branches out to three separate exits. The precooler is located in one branch, while the air cycle machine fan, the primary heat exchanger, and the secondary heat exchanger are located in the other. This configuration provides more cooling air flow and no heating of the ram air before the precooler inlet. During ground operation, however, the ACM fan draws air backwards through the precooler, slightly increasing the secondary heat exchanger inlet temperature.
The third branch is the emergency ram air branch which is directed toward the cold air plenum downstream the ECU. This circuit operates only when normal and emergency air are not available.

The engine bleed air flow is split between the precooler and the precooler bypass valve as a function of valve position. The thermostat that controls the bypass valve is set to 300°F which optimizes cooling and total air flow. At temperatures above this 300°F the bypass valve is closed, with all of the bleed flow passing through the precooler.

Bleed Air Overtemperature / Overpressure Protection

Two overtemperature switches are installed in the bleed air system. One overpressure switch is installed upstream of the shutoff valve. The switches provide overtemperature and overpressure indications to the EICAS by the controller.
The overtemperature switches are set to 550°F and the overpressure switch is set to 50 psi.

Emergency Air Pressurization

Emergency air pressurization is operated form the right engine bleed air by selecting EMERG on the ECS mode selector. It allows L.P. bleed air to flow directly into the cabin through an emergency heat exchanger which is cooled by a separate inlet and outlet scoops and reduces the inlet temperature into the cabin.
The pressurized emergency air enters the cabin through two check valves installed on the pressure bulkhead.

Environmental System Control Unit (ECU)

The flow that exits the regulator enters the flow control venturi and then into the primary heat exchanger, where the bleed air temperature is reduced. The air enters the compressor of the three wheel air cycle machine where pressure is increased by the compression process. The secondary heat exchanger removes the heat generated during compression by cooling the air to a temperature near that of ram air.

The air reaches the turbine bypass valve which, if open, diverts most of it directly to the plenum. When the turbine bypass valve is open, the ACM slows down, and the compressor bypass check valve allows bleed air to bypass the compressor. Turbine bypass valve position is controlled by the cabin pressure computer, in response to an altitude signal from the ADC.
At altitude greater than 40,000 ft the turbine bypass valve is open, and during descent through 39,000 ft is closes.

Temperature Control System

The temperature control system has separate controls for cabin and cockpit.
The electropneumatic temperature control system is controlled by the Air conditioning controller (ACC). Air temperatures at the ECU discharge and in the flight deck and passenger cabin zones are automatically regulated. The ACC receives altitude and SAT information.

The automatically controlled supply air temperature is limited to a predetermined value. The low limit sensor setting is 35°F to prevent icing, while the high duct temperature limiter setting is 160°F to protect the furnishing materials and occupants form excessive temperature. The high duct temperature limiter closes the trim air valves if limit is exceeded.

Air Distribution System

Air is distributed in the cabin and cockpit through separate air supply ducts.
The ducts are routed from the cold air plenum, at the ECU outlet through fairing underneath the baggage compartment directly into the pressure floor. Check valves installed in the pressure floor and protect against rapid cabin decompression in case of duct rupture, upstream of the floor.

MODES OF OPERATIONS

Ground Mode

While operating on ground, the outflow valve remains fully open. This mode is maintained if the following conditions are met:

1. Landing gear extended
2. Thrust lever position less than MCR (Max Cruise)
3. Airspeed less than 100 KIAS
4. Aircraft altitude less than 15,000 ft

Takeoff Mode

When the thrust levers are advanced beyond MCR with the aircraft on the ground, the system enters the takeoff (prepressure) mode. This mode eliminates any discernible pressure transients during aircraft climb by allowing the outflow valve to attain a controlling position before lift-off. During the prepressurization mode, the cabin altitude descends, at a maximum rate of 1000 fpm, to an altitude of 250 ± 50 feet below the cabin altitude that existed before thrust lever advance. The prepressurized cabin altitude is maintained until either the thrust levers are retarded, the aircraft becomes airborne, or airspeed exceeds 100 KIAS.

Climb Mode

For normal takeoff, the cabin pressure control system switches directly from takeoff mode to climb mode. The switch is initiated when the CPCS receives airborne signal from the landing gear oleo switch or airspeed exceeds 100 knots.
During climb mode, a schedule of cabin altitude versus aircraft altitude is calculated, based on cabin pressure. This schedule is referred to as the climb schedule, which is different for each takeoff altitude.

Cruise Mode

As the aircraft reaches the desired cruise altitude, the CPCS maintains cabin altitude according to the climb schedule. Once the aircraft has

maintained a stable altitude with no additional climb or descent, the system holds the cabin altitude at the climb schedule value. Stable aircraft altitude is defined as a change of less than ±200 ft from the altitude detected before the system allows changes in cabin pressure.

Descent Mode

Once descent is started, the descent cabin schedule is used in conjunction with the selected landing elevation to generate desired cabin altitude control points. The computed cabin descent schedule altitude is compared to the selected landing altitude, and the higher value is used as the desired cabin altitude. The lowest actual cabin altitude that could be reached is -1000 ft.
Descent is defined as a drop in aircraft altitude of 500 ft or more from the aircraft altitude during cruise. Once descent is initiated, the system stays in descent mode unless the aircraft subsequently climbs, higher than maximum cruise altitude, whereupon it transitions into climb mode. While in descent mode, if the controller detects a true airspeed of 90 knots and either thrust lever is retarded to less than MCR or weight on wheels is sensed, than the controller enters landing mode.

Landing Mode

Under normal conditions, landing mode is entered from descent mode when the aircraft touches down. Upon landing, cabin altitude may be higher or lower than the landing field elevation. In this case, the system equalize cabin pressure to the outside pressure for a period of 60 seconds to comfortably remove any residual pressure (or vacuum) that may remain in the cabin. The maximum rate of cabin altitude decrease is 300 fpm and the maximum rate of increase is 500 fpm.
After 60 seconds the controller goes into ground mode, where the outflow valve fully opens.
Landing mode may also be entered from climb mode, where the 60 seconds of control applies in same manner as when entered form descent mode.

Takeoff Abort

If the thrust levers are retarded prior to lift-off, the controller stops prepressurization. The cabin altitude is rated back to the takeoff field elevation at 500 fpm for 60 seconds. At this point, ground mode is initiated.

Touch and Go

If any time after touchdown before ground mode initiation the thrust levers are advanced to takeoff position, the CPCS immediately enters takeoff (prepressure) mode. If the aircraft becomes airborne again during landing mode before takeoff position is detected, the controller immediately enters descent mode.

Maintenance Test (Verify Mode)

A CPCS maintenance test is initiated at any time during ground operation by turning FIELD ELEV knob counterclockwise five detents past -1000 ft.
Selection of the verify mode initiates a full self-test and system test to identify system faults to the LRU level. Verify mode causes the controller to automatically override all other inputs and faults and takes command of the CPCS.

Manual Mode

Manual mode may be used on ground and flight. This stops cabin altitude in the last commanded position and allows cabin altitude change. Butterfly valve, controlled by CABIN ALT INCR/DCRS knob controls the airflow.
The cabin altitude rate of change than depends on the changes in aircraft altitude and variation in cabin inflow.
While in manual mode, cabin altitude is limited to 14,000 ± 500 ft and rate of change is limited to 8,000 fpm maximum. The pneumatic pressure relief function of the relief valve limits the cabin to ambient differential pressure to 9.0 psi maximum.
Manual mode overrides the automatic mode of operation.

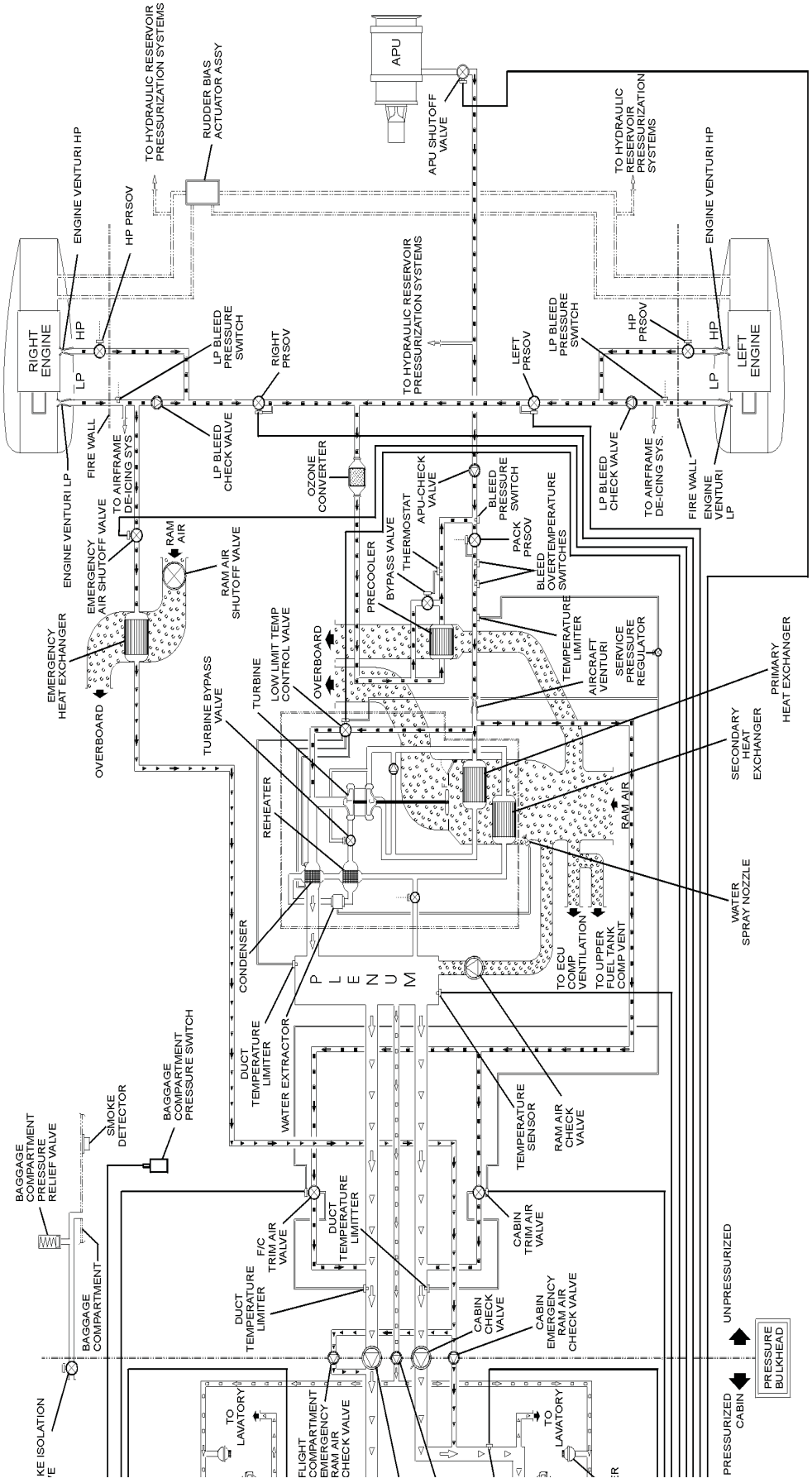

Figure 5-19. Environmental Control System - Schematic (Sheet 1 of 2)

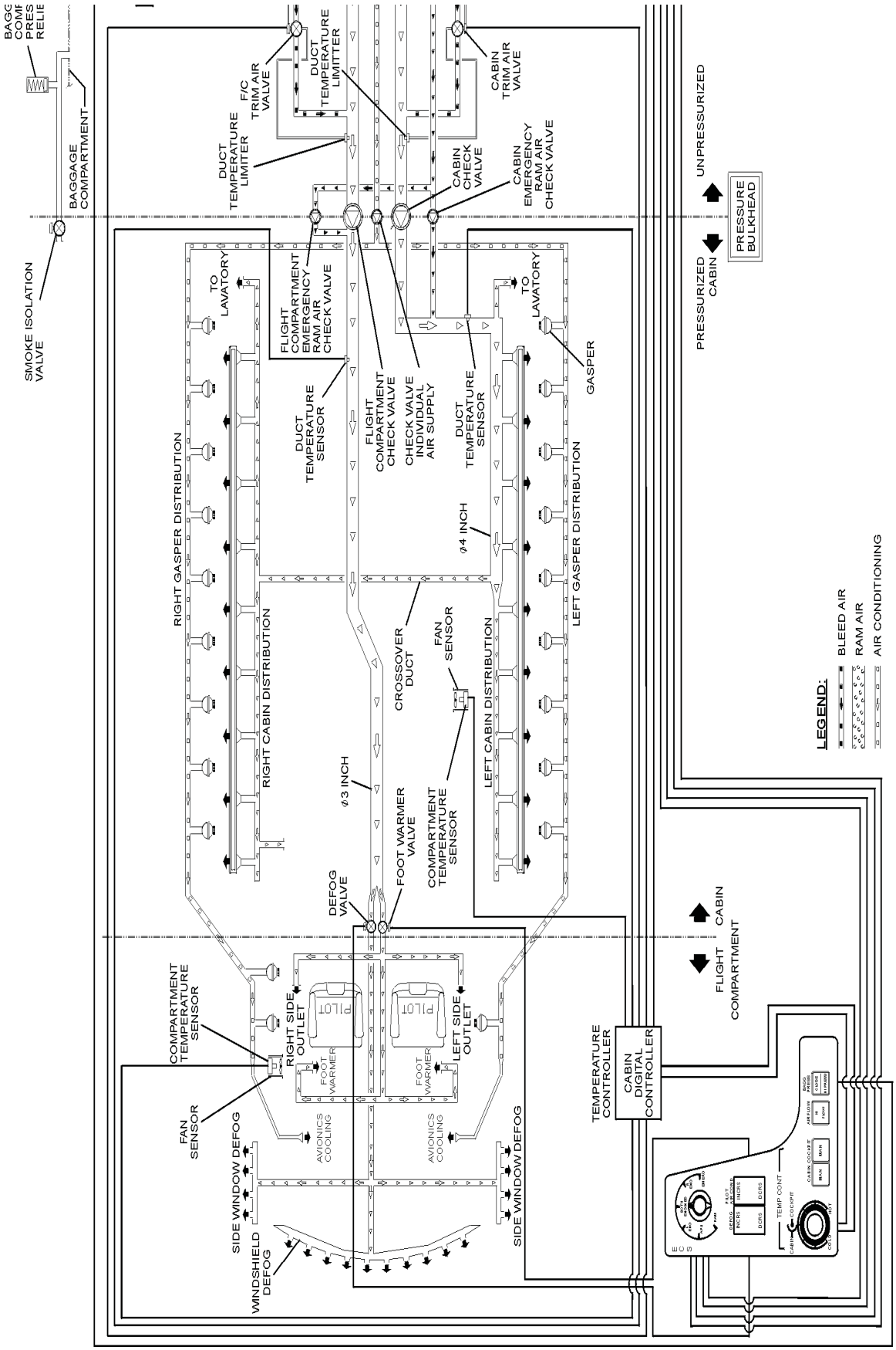

Figure 5-20. Environmental Control System - Schematic (Sheet 2 of 2)

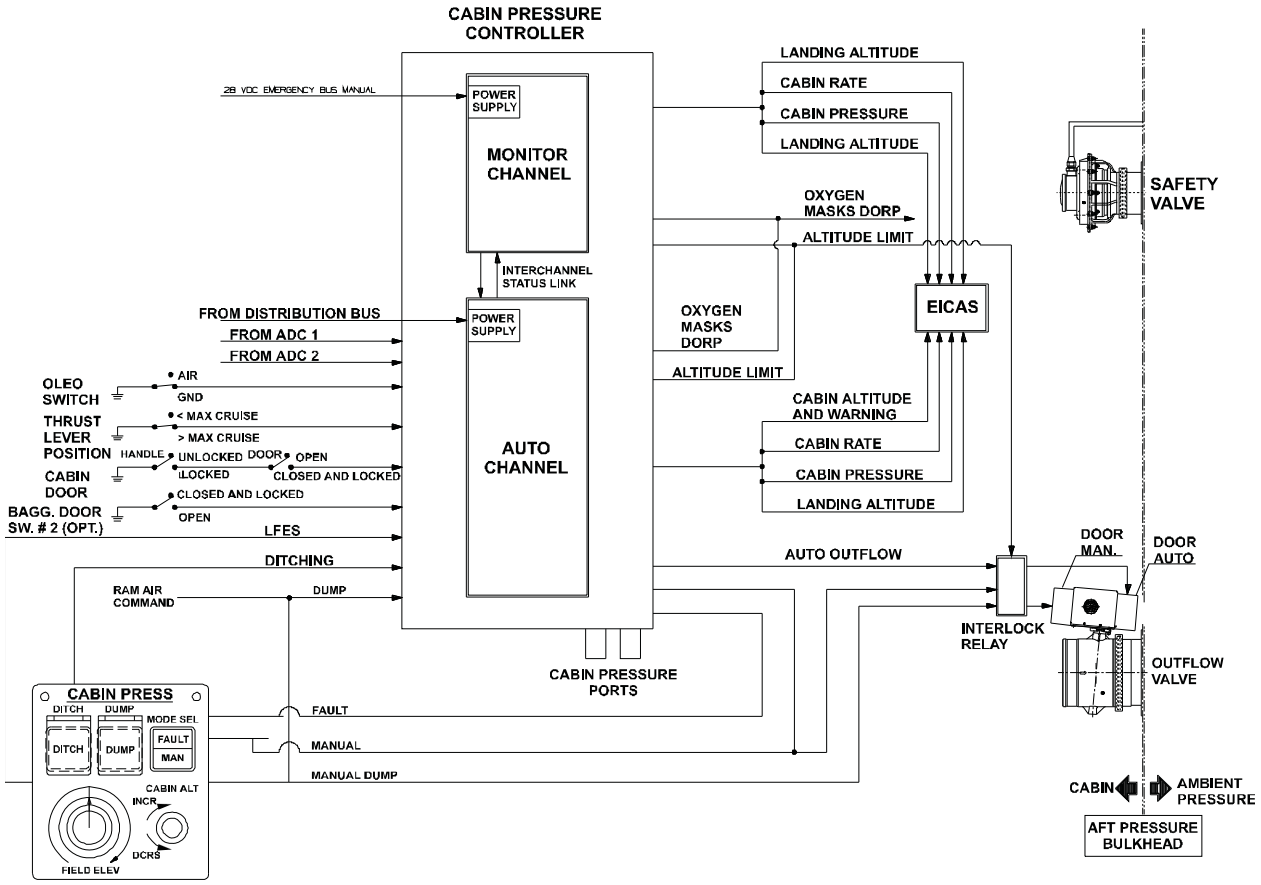

Figure 5-21. Cabin Pressure Control System - Schematic

ENVIRONMENTAL CONTROL SYSTEM CONTROLS AND INDICATORS

FIELD ELEV selector - enables landing field elevation selection in AUTO mode between -1000 ft to 14,000 ft

MODE SEL FAULT/MAN pushbutton - enables selection of MANUAL mode in both flight and ground operations. **FAULT** light comes on after automatic system failure

CABIN ALT INCR / DCRS knob - used to increase or decrease cabin altitude during manual mode of operation. The knob is spring loaded to OFF position.

A green MAN indicator light in FAULT/MAN pushbutton flickers as a function of knob rotation and duration; approximately two flickers provide 500 fpm rate of change

DUMP pushbutton - used to dump cabin pressure

DITCH pushbutton - used to close outflow valve in ditching mode.

CABIN AIR selector - Controls air source shutoff valves according to following positions:

RAM - Closes both engine bleed air supplies and opens outflow valve, simultaneously dumping cabin pressure through outflow valve. Used only as required at altitudes below 13,000 ft. Temperature control is not available in RAM position.

APU - Selects bleed air from APU only

EMERG - Connects R engine, low-pressure bleed air port, directly to mixing plenum in cabin. Provides emergency air pressure source, to prevent cabin decompression, if air-conditioning system fails.

L ENG - Selects bleed air from left engine only.

R ENG - Selects bleed air from right engine only.

BOTH ENGINES - Selects bleed air from both engines

PILOT AIR COND switch - INCRS position increases conditioned air flow to foot warmer and side outlet. DCRS position decreases conditioned air flow to the crew

DEFOG switch - INCRS position increases conditioned air flow for windshield and side window defog. DCRS position decreases conditioned air flow

CABIN MAN pushbutton - Allows selection of automatic or manual control of cabin temperature. MAN position overrides AUTO system.

COCKPIT MAN pushbutton - Allows selection of automatic or manual control of cockpit temperature. MAN position overrides AUTO system

COCKPIT / CABIN HOT COLD selector - Sets the desired cabin or cockpit temperature

BAGG / SMOKE pushbutton/annunciator - Pressed to isolate the baggage compartment from the cabin. **CLOSE** annunciator is on. **CLOSE** annunciator is on also if baggage compartment door is open

Warning Messages

CABIN ALT HIGH - Cabin altitude above 10,000 ft

CABIN DUCT TEMP HI - Excessive duct-air temperature in cabin air ducts

COCKPT DUCT TEMP HI - Excessive duct-air temperature in cockpit air ducts

APU BLEED AIR LEAK - Leak or rupture in APU bleed air ducts

BLEED AIR LEAK (L/R) - Leak or rupture in bleed air ducts

BLEED PRESS/TEMP HI - Excessive pressure or temperature downstream of pack pressure regulator

Caution Messages

AUTO PRESSURIZ - Cabin automatic pressure control system malfunction

BAGGAGE DOOR - Baggage door is unlocked. Baggage compartment pressurization valve automatically closes

BAGGAGE SMOKE - Smoke in baggage compartment

CABIN AUTO TEMP - Cabin automatic temperature control malfunction

COCKPT AUTO TEMP - Cockpit automatic temperature control malfunction

CABIN DOOR - Cabin door is unlocked. Automatic cabin pressure controller reduces pressurization when aircraft is below 14,000 ft

EMERGENCY EXIT - Emergency exit is unlocked

NOSE TEMP HI - Nose compartment temperature exceeds 55°C

Advisory Messages

BAGGAGE SMOKE TEST OK - Successful baggage compartment smoke detector test

PRESSURIZ TEST OK - Successful cabin pressure control system test

Status Messages

PRESSURIZ IN TEST - Cabin pressure control system test is in progress

PRESSURIZ MONITOR - Malfunction in cabin pressure control monitoring

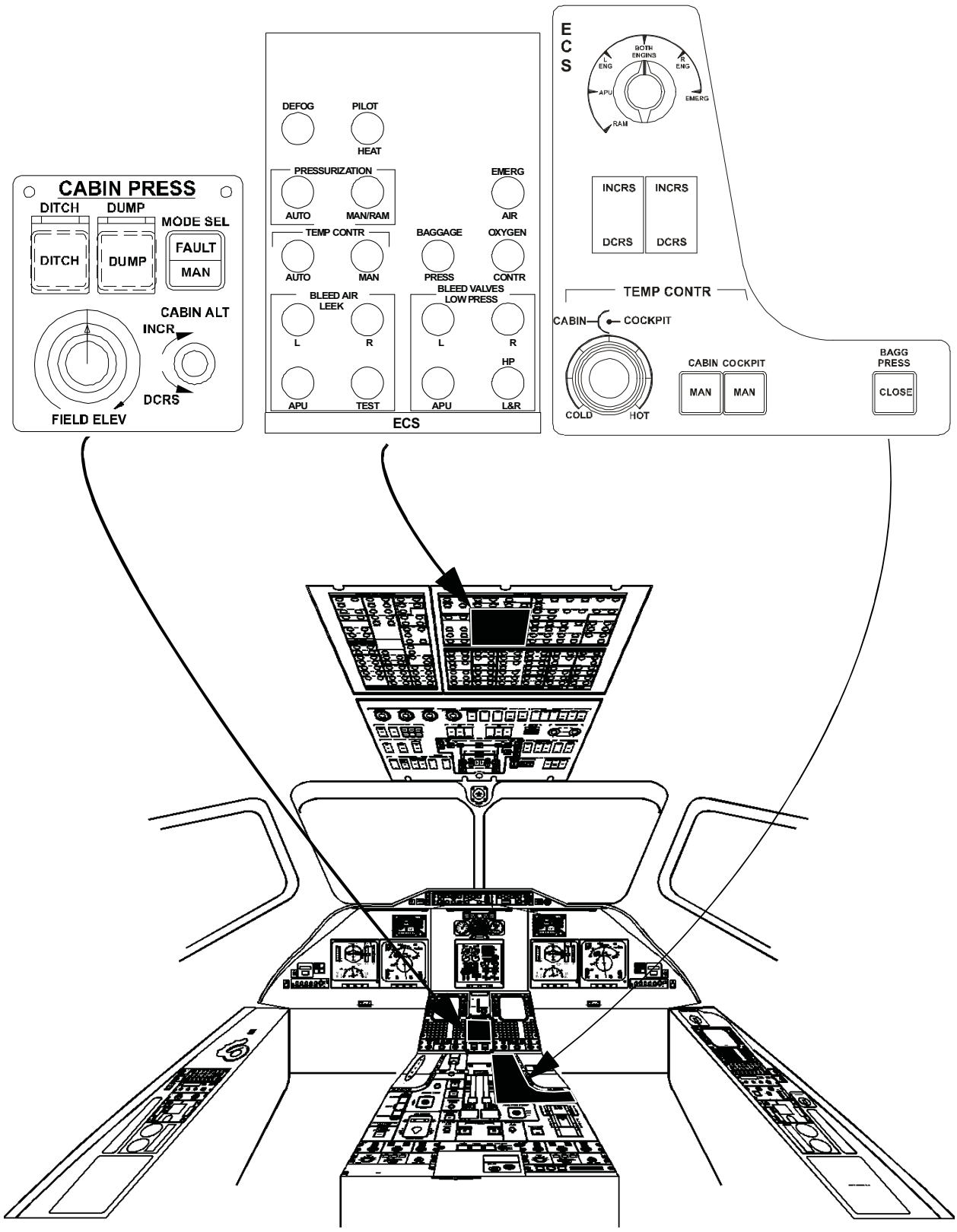

Figure 5-22. ECS Controls and Indicators