2A-21-10: General

The air conditioning system provides pressurized and temperature controlled airflow to maintain a comfortable environment for the occupants of the aircraft and provides a source of equipment cooling.

Hot pressurized air from the compressor sections of the engines or the auxiliary power unit is cooled through a series of processes by the Environmental Control System (ECS) Air Conditioning Packs (ACPs), remixed with some of high temperature bleed air to achieve the desired temperature, and then delivered throughout the airplane. Distribution ducts provide air to the cockpit, passenger cabin, and baggage compartment.

The higher pressure of this airflow allows regulation of the ambient pressure within the airplane to maintain an air density comfortable for breathing even though the airplane may be at the highest operating altitude limit of fifty-one thousand (51,000) feet. Air density within the airplane is controlled by regulating how much of the pressurized conditioned air remains within the aircraft. The airflow leaving the aircraft is regulated by a Thrust Recovery Outflow Valve (TROV) that opens and closes in response to automatic or manual commands to maintain the desired air density level.

The air conditioning system is divided into the following operational subsystems:

- 2A-21-20: Airflow and Temperature Control
- 2A-21-30: Pressurization Control

2A-21-20: Airflow and Temperature Control

1. **General Description:**

   The airflow and temperature control uses Air Conditioning Packs (ACPs) to produce a pressurized and temperature controlled air source to maintain a comfortable atmosphere within the aircraft. (See Figure 1.) The ACPs modify high temperature and high pressure bleed air drawn from the aircraft engines or APU. Either or both engines or the APU may supply the bleed air to the ACPs. Normally the APU is used as a bleed air source on the ground until engines are started; after engine start each engine supplies bleed air to the corresponding side ACP (left engine to left ACP, etc.). The G550 APU is capable of supporting bleed air to the ACPs for takeoff up to fifteen hundred (1,500) feet. This allows full engine power to be used for takeoffs at high-altitude airports or in circumstances of limited runway length, since bleeding air from the engines marginally reduces available takeoff thrust.

   Engine bleed air supplied to the ACPs is taken from the lower temperature and pressure fifth (5^{th}) stage and/or higher temperature and pressure eighth (8^{th}) stage of the engine compressor. Under most operating conditions, fifth (5^{th}) stage bleed air pressure and temperature is adequate for aircraft systems operation. At low power settings, eighth (8^{th}) stage air may be required to meet minimum pressure and/or temperature needs. When the pressure of the eighth stage air exceeds that of the fifth stage, a check valve closes to prevent eighth stage bleed air from entering the engine compressor through the fifth stage bleed valve. The bleed air in the supply manifold is controlled and regulated to forty (40) psi and four hundred degrees Fahrenheit (400°F ± 10), or five hundred degrees Fahrenheit (500°F± 10) when only one engine is available for bleed air. Engine bleed air entering the ACPs is regulated by pack inlet valves to a lesser pressure of thirty-five (35) psi. if both engines are supplying bleed air. If only one engine is available as a bleed air source, the pack inlet valve of the remaining engine opens to allow maximum possible inlet air (within the ACP compressor discharge temperature limit of 425°F).

Immediately prior to entering the ACP, engine bleed air is scrubbed by a chemical reaction within the linings of ozone converters mounted downstream of the pack inlet valves. The ozone converters break down atmospheric ozone into oxygen.

Scrubbed bleed air enters the ACP, first passing over the primary stage of an air to air heat exchanger. The heat exchanger uses ambient air drawn into a ram air scoop in the dorsal fin as a cool air source to initially reduce bleed air temperature. On the ground, ambient air is drawn into the air scoop by a fan powered by the rotation of the ACP turbine (described in the following section). In flight, with high ram air pressure available from increased airspeed, most of the ram air in the inlet bypasses the fan. The ambient cooling air is exhausted through louvers in the lower tail section of the aircraft.

After initial cooling the bleed air is routed to the compressor side of the ACP. Compressor rotation is powered by the turbine side of the ACP. Both the compressor and the inlet duct fan share a common shaft with the turbine section. The spinning motion of the compressor approximately doubles the pressure of the incoming air (in order to drive the turbine side of the ACP) and also warms the air. Some of this warm air (compressor outlet air is limited to 425°F) is ducted to the turbine side of the ACP to prevent icing in the water extraction operation of the condenser and also is used to maintain a minimum air temperature at the inlet to the ACP turbine. Most of the warmer, pressurized air is ducted through a secondary heat exchanger in the ram air duct for recooling.

The cooler pressurized air is routed for additional temperature loss and water extraction. Moisture is removed by passing the air through vanes in the condenser where the air is centrifugally spun, forcing heavier water molecules to the outside of the condenser duct where the water is separated and drained from the ACP. The air is then passed through a heat exchanger where it is warmed to vaporize any remaining moisture.

The air then is directed to impinge on the blades of the turbine section of the ACP, spinning the turbine blades and powering both the compressor side and the inlet duct fan. The energy dissipated in rotating the ACP turbine results in further cooling of the pressurized air. To maintain the turbine discharge air at a temperature sufficient to prevent ice formation, a low-limit valve adds some hot engine bleed air to the exhaust side of the turbine. The temperature moderated cold air is passed through the condenser where the reduced temperature is used to enable the initial water extraction process, and is finally moderated by incorporation of warmer compressor side air from a turbine bypass valve input to produce the final ACP discharge air.

The turbine bypass valve provides an additional function at high altitudes. Above thirty-five thousand (35,000) feet, cabin heating requirements are greater than cabin cooling, and additional airflow is needed to maintain cabin pressurization. For these reasons the turbine bypass valve opens to allow a more direct path for much of the engine bleed air in the final ACP output rather than routing all of the air through the turbine expansion cooling process. A corollary function occurs at thirty-five thousand (35,000) feet - with overall cabin air supply temperatures warmer, additional cooling airflow from the cold air manifold is available for routing to the left and right electronics equipment racks to maintain optimal component operating temperatures.

The modulated ACP airflow of both packs enters into a common cold air manifold for distribution to the aircraft interior. The cold air manifold is paired with a hot air manifold to provide sources of supply for mixing air of different temperatures to achieve a desired comfort level in the cabin and cockpit. (Both the cold and hot air manifolds are located beneath the flooring at the aft section of the passenger cabin - see Figure 2.) The hot air manifold is supplied by two ducts that are connected to each of the ACP bleed air inlets downstream of the ozone scrubbers. The ducts supply air at a nominal temperature of four hundred degrees Fahrenheit (400°F) to the hot air manifold for blending with conditioned air in the cold air manifold.

The aircraft interior is supplied with temperature blended air through three supply ducts:

- Cockpit supply duct
- Forward cabin supply duct (zone one)
- Aft cabin supply duct (zone two)

All three ducts are connected directly with the cold and hot air manifolds through trim air valves. The three trim air valves modulate the amount of hot air admitted into the supply ducts, warming the cold air to achieve the desired temperature at each supplied location. The addition of hot air by the trim air valves is controlled by temperature selector switches on the BLEED AIR / TEMP CONTROL panel on the cockpit overhead.

The forward and aft cabin supply ducts are divided to supply each side of the cabin with air outlets located in the cabin sidewalls at floor level. The cockpit supply duct is split to supply the pilot and copilot sides of the cockpit and at foot level near the rudder pedals. A valve in the cockpit air supply duct allows the flight crew to select either a normal or low airflow. All three supply ducts are fitted with baffled silencers to reduce airflow noise.

A separate gasper duct, connected only to the cold manifold, supplies cold air to the cabin overhead side panel eyeball outlets.

The airflow and temperature control is divided into the following subsystems:

- ACP controls
- Cabin and cockpit temperature controls
- Equipment cooling

2. Description of Subsystems, Units and Components:

A. Air Conditioning Pack (ACP) Controls:

Control switches for the left and right ACPs are located on the BLEED AIR / TEMP CONTOL panel on the copilot side of the cockpit overhead labelled L PACK and R PACK. (See Figure 3). Above the pack switches are the bleed air source control switches that select options for ACP supply. Bleed air supply ducting includes an isolation valve that enables the APU to supply both ACPs, each engine bleed to supply the corresponding ACP (e.g. L ENG to L PACK) or for one engine to supply both ACPs.

After setting the bleed air supply to the ACPs, selecting the L PACK and/or R PACK switch on signals the Air Conditioning Controller (ACC) (located behind a closeout panel in the forward left hand side of the baggage compartment) for that pack to perform the following:

- Open the ACP inlet valve and modulate bleed air intake to meet cooling demands

- Monitor the ACP outlet temperature
- Monitor compressor outlet temperatures, reducing compressor outlet temperature by positioning the ACP inlet valve to minimum flow if temperature exceeds 425°F
- Monitor turbine inlet temperature, warming air entering the turbine by routing it through the reheater if inlet temperature falls to 75°F
- Monitor and open the compressor bypass valve if compressor discharge air pressure is too low
- Open the turbine bypass valve above 35,000 feet to increase airflow to the aircraft interior
- Provide maximum air output during single ACP operation
- Provide monitoring and fault information to the Monitor and Warning System (MWS)

The ACCs are linked to the Modular Avionics Units (MAUs) over ARINC-429 connections for input and output information (the left ACC to MAU #1, right ACC to MAU #2). The ACCs obtain altitude, outside air temperature (OAT) and pack switch information from the Flight Management System (FMS) through the MAUs for ACP control functions (other information pertaining to bleed air status is also used). The ACCs communicate ACP health and status information back to the MAUs to be formatted for ASCB-D data sharing, including the Monitor and Warning System (MWS). If ARINC-429 data connection is lost, the ACCs use default settings for ACP operation to preserve system function. The default mode assumes an aircraft altitude of fifteen thousand (15,000) feet and an Outside Air Temperature (OAT) of zero (0°C). ACP performance degradation in the default mode depends upon actual aircraft altitude and OAT - for instance the turbine bypass valve will not open if the aircraft is above thirty-five thousand (35,000) feet, nor will additional cooling air to the electronic equipment racks be available.

Indirect control of the ACPs is provided by the switches on the ENGINE START panel. (See Figure 4). If the APU is supplying bleed air for the operation of the ACPs prior to engine start, selecting the MASTER CRANK or MASTER START switch ON will shut down the right ACP. Selecting the START L ENG or START R ENG switch to ON will shut down the left ACP. The OFF legend in each pack switch will illuminate while the ACPs are not operating. The ACPs are shut down by the ACC closing the inlet valve of each ACP. When the first engine start is complete, the left ACP inlet valve will open and the left pack will return to normal operation. When the MASTER START switch is selected OFF, the right ACP will return to normal operation. This ACP automatic switching function for engine starts is confined to ground operations by Weight-On-Wheels (WOW) switch position to preclude loss of pressurization during inflight engine starts.

Ambient ram air is normally used only for cooling in the ACP heat exchangers, after which it is exhausted from the aircraft through the louvers on the aft rear section of the fuselage. Some operational circumstances may require use of ambient air within the aircraft rather than conditioned ACP air. In these instances, selecting the RAM AIR switch on the TEMP CONTROL panel to RAM will direct ambient air into the cold and hot air manifolds completely bypassing the ACPs. When the RAM AIR switch is activated, the ACPs will shut down and the aircraft will immediately depressurize (the L PACK and R PACK switches will illuminate OFF). Circumstances that might dictate use of the RAM AIR switch are:

- Overpressurization due to loss of system control
- Smoke removal from the aircraft interior
- Ditching over water

B. Cabin and Cockpit Temperature Control:

The operation of the trim air valves, mixing hot manifold air with cold manifold air, controls the temperature of the air entering the cabin and cockpit. Temperature control selectors on the TEMP CONTROL panel on the cockpit overhead signal the Air Conditioning Controllers (ACCs) to adjust the trim air valves to add or reduce hot air input to achieve the desired temperature. (See Figure 3). There is a rotary temperature control selector for each supply duct: COCKPIT, FWD CABIN and AFT CABIN. The function of each temperature control selector is controlled by the corresponding AUTO / MAN mode switch above the selector. In the AUTO mode, the temperature selector range is from sixty (60 ±2°F) degrees at the COLD setting to ninety (90 ±2°F) at the HOT setting. In the MAN mode, the temperature selector directly controls the position of the trim air valve through the ACC. When selecting temperatures in the MAN mode, the TEMP DISPLAY switch (described in the following paragraphs) should be selected to the DUCT position to avoid a supply duct overheat (at 215 ±15°F) or duct ice formation.

LED temperature displays for the cockpit, forward and aft cabin are positioned above the AUTO / MAN mode select switches on the TEMP CONTROL panel. Each digital display may be selected to one of three readouts by using pushbuttons on the TEMP CONTROL panel:

(1) With the AUTO TEMP SELECT pushbutton set to ON, the temperature readouts display the desired temperatures set with the rotary temperature selectors for each of the three air conditioned areas (e.g. cockpit to 68°F, fwd cabin to 70°F and aft cabin to 72°F).

(2) With the AUTO TEMP SELECT pushbutton set to OFF (illumination extinguished), the TEMP DISPLAY pushbutton may be used to set the digital temperature readout to reflect the actual temperature in the air conditioned areas by depressing the button to the ZONE position (illuminated blue).

(3) With the AUTO TEMP SELECT pushbutton set to OFF and the TEMP DISPLAY pushbutton set to DUCT (illuminated green), the digital temperature readouts reflect the actual temperature in the supply ducts to the air conditioned areas, read from temperature sensors downstream of the trim air valves. The TEMP DISPLAY pushbutton alternates between ZONE and DUCT each time the button is depressed.

Zone temperature readings are taken from temperature sensors that are positioned at variable locations within each zone. Location of the sensors is dependent upon aircraft interior customizing and not fixed in production aircraft. Each temperature sensor has a dedicated fan to circulate zone air over the sensor. There are no controls associated with the fans.

The failure of temperature sensing information, auto temperature control circuits, trim air valves or a supply duct over-temperature will be sensed by the ACCs and a Crew Alerting System (CAS) message initiated prompting the flight crew to attempt manual control of zone temperatures.

C. Equipment Cooling:

Many electronic installations in the aircraft require a specific temperature range for optimum operation. Heat generated by electronic equipment must be dispelled to maintain the required temperature range. Cabin and cockpit conditioned air is used to cool equipment by ducting the airflow in the desired direction and/or fans mounted in equipment racks or integral to the equipment unit. See Figure 5. Fans are installed in:

- Electronic Equipment Racks (EERs): Left (LEER), Right (REER) and Baggage Compartment or Aft (AEER)
- Passenger Services Unit (PSU)
- Display Units (DUs)

The LEER and REER each contain an electrically-powered, two-speed cooling fan. Below thirty-five thousand (35,000’) feet, the fans operate at high speed. Above 35,000 feet, the ACC shifts the fans to low speed, provided both ACPs are operating. If only one ACP is available, fan speed remains high above 35,000 feet. The Left PSU fan pulls air through ducts in the passenger compartment that are fitted with eyeball outlets for passenger ventilation. The speed of the PSU fan also changes at 35,000 feet, but in the reverse of the EER fans - the PSU operates at low speed below 35,000 feet and shifts to high speed above 35,000 feet. The Left PSU duct exhaust is directed into the top of the LEER to assist equipment cooling. LEER airflow is routed through the equipment racks and over the Power Distribution Box (PDB) before exhausting through louvers into the area beneath the forward cabin floor. The Transformer Rectifier Units (TRUs) are located in the compartment beneath the forward cabin floor and are cooled by the exhaust of LEER fan airflow. Airflow is assisted by an integral fan on each TRU. After passing through the underfloor compartment, the air is drawn upward into the bottom of the REER by the action of a cooling fan in the right PDB at the bottom of the REER. The underfloor air cools the PDB and mixes with the cooling air drawn into the top of the REER by the REER fan. The combined flow is then exhausted overboard through the Thrust Recovery Outflow Valve (TROV) that is located behind the REER.

The TROV, shown in Figure 6, has a variable opening to control the rate at which the conditioned air exits the aircraft. Aircraft pressurization is controlled by varying the size of the TROV opening. If the TROV is fully open, the aircraft is not pressurized since the flow of ACP air is not restricted. As the aircraft climbs, the size of the TROV opening decreases to retain more ACP conditioned air within the aircraft, creating a pressurized atmosphere in the interior controlled with the TROV.

The Baggage Compartment or AEER contains a single-speed cooling fan. The fan operates whenever the Left Main DC bus is powered and the fan circuit breaker is closed.

Each Display Unit (DU) has an integral fan that operates whenever the DU is powered.

All EER fans are monitored for failure. Temperature sensors in the areas cooled by the fans provide indications of degraded operation resulting in equipment overheating. Any detected failure is displayed as a message on the CAS window.

3. Controls and Indications:

(See Figure 3 through Figure 5.)

Airflow and temperature controls are depicted graphically on the ECS / Press synoptic 2/3 window display. The synoptic window contains:

- Cabin zone actual, selected and duct temperature digital readouts
- ACP outlet temperature digital readout
- Information on the bleed air system and cabin pressurization control settings

The ECS / Press system 1/6 window display contains the same digital readout information without the graphic of system components.

NOTE:

A detailed description of the ECS / Press synoptic page appears in Section 2B-07-00.

A. Circuit Breakers (CBs):

The following CBs protect the airflow and temperature control:

Circuit Breaker Name:	CB Panel:	Location:	Power Source:
L PACK CONT	LEER	D-10	L ESS DC Bus
R PACK CONT	REER	D-9	R MAIN DC Bus
FWD CABIN SENSOR FAN	LEER	D-9	L MAIN DC Bus
L EER FAN	LEER	D-8	L MAIN DC Bus
R EER FAN	LEER	D-7	L MAIN DC Bus
CAB AUTO TEMP	LEER	E-11	L ESS DC Bus
CKPT AUTO TEMP	REER	E-8	R ESS DC Bus
AFT CABIN SENSOR FAN	LEER	E-9	R MAIN DC Bus
CAB MAN TEMP	LEER	F-11	L MAIN DC Bus
CKPT MAN TEMP	REER	F-8	R MAIN DC Bus
AFT EQ FAN	LEER	F-8	L MAIN DC Bus
CKPT AIR-FLOW CONT VLV	REER	F-10	R ESS DC Bus
L PSU FAN	LEER	F-7	L MAIN DC Bus

B. Crew Alerting System (CAS) Messages:

The following CAS messages are associated with the airflow and temperature control system:

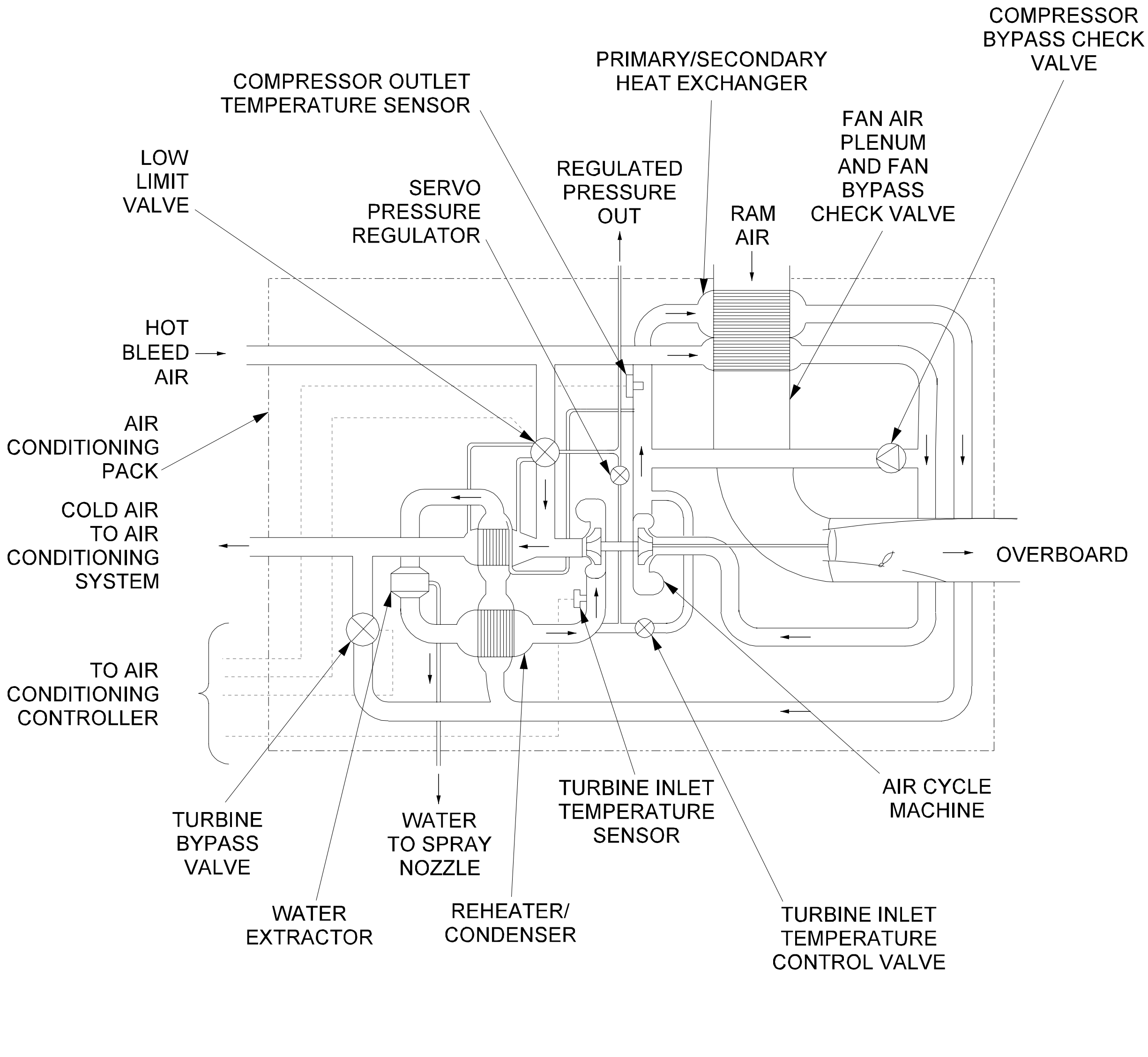
Area Monitored:	CAS Message:	Message Color:
Aft EER	Aft Equipment Hot	Red
Aft EER	Baggage EER Hot	Amber
L / R turbine inlet temperature (ACC)	L-R Cool Turbine Hot	Amber

Area Monitored:	CAS Message:	Message Color:
L / R ACC	35K Altitude Trip Fail	Amber
L / R ACC	L-R ACS Fail	Amber
R ACC forward cabin duct	Select Manual Temperature F	Amber
L ACC aft cabin duct	Select Manual Temperature A	Amber
L ACC cockpit duct	Select Manual Temperature C	Amber
DUs	DU 1-2-3-4 Overheat	Amber
TRUs	L-R Main TRU Hot	Amber
TRUs	Aux TRU Hot	Amber
TRUs	L-R Essential TRU Hot	Amber
EERs	L-R EER Hot	Amber
PDBs	L-R PDB Overheat	Amber
L / R ACC	L-R ACS Maintenance	Blue
L / R ACC ARINC link	L-R ACS Default Mode	Blue
Aft cabin temp fan speed	Aft Cabin Temp Fan Fail	Blue
Aft EER fan speed	Aft Equipment Fan Fail	Blue
Forward cabin temp fan speed	Forward Cabin Temp Fan Fail	Blue
L PSU fan speed	L PSU Fan Fail	Blue
L / R EER fan speeds	L-R EER Fan Fail	Blue

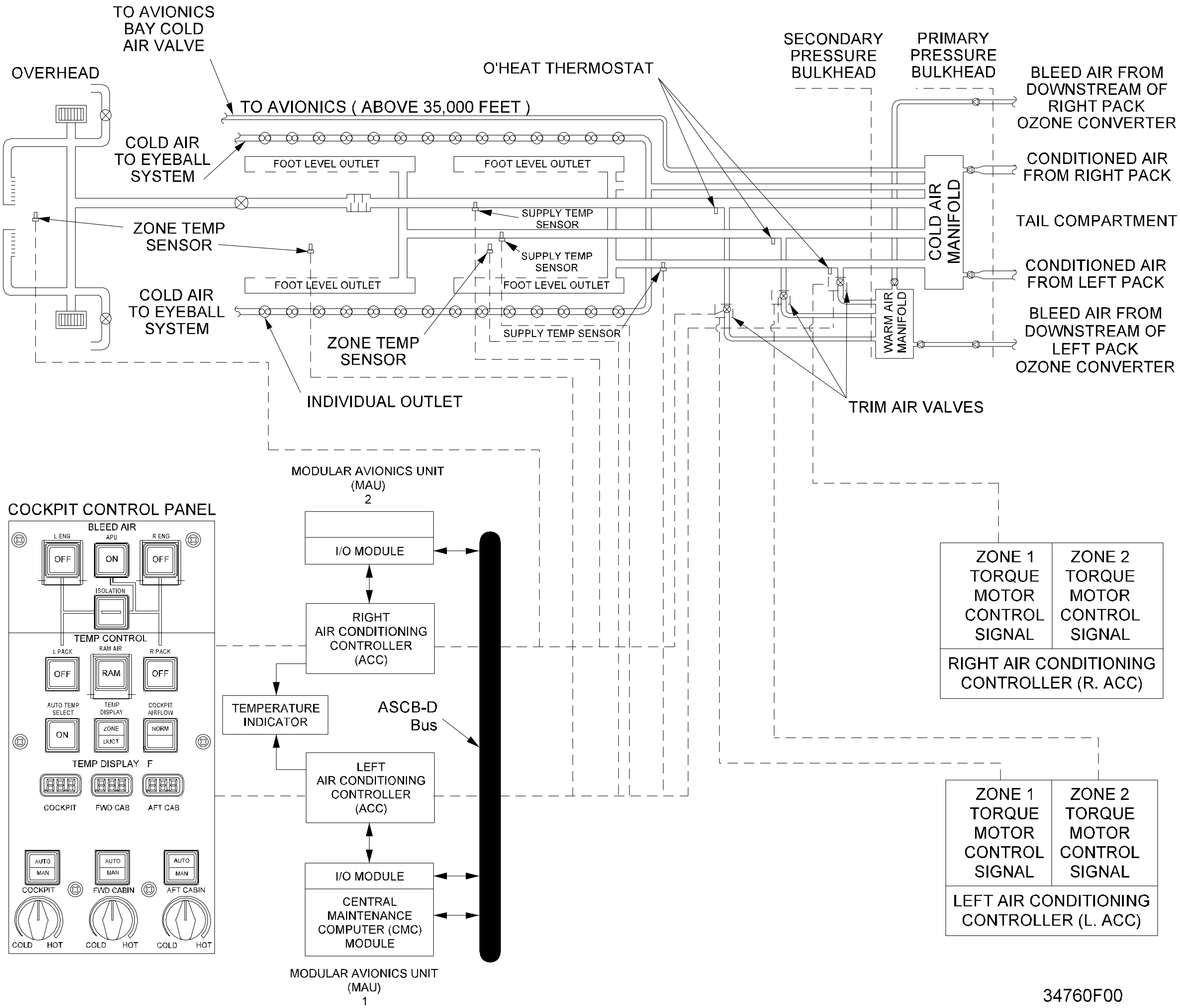
4. Limitations:

A. Flight Manual Limitations:

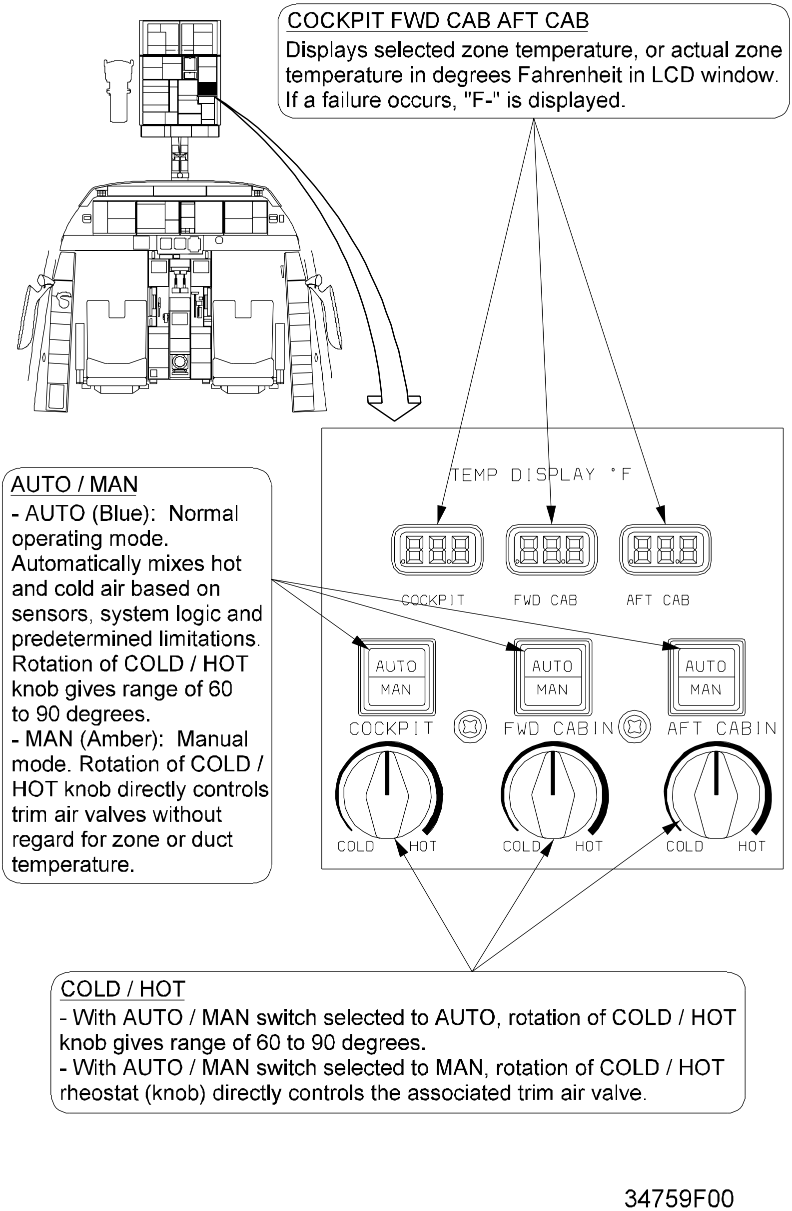
There are no limitations established for airflow and temperature control at the time of this writing.



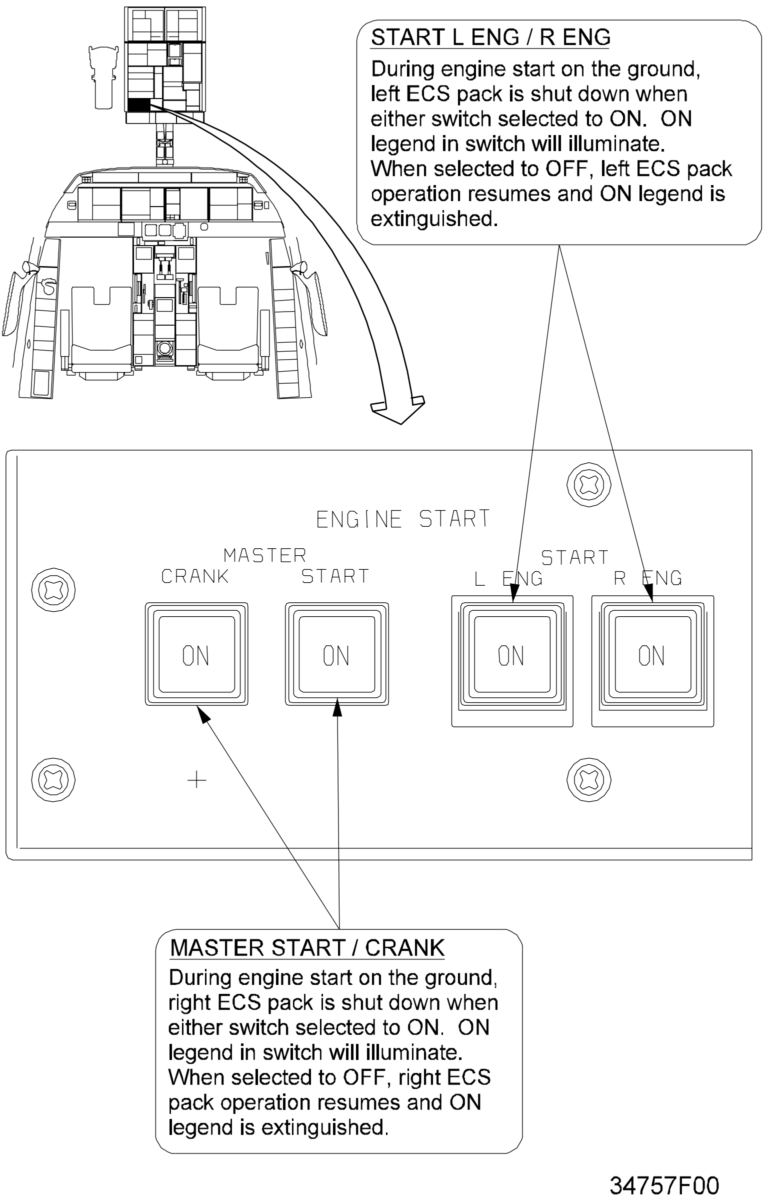
Air Conditioning Pack
Simplified Block Diagram
Figure 1



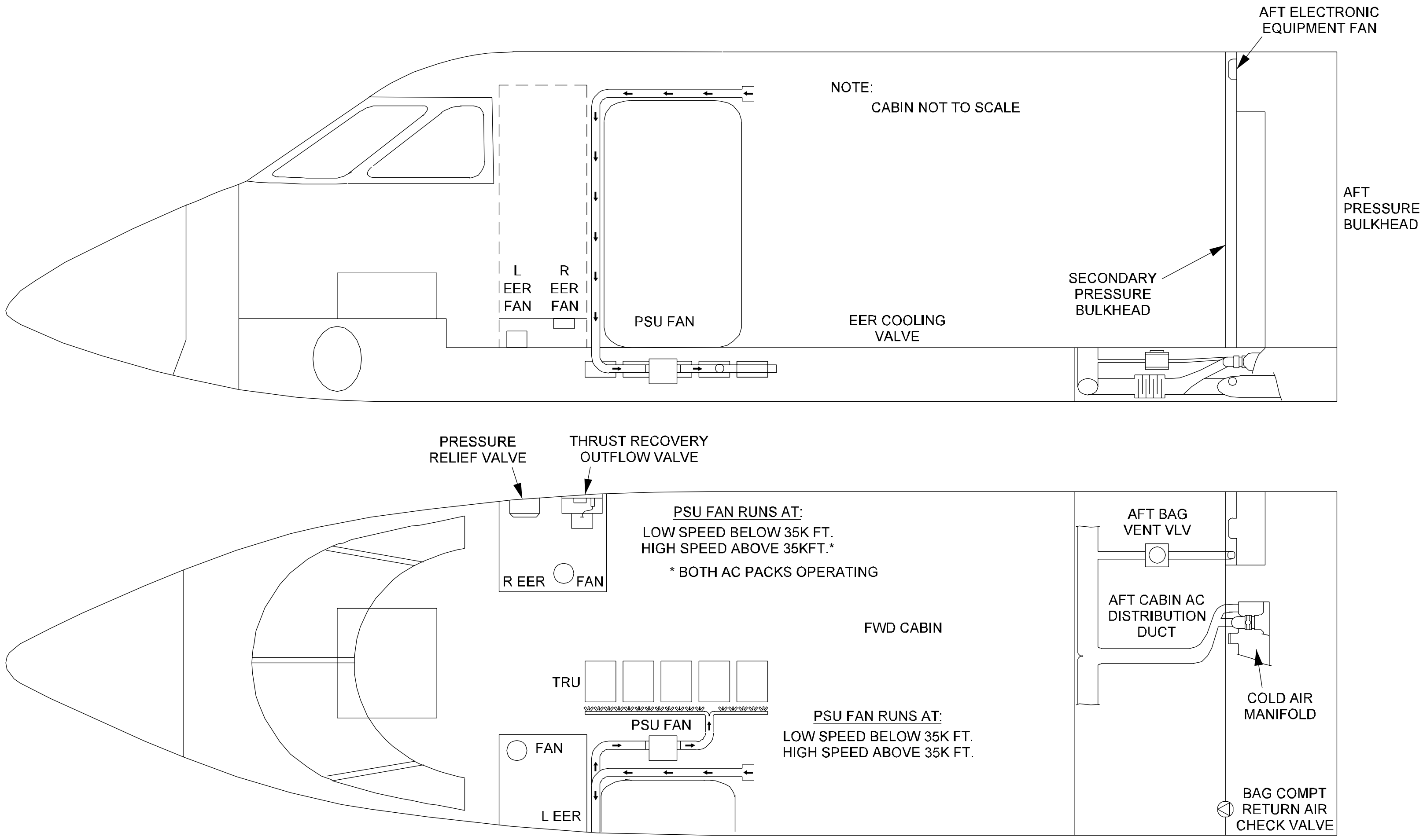
Airflow and Temperature Control Simplified Block Diagram
Figure 2



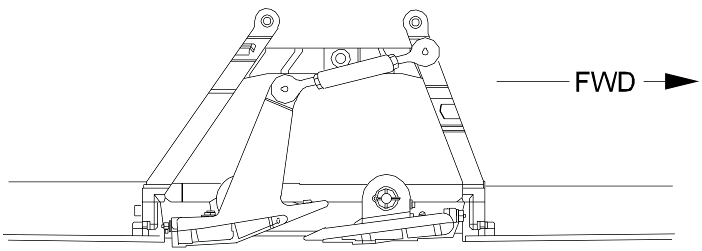
Temperature Control Panel
Figure 3



Engine Start Control Panel
Figure 4



Equipment Cooling Fans
Figure 5



Thrust Recovery Outflow Valve
Figure 6

2A-21-30: Pressurization Control

1. General Description:

The atmosphere within the pressurized section of the aircraft fuselage is regulated to maintain a density range sufficient for breathing without supplemental oxygen, approximating conditions of the ground environment. The air within the aircraft cabin and cockpit can be controlled to the equivalent of sea level atmospheric pressure up to an aircraft altitude of approximately thirty-one thousand (31,000) feet at a differential pressure limit of 10.28 psi on the pressurized cabin structure. In normal operations, the air within the cabin and cockpit is maintained at a pressure equivalent of six thousand (6,000) feet above sea level at cruising altitudes up to fifty-one thousand (51,000) feet.

Pressurization is controlled by regulating the escape of conditioned air produced by the Air Conditioning Packs (ACPs). Conditioned air is released from the aircraft through the Thrust Recovery Outflow Valve (TROV). The TROV, shown in Figure 6, changes the size of the opening available for release of conditioned air, thereby maintaining the desired pressure level within the aircraft.

The TROV is electrically operated in response to commands from the Cabin Pressure Controller (CPC) that has three modes of operation: automatic (AUTO), semi-automatic (SEMI) and MANUAL. The modes of operation are selected with switchbuttons on the CABIN PRESSURE CONTROL panel on the cockpit overhead (see Figure 8). System performance can be monitored on the CABIN PRESSURE SELECTOR PANEL, mounted in the cockpit center console to the right of MCDU #3 (see Figure 9). The selector panel has digital readouts of aircraft altitude, cabin altitude, landing field elevation, barometer setting and cabin altitude rate of change (climb or descent). With the CPC in the AUTO mode, the digital readouts passively monitor system operation. If the CPC mode defaults to SEMI mode or is selected to MANUAL mode, rotary selector knobs corresponding to the digital readouts become active to provide command inputs to control pressurization.

Because the correct operation of the pressurization system is critical to passenger and crew safety, system components are highly redundant. The TROV may be operated by any of three electrical actuators (motors), two powered by 115V AC current and the other by 28V DC current. The CPC, in addition to the three operational modes, has two control channels available for AUTO and SEMI mode operation. Data for the control channels can be provided by Air Data Modules (ADMs) #1, #2 or #3. In MANUAL mode, cabin altitude data is obtained directly from the separate Cabin Pressure Acquisition Module (CPAM) that shares static pressure inputs with the standby instruments. If all control of pressurization is lost, a Cabin Pressure Relief Valve (CPRV) will open to relieve overpressure to prevent structural damage to the fuselage, windows and doors. The CPRV also opens to prevent negative pressure within the aircraft, both to prevent damage and to facilitate opening normal exit doors or emergency exit windows.

Although the baggage compartment is pressurized during flight to allow passengers access to personal luggage, a smoke removal valve above the door between the cabin and baggage compartment can depressurize the baggage compartment in flight to aid in evacuating noxious fumes or smoke from the cabin.

The components of the pressurization system are:

- Trust Recovery Outflow Valve (TROV)
- Cabin Pressure Controller (CPC)

- CABIN PRESSURE CONTROL panel
- CABIN PRESSURE SELECTOR panel
- Cabin pressure indications
- Cabin Pressure Acquisition Module (CPAM)
- Baggage compartment shutoff and smoke removal valves
- Cabin Pressure Relief Valve (CPRV)

2. Description of Subsystems, Units and Components:

A. Thrust Recovery Outflow Valve (TROV):

The TROV is a new design for the G550. Previous aircraft incorporated a round opening with a butterfly-type valve to exhaust pressurized air from the fuselage. Although this type of outflow valve performed well, the structure of the opening and valve created measurable drag on the aircraft, resulting in additional thrust requirements from the aircraft engines to maintain selected airspeed. The design of the TROV eliminates much of the drag of previous designs, thus recovering the additional thrust required by the older type valves.

The aerodynamic shape of the TROV has two opposable shutters mounted vertically within a square frame. The forward shutter pivots outward and the aft shutter pivots inward to provide an opening to exhaust pressurized air. The size of the opening created by shutter movement controls aircraft pressurization.

The shutters are positioned by one of three electrical drive motors (two AC and one DC). Linkages between the shutters ensure symmetrically opposite movement. The operating drive motor rotates a gear mechanism that moves the shutters. The design of the gears is such that positive motor input is required to move the shutters in either direction. This prevents shutter movement and loss of pressurization control in the event of electrical system malfunctions or failure.

When the CPC is operating in AUTO or SEMI mode either of the 115V AC motors is available to move the TROV shutters. Each motor is associated with one of the two CPC control channels (#1 and #2). To preserve the longevity of the pressurization system components, the active channel switches with every flight (CPC logic requires that the aircraft be on the ground with weight on wheels, be fully depressurized for one minute with the TROV fully open before control channels swap - the logic avoids repetitive changes during touch and go landings). If the AC motor normally associated with the active control channel malfunctions, the CPC will automatically switch to the remaining AC drive motor. If a malfunction or failure of the 115V AC power system renders both motors inoperative, the CPC will signal the failure to the flight crew, prompting selection of MANUAL mode. In manual mode the DC motor positions the TROV shutters using switch commands directly from the cabin pressure control panel, bypassing the CPC.

Failure of a single CPC channel is annunciated on the Crew Alerting System (CAS) display window as a blue CPCS Channel (1 or 2) Fail advisory. Failure of both channels prompts an amber CPCS Fail - Select Manual caution CAS message and illuminates the FAULT section of the FAULT / MANUAL pushbutton on the cabin pressure control panel. If the TROV malfunctions (independent of the operating control system) a blue

Outflow Valve Fault advisory CAS message is displayed.

B. Cabin Pressure Controller (CPC):

The dual channel digital CPC is installed in the Right Electronic Equipment Rack (REER). The CPC is linked via ARINC-429 bus connections to MAU #1 and #2, ADM #1, #2 and #3, FMS #1 and #2, and wire connections the CPAM and the cabin pressure indicator above the cabin pressure control panel. See Figure 7. The CPC uses the ADM and FMS connections for required data in the AUTO or SEMI mode and communicates through the MAUs and integrated Accelerated Graphics Modules (AGMs) for display of pressurization information on synoptic and system windows on the Display Units (DUs). Hardwire connections provide commands to the AC powered TROV motors, feedback of TROV shutter position, inputs from weight-on-wheels switches, door position switches, selector switches on the cabin pressure control panel, and the CPRV.

The CPC operates in AUTO or SEMI mode using one of the two control channels to position the TROV, regulating cabin pressurization. The active control channel changes with every complete flight cycle, but there is no indication of the channel in use unless there is a channel failure CAS message. During normal operation in the AUTO mode, the CPC derives information from the active FMS for aircraft airspeed, landing field altitude, aircraft rate of climb or descent and uses ADM input for aircraft pressure altitude and barometric correction. CPC channel #1 defaults to ADM #1 with ADM #3 as primary backup, then ADM #2. Channel #2 defaults to ADM #2 with ADM #3 as primary backup, then ADM #1. The CPC unit has an integrated cabin altitude sensor that furnishes data to the active control channel. During CPC AUTO mode, no crew action is required and the cabin pressure selector panel serves only as a display of pressurization information.

In typical flight operations with the CPC in AUTO mode, the pressurization sequence begins with a pre-pressurization phase during takeoff. With the FLIGHT / LANDING pushbutton on the cabin pressure control panel selected to FLIGHT, taxi speed ≥ nine (9) knots, the power levers to the takeoff position, and a cabin or baggage door previously opened and closed, the CPC signals the TROV to a position to pressurize the aircraft to five hundred (500) feet below field altitude. As the aircraft climbs, software in the CPC controls cabin altitude, ascending the cabin at a software programmed rate (up to 500 fpm) to a maximum cabin altitude of six thousand (6,000) feet. When the aircraft starts a descent, the CPC uses FMS data for distance to landing airfield, airfield elevation and ground speed to set up a descent rate (up to 300 fpm) for the cabin such that the cabin altitude will be slightly below landing airfield elevation at touchdown. After touchdown, with weight-on-wheels, the TROV opens to depressurize at a rate of 500 fpm for one minute, 2,000 fpm for the second minute, then goes to a full open position. The CPC then swaps control channels for the next flight evolution.

The TROV will also automatically close upon engine shutdown to prevent the entry of debris or other extraneous matter (birds, insects, etc.) that might interfere with system operation.

If a malfunction or failure causes the loss of both CPC control channels, CAS messages alert the crew to select the MANUAL mode with the FAULT

/ MANUAL pushbutton on the cabin pressure control panel (the FAULT indication will be illuminated until MANUAL is selected, then MANUAL will be illuminated). In the MANUAL mode the crew controls the TROV directly by using the rotary switch labelled MAN HOLD. The switch is spring-loaded to the neutral position. Rotating the switch to the left closes the shutters of the TROV and descends cabin altitude; rotation to the right opens the shutters and climbs cabin altitude. The opening and closing rate of the TROV shutters is proportional to the directional displacement of the knob. Position of the TROV shutters is indicated to the right of the rotary knob. Whenever the TROV shutters are moving an amber light above the position indicator will flash at a rate proportional to the speed of shutter movement.

Positioned directly above the MAN HOLD knob is an indicator panel containing a digital cabin altitude readout labelled CABIN ALT FT, a digital indication of cabin differential pressure in psi labelled DFRN PRESS, and an analog cabin rate of change indicator labelled RC. In MANUAL mode, the flight crew moves the shutters of the TROV with the MAN HOLD rotary knob and monitors pressurization parameters with the indicators above the knob.

Certain CAS messages will be displayed in the event of pressurization limits are exceeded. If the cabin altitude exceeds eight thousand (8,000) feet, a red Cabin Pressure Low CAS warning will be displayed. If the aircraft is in coupled flight (autopilot engaged) at an altitude of forty thousand feet (40,000 ft) or above when the cabin altitude reaches 8,000’, the aircraft will enter an emergency descent mode, turning left ninety (90°) degrees and beginning a rapid descent to fifteen thousand (15,000) feet. This feature is incorporated for protection in the case of an incapacitated flight crew.

NOTE:

> The cabin pressure low trip point of 8,000’ cabin altitude will be automatically reset in AUTO mode when landing at high altitude airports. If the landing airfield elevation is between 7,500’ and 9,400’, the cabin low pressure warning will be reset to trip at a cabin altitude of 10,000’. If landing field elevation is greater than 9,400’, the trip point will be reset to 14,500’. If the aircraft is operating in the SEMI pressurization mode, the flight crew should insure that the correct landing field elevation is set in the cabin pressure selector panel.

NOTE:

> Automatic deployment of passenger oxygen masks occurs at 13,000’ (±500) cabin altitude.

Other CAS messages are displayed in circumstances when the cabin is over-pressurized and poses a structural hazard to the fuselage, cabin window seals and door seals. Over-pressurization may occur in extremely rapid climbs to altitude where the pressurization rate of climb cannot keep pace with aircraft altitude. An amber caution CAS message is displayed at a pressure differential of 10.28 psi, and a red warning CAS message is displayed at a pressure differential of 10.48 psi. The Cabin Pressure Relief Valve (CPRV) should begin to open between 10.18 and 10.40 psi differential to vent the excess cabin pressure.

A Built-In-Test (BIT) function resides in each channel of the CPC. The BIT provides a cross-check of the measured cabin pressure, ADM inputs, FMS inputs and discretes. Each channel performs a BIT on the active TROV shutter motor. Any detected faults or failures are displayed either as CAS messages and ECS / Press synoptic or system window notation or stored in the Central Maintenance Computer (CMC) database for later retrieval.

C. CABIN PRESSURE CONTROL Panel:

The CABIN PRESSURE CONTROL panel on the cockpit overhead provides pushbutton switches and a rotary (spring-loaded neutral) knob for pressurization mode selection and manual control (see Figure 8). An indicator of TROV shutter position is also furnished. The pushbutton switches are illuminated to indicate the active pressurization mode. The FAULT portion of the FAULT / MANUAL pushbutton also serves as an indication of AUTO and SEMI mode failure. Selections on the panel enable the flight crew to perform and control the following functions:

- Select the AUTO, SEMI or MANUAL mode of operation.
- Select the FLIGHT or LANDING mode of operation.
- Manually position TROV shutters to open or close, or to any intermediate position.
- Monitor the rate of TROV shutter movement.

D. CABIN PRESSURE SELECTOR Panel:

The CABIN PRESSURE SELECTOR panel is located on the aft right side of the cockpit center pedestal (see Figure 9). Panel feature functions are contingent on the mode of operation of the pressurization system:

- With the pressurization system in the AUTO mode, the CABIN PRESSURE SELECTOR panel digital Liquid Crystal Displays (LCDs) display FMS and ADM data currently in use by the CPC. The rotary selector knobs are disabled.
- With the pressurization system in the SEMI mode, the rotary selector knobs are active and are used in conjunction with the LCD displays to enter aircraft / cabin altitude, barometric correction, landing field elevation and cabin rate of climb / descent.

E. Cabin Pressure Indications:

The cabin pressure is monitored with the indicator labeled CABIN ALT FT, located above the CABIN PRESSURE CONTROL panel (see Figure 10). The indicator has digital displays for cabin altitude and cabin differential pressure. An analog dial displays cabin rate of change with a conventional needle pointer.

F. Cabin Pressure Acquisition Module:

The Cabin Pressure Acquisition Module (CPAM) is located in the bottom section of the Right Electronic Equipment Rack (REER). It is a self-contained unit with a dedicated connection to the aircraft static pressure lines and an independent cabin pressure sensor. If a CPC control channel senses invalid cabin pressure data, it first compares the cabin pressure data with the information formulated by the other inactive control channel. If the data do not agree, the active control channel compares data with information from the CPAM to decide information validity.

When operating in MANUAL mode, only CPAM data is available for cabin pressure altitude and cabin differential pressure. CPAM data in manual mode is displayed in the digital cabin pressure indicators above the CABIN PRESSURE CONTROL panel.

G. Baggage Compartment Shutoff and Smoke Removal Valves:

The baggage compartment is pressurized during flight to allow passenger access to personal belongings. Conditioned air is routed through a baggage compartment shutoff valve into cooling ducts to flow over the electronic equipment in the baggage compartment racks. The shutoff valve will close at a differential of between 1.5 to 3.2 psi if the baggage compartment becomes depressurized to prevent deterioration of cabin pressure. A blue advisory CAS message of “Baggage Compartment Low Pressure” will be annunciated if a pressure differential reaches four (4) psi between the cabin and the baggage compartment.

The door separating the passenger compartment and the baggage compartment is normally closed unless access is required. When closed, the door acts as a secondary pressurized bulkhead. Since the baggage compartment is normally pressurized to a slightly higher level than the passenger compartment to induce air flow, a split flapper vent valve in the top left of the internal baggage compartment door allows the higher pressure air to into the cabin. The valve is hinged to allow airflow only into the cabin, and will close if the baggage compartment becomes depressurized to prevent loss of cabin air through the baggage compartment.

The baggage compartment may be deliberately depressurized to remove smoke from the interior of the aircraft. A manually operated valve, installed above the baggage compartment access door on the cabin side, provides smoke removal. (The valve is shown in Figure 11). Rotating the valve handle from the NORMAL OPS position to the VENT SMOKE position opens an air vent into the baggage compartment and deflates the seal on the baggage compartment external access door, depressurizing the baggage compartment. Contaminated air within the aircraft will then flow into the baggage compartment and exit the aircraft around the collapsed external door seal. Once smoke is removed, returning the valve to the NORMAL OPS position allows repressurizing of the baggage compartment by re-inflating the external door seal.

H. Cabin Pressure Relief Valve (CPRV):

The CPRV is located under the lower shelf of the REER, adjacent to the TROV. It prevents excessive positive or negative pressures from damaging the aircraft fuselage, doors and window and associated seals. The CPRV provides:

- Positive differential pressure relief at 10.18 to 10.40 psi
- Negative differential pressure relief at -0.25 psi
- Cabin repressurization rate limiting
- Additional outflow capability during ground operations

During ground operations when the TROV is fully open, the cabin pressure relief valve also opens to ensure a minimal differential cabin pressure with high ACP output.

3. Controls and Indications:

(See Figure 8 through Figure 10.)

A. Circuit Breakers (CBs):

The following CBs protect the pressurization system:

Circuit Breaker Name:	CB Panel:	Location:	Power Source:
CAB PRESS CHAN 1	LEER	D-11	ESS AC Bus
CAB PRESS CHAN 2	REER	D-8	R Main AC Bus
CAB PRESS MAN CONT	LEER	E-8	L ESS DC Bus
CAB PRESS RELIEF VLV	REER	E-10	R Ess DC Bus
CAB PRESS IND	REER	E-11	R Ess DC Bus

B. Crew Alerting System (CAS) Messages:

The following CAS messages are associated with the pressurization system:

Area Monitored:	CAS Message:	Message Color:
CPC / CPAM	Cabin Differential — 10.48	Red
CPC / CPAM	Cabin Pressure Low	Red
CPC / CPAM	Cabin Differential — 10.28	Amber
CPC	Cabin Pressure Manual	Amber
CPC	CPCS Control Panel Fail	Amber
CPC	CPCS Fail — Select Manual	Amber
CPC	CPCS Low Air Flow	Amber
CPAM	CPAM Fail	Amber
FMS data	Cabin Pressure Semiauto	Blue
CPC	CPCS 1-2 Fail	Blue
CPC	CPCS Channel 1-2 Fail	Blue
FMS data	CPCS Landing Elevation Fail	Blue
CPC	CPCS Maintenance Required	Blue
CPC	CPCS Select Panel Fault	Blue
TROV position	Outflow Valve Fault	Blue
BAG Compartment	Baggage Compartment Low Pressure	Blue
Internal Baggage Compartment door open position	Internal Baggage Door	Blue

4. Limitations:

A. Flight Manual Limitations:

(1) Cabin Pressurization Control:

(a) Maximum cabin pressure differential permitted is 10.48 psi.

(b) Maximum cabin pressure differential permitted for taxi, takeoff or landing is 0.3 psi.

(2) Internal Baggage Door:

(a) General:

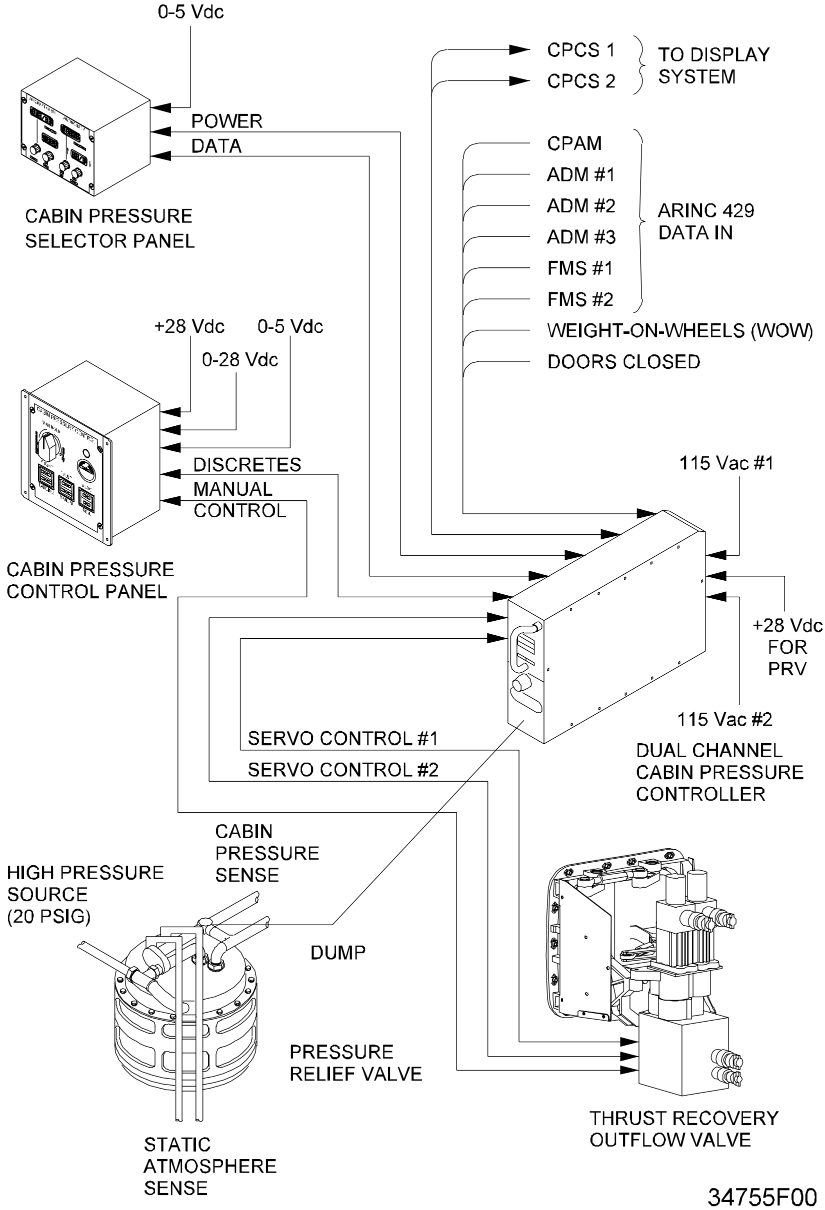
The internal baggage door shall remain closed above 40,000 feet. Access to the baggage compartment above 40,000 feet is permitted, provided the door is closed after exiting the compartment.

(b) When Above 40,000 Feet:

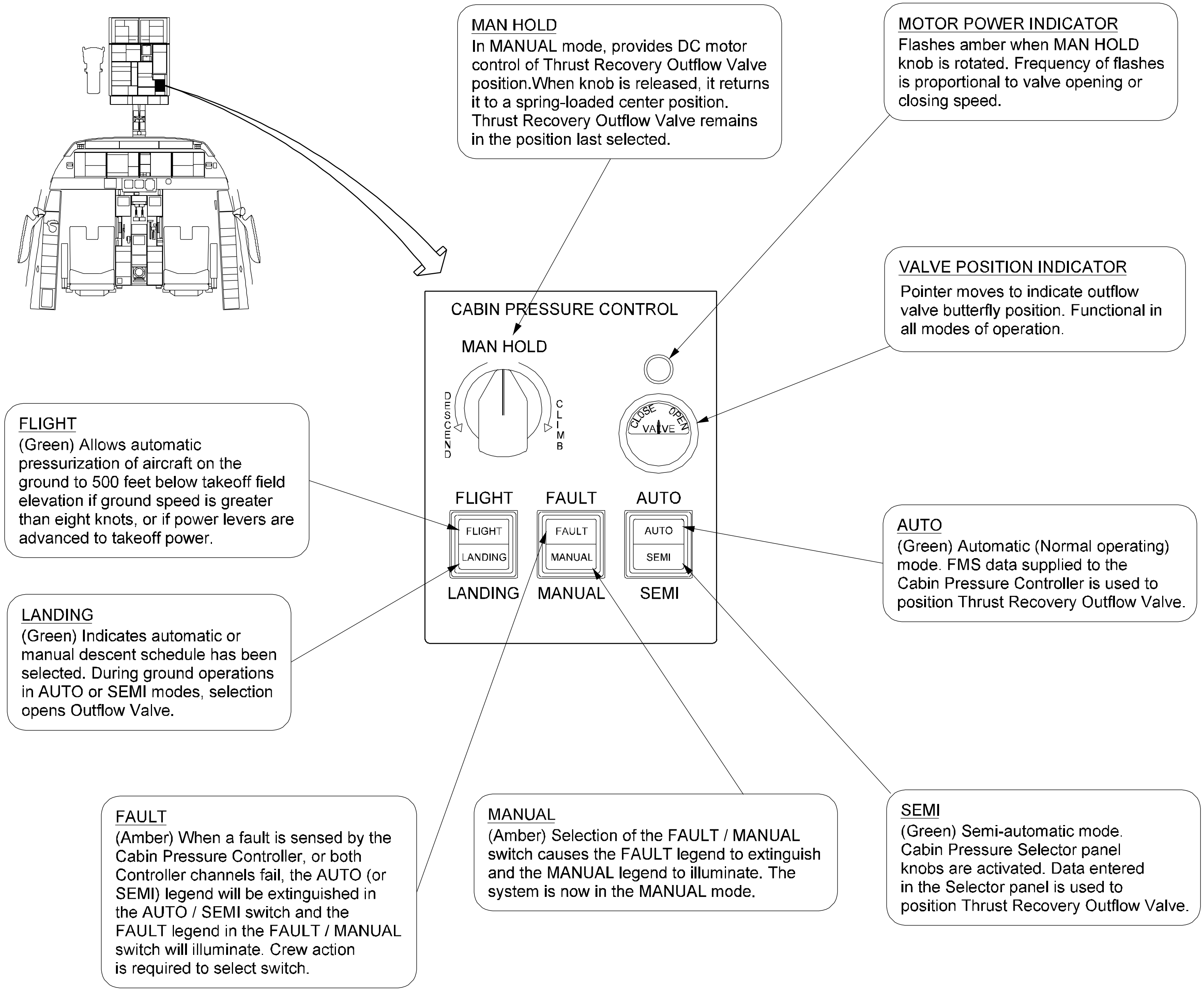
Time with the internal baggage door open above 40,000 feet is limited to five (5) minutes. The flight crew is required to ensure that door is closed and the “Internal Baggage Door”CAS advisory message extinguished within five (5) minutes when the aircraft is above 40,000 feet.

(c) If Operating on a Single ECS Pack:

If operating on a single ECS pack, access to the baggage compartment is allowed only at or below 45,000 feet.



Pressurization System Simplified Block Diagram
Figure 7



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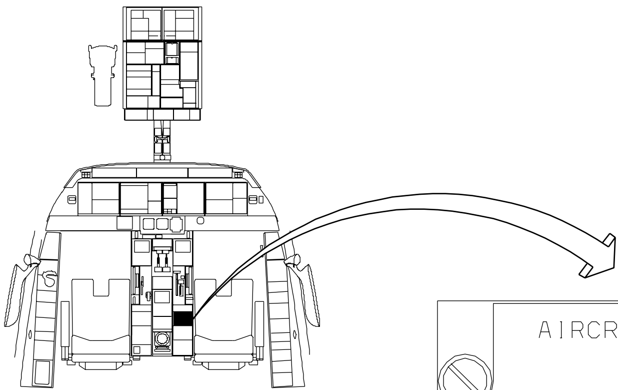
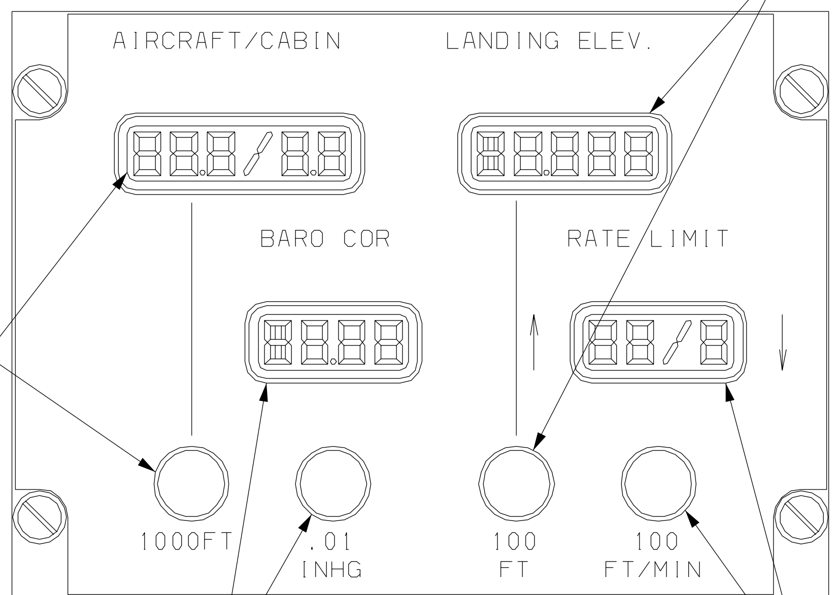
Cabin Pressure Control
Panel
Figure 8



LANDING ELEV

- Elevation data is displayed in 100 foot increments, ranging from -1000 to 15000 feet, in LCD window.
- In AUTO mode, FMS / ADM data is used and selector knob is disabled.
- In SEMI mode, data is manually input using selector knob.



AIRCRAFT / CABIN

- Altitude data is displayed in 1000 foot increments, ranging from 0.0 / 0.0 to 60.0 / 8.0, in LCD window.
- In AUTO mode, FMS / ADM data is used and selector knob is disabled.
- In SEMI mode, data is manually input using selector knob.

BARO COR

- Barometric correction data is displayed in hundredths of an inch of mercury (INHG) from 28.00 to 31.00, in LCD window.
- In AUTO mode, FMS / ADM data is used and selector knob is disabled.
- In SEMI mode, data is manually input using selector knob.

RATE LIMIT

- Cabin Rate-of-Climb Data is displayed in 100 foot increments in the left side (↑) of LCD window.
- Cabin Rate-of-Descent Data is displayed in 100 foot increments in the right side (↓) of LCD window.
- Range is ↑0/0↓ to ↑33/9↓ .
- In SEMI mode, data displayed is manually input using selector knob at bottom of panel.

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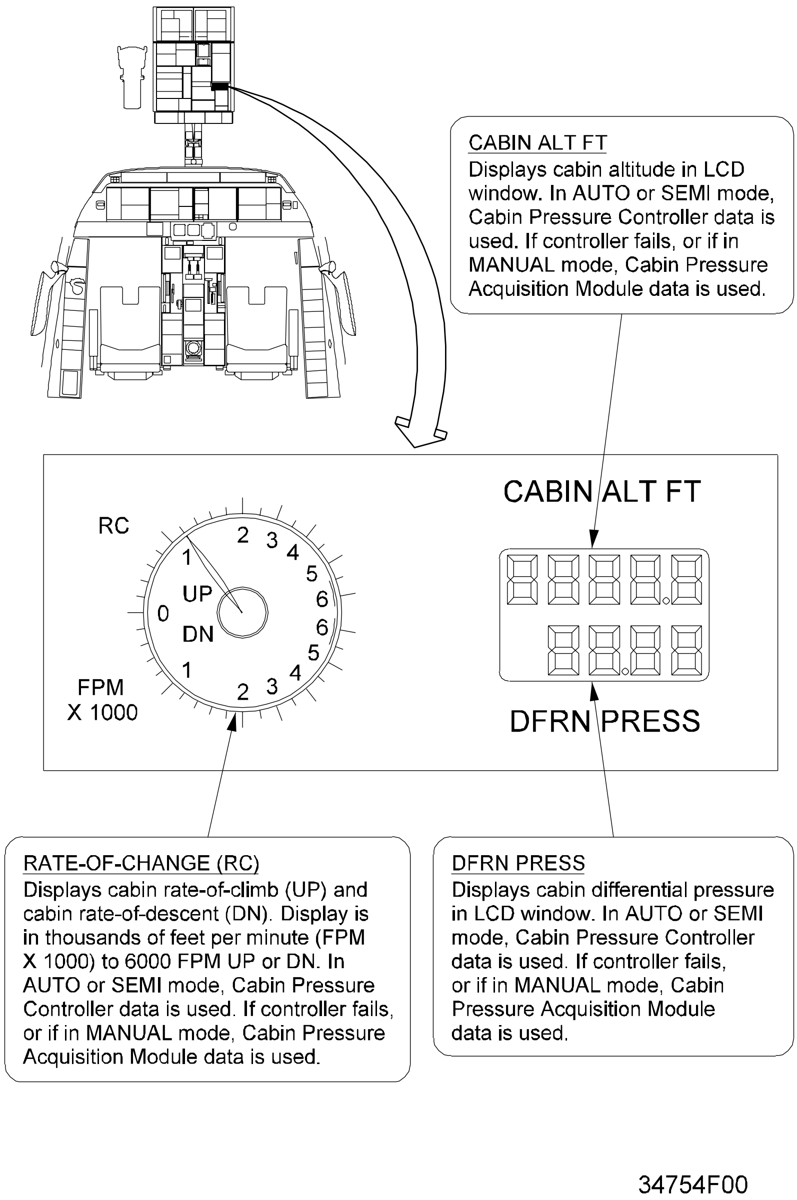
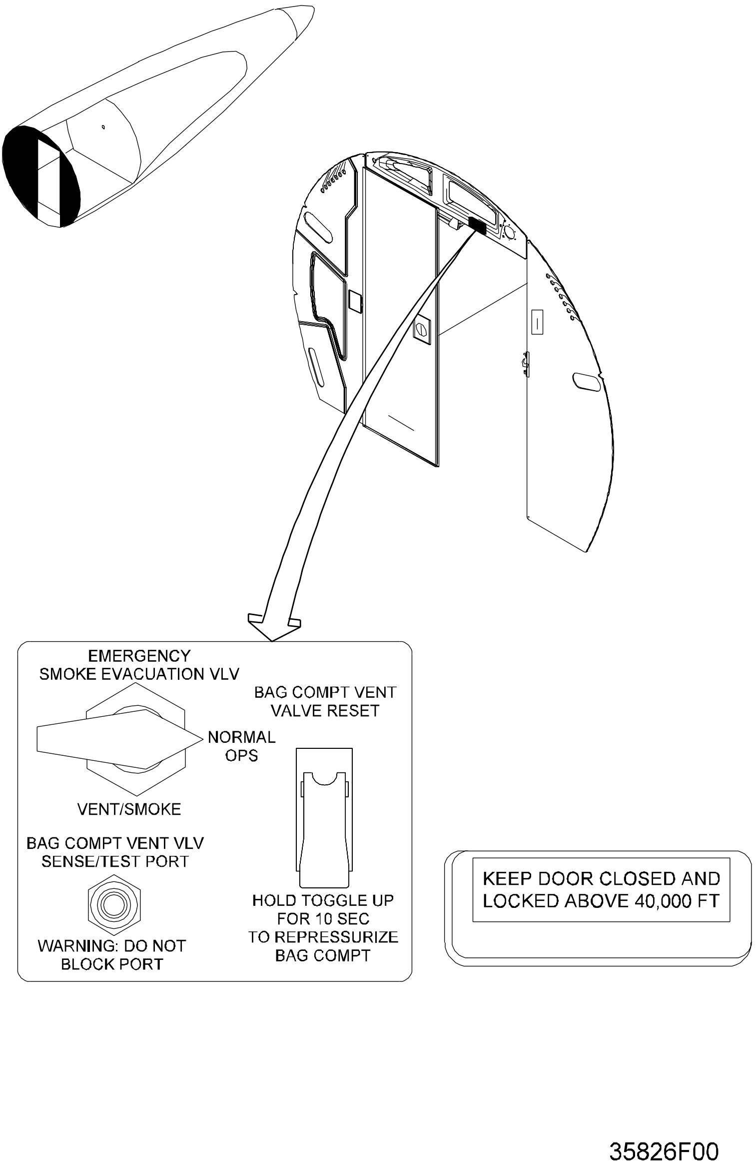
Cabin Pressure Selector Panel
Figure 9



Cabin Pressure Indicator Panel
Figure 10



Baggage Compartment Smoke Vent Valve
Figure 11