

GULFSTREAM IV

OPERATING MANUAL

AIR CONDITIONING

2A-21-10: General

The air conditioning system for the Gulfstream IV is designed to provide all areas within the pressure vessel with a safe and comfortable temperature and pressure (cabin altitude) throughout the aircraft's operating envelope. The system employs a "dual pack" concept and, although each pack is controlled separately, failure of one pack still leaves the remaining pack capable of supplying conditioned air to both cabin and cockpit, if required.

To achieve this function, the air conditioning system provides the flight crew with a means to accomplish the following:

- Control, regulate and monitor the amount of conditioned air within the pressure vessel to achieve and maintain selected or preprogrammed cabin pressure (altitude), while still allowing exchange of the air at regular intervals for occupant comfort. This is accomplished by modulation of a single outflow valve. The outflow valve is automatically controlled by the cabin pressure controller in the normal operating mode, but can be controlled manually.
- Select and control bleed air entering and exiting two environmental control system refrigeration pack assemblies, referred to as the Left and Right ECS Packs. Source air into the ECS Packs is provided to a bleed air manifold by either external air or APU air (while on the ground), or by the aircraft's engines (on ground or in flight). Through use of an isolation valve, air from the bleed air manifold can be directed to either ECS Pack. This results in a constant mass of conditioned air for all areas within the pressure vessel.
- Control the temperature of conditioned air delivered to the cockpit and cabin areas (referred to as zones) within the pressure vessel. This is done using the two ECS packs to cool incoming air and deliver it to a conditioned air manifold. Valves mix hot bleed air with cold conditioned air to modulate the temperature of the air coming from the manifold into the pressure vessel. Cockpit control and indication is also provided.

The Air Conditioning system is divided into the following subsystems:

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

2A-21-20: Pressurization System

1. General Description:

The pressurization system controls, regulates and monitors the amount of conditioned air within the pressure vessel to achieve and maintain a safe and comfortable cabin pressure (cabin altitude), up to the airplane's maximum operating altitude. While normally preprogrammed, cabin altitude can also be controlled manually. Cabin conditioned air is also exchanged at regular intervals for occupant comfort.

With airflow supplied from the ECS packs, the pressurization system maintains cabin altitude by regulating the amount of air exhausted overboard through a single outflow valve. Once the flight crew has programmed the system, operation is virtually automatic.

The pressurization system is capable of maintaining a cabin altitude of 6,550 feet at a maximum inflight altitude of 45,000 feet. Sea level cabin pressure can be

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maintained to a maximum inflight altitude of 22,000 feet. If cabin altitude should exceed 10,000 feet, warnings and annunciations are provided to the flight crew so that appropriate action may be taken.

The pressurization system performs the following functions:

- Automatically maintains selected cabin altitude through isobaric pressurized operation
- Automatically limits maximum cabin pressure differential
- Provides safety pressure relief operation
- Provides negative (vacuum) pressure differential control
- Allows manual barometric correction for pre-programmed Landing Field Elevation (LFE)
- Permits manual cabin altitude control through control of the outflow valve
- Automatically limits cabin altitude rate-of-change to a maximum of 3,000 feet-per-minute (FPM) during pressurization and depressurization
- Provides crew-selected cabin altitude rate-of-change
- Regulates and smooths cabin pressurization to prevent pressurization surges or “bumps”
- Provides rapid cabin ventilation for smoke removal

Normally the pressurization system limits cabin pressurization differential to 9.55 ± 0.1 psid. As differential pressure reaches 9.55 psid, an amber CABIN DFRN 9.6 caution message is displayed on the Crew Advisory System (CAS) and the pressurization system begins limiting outflow valve closure.

If the pressurization system malfunctions and cannot limit maximum cabin pressure differential to 9.55 ± 0.1 psid, a safety valve limits pressure differential to 9.7 ± 0.1 psid. As differential pressure reaches 9.8 psid, a red CABIN DFRN 9.8 warning message is displayed on CAS.

The pressurization system receives information from the two Air Data Computers (ADC #1 and ADC #2). It also uses the Weight-On-Wheels (WOW) system (commonly referred to as the nutcracker system) to control various system operating modes.

Under typical flight conditions, the flight crew programs the system prior to takeoff. Apart from selection of the FLIGHT/LANDING mode switch or adjustment of LFE, system operation is virtually automatic.

Major components of the pressurization system are:

- Cabin Pressurization Transducer
- Cabin Pressure Outflow Valve
- CABIN PRESSURE CONTROL Panel
- Cabin Pressurization Selector Panel
- Cabin Pressure Safety Valve
- Cabin Rate Pressure Switch
- Cabin Pressure Warning Switch
- Cabin Differential Pressure / Altimeter / Rate-of-Climb Indicator

2. Description of Subsystems, Units and Components:

(See Figure 1.)

A. Cabin Pressurization Transducer:

The solid-state cabin pressurization transducer is the heart of the pressurization system. Located in the electronics area of the entrance compartment, produces the output signal to the outflow valve motor based on the following input data:

- Inputs from the cabin pressurization selector panel
- Corrected static pressure data from the ADCs (or Digital Air Data Computers [DADCs])
- FLIGHT or GROUND mode from the nutcracker system
- Sensed cabin pressure from inside the pressure vessel

To prevent undesired outflow valve movement from transient power surges, the transducer obtains a clean, stable supply of power from an Electromagnetic Interference (EMI) filter installed in the radio rack.

Within the transducer are circuits that limit cabin differential pressure in flight to 6,550 feet with an airplane altitude of 45,000 feet.

B. Cabin Pressure Outflow Valve:

A single pressurization outflow valve is installed under the lower shelf of the radio rack. It is an electrically-controlled, motor-driven valve that determines the amount of cabin air exhausted overboard, thus controlling cabin pressurization. It is capable of moving from fully open to fully closed in approximately ten (10) seconds.

The outflow valve is a butterfly type valve with an electro-mechanical actuator and a potentiometer that provides valve position information to the position indicator on the CABIN PRESSURE CONTROL panel. Within the actuator are a DC motor with DC brakes, an AC motor with AC brakes and a motor-generator.

The AC motor, which operates the outflow valve in the Automatic (AUTO) mode, responds to signals from the cabin pressurization transducer. The DC motor operates the outflow valve in the MANUAL mode by responding to signals from the CABIN PRESSURE CONTROL panel manual control knob. Both motors are capable of extremely slow or fast operation, or at any intermediate speed required by the controlling device.

During normal system operation (AUTO mode), the cabin pressurization transducer opens and closes the outflow valve using the AC motor. While the AC motor is in operation, the DC motor brake engages to prevent DC motor movement. The motor-generator in turn provides a rate-of-change signal back to the cabin pressurization transducer.

With the system in MANUAL mode, the manual control knob provides a DC signal to position the outflow valve. The AC motor brake engages to prevent AC motor movement. Although the motor-generator is inactive, the potentiometer still provides valve position information to the valve position indicator.

In the unlikely event that both Essential AC and Essential DC bus power sources are lost, the outflow valve will cease operation and remain at the last position commanded.

C. CABIN PRESSURE CONTROL Panel:

(See Figure 3.)

The CABIN PRESSURE CONTROL panel, located on the cockpit overhead panel, has controls and indicators for:

- Manual control of the outflow valve
- Position of the outflow valve
- Selection of either FLIGHT or LANDING pressurization schedules
- Selection of either AUTO or MANUAL mode of operation
- Selection of either ADC #1 or ADC #2 to supply static pressure information to the pressurization transducer

The cabin pressure control panel operates on 28V DC from the Essential DC bus and 115V AC, 400 Hz from the Essential AC bus.

D. Cabin Pressurization Selector Panel:

(See Figure 4.)

Automatic operation of the pressurization system requires crew inputs on the cabin pressurization selector panel, located on the copilot's flight panel. It contains control knobs and indicator tapes for setting the following:

- FLIGHT: flight plan's maximum aircraft altitude and corresponding cabin altitude to be maintained
- BARO CORR: barometric pressure correction to local conditions (28.00 to 31.00 inches of mercury)
- LDG: preprogrammed LFE (-1,000 to +15,000 feet)
- RATE: cabin altitude rate-of-change for climb and descent in FPM (minimum UP: 50 FPM, minimum DOWN: 30 FPM, maximum UP: 2,000 FPM, maximum DOWN: 2,000 FPM)

Each control knob is connected to a variable resistor and gear train that drives the indicator tape. Once programmed, the cabin pressurization selector panel supplies driving signals to the pressurization transducer.

E. Cabin Pressure Safety Valve:

A pressurization safety valve, located below the radio rack, provides safety pressure relief, vacuum relief and pressurization rate limiting. Because it operates entirely on cabin and ambient pressure, it is independent of all other components in the pressurization system and requires no external power source.

Should the AUTO or MANUAL control mode of the pressurization system malfunction and cabin pressure builds up to approximately 9.7 ± 0.1 psid, the safety valve will open. It then modulates to limit cabin pressure to the safety relief pressure of 9.8 psid.

F. Cabin Rate Pressure Switch:

The cabin rate pressure switch functions strictly as a safety device by sensing the rate at which the cabin altitude is increasing (losing pressure). If a failure should occur that results in rapidly rising cabin altitude, the rate switch inhibits automatic (AC) control of the outflow valve and shifts to manual (DC) control. This would occur at loss rates of approximately 3,000 FPM.

G. Cabin Pressure Warning Switch:

The cabin pressure warning switch, located on the right side of the entrance compartment, is an aneroid-operated switch that reacts to cabin altitude. If cabin altitude exceeds 9,250 $\pm$ 750 feet, the switch causes a red CABIN PRESS LOW warning to be displayed on CAS and, if installed, on the Standby Warning Lights Panel (SWLP).

H. Cabin Differential Pressure / Altimeter / Rate-of-Climb Indicator:

(See Figure 5.)

The cabin differential pressure / altimeter / rate-of-climb indicator is located on the overhead panel above the CABIN PRESSURE CONTROL panel. It provides the following indications:

- (1) Cabin Differential Pressure: The cabin differential pressure indicator (labeled DFRN PRESS) is driven by the cabin pressurization transducer. The display indicates cabin differential pressure to the nearest 1/100th psid on a four digit display.

If cabin differential pressure reaches 9.6 psid, an amber CABIN DFRN-9.6 caution message is displayed on CAS and an amber light above the indicator will illuminate. If differential pressure reaches 9.8 psid, a red CABIN DFRN-9.8 warning message is displayed on CAS and a red light above the indicator will illuminate.
- (2) Cabin Altimeter: The cabin altitude indicator (labeled CABIN ALT) is located adjacent to the differential pressure indicator. It displays cabin altitude in feet (FT) on a five digit display.
- (3) Cabin Rate-of-Change Indicator: The cabin rate-of-change indicator (labeled RC) is located beneath the cabin altimeter. It displays cabin altitude rate-of-change in FPM on a four digit display. A plus or minus sign precedes the digits to show cabin climb or descent.

3. Modes of Operation:

A. Automatic Operation Mode:

Automatic operation of the cabin pressurization system can best be understood by using a typical flight scenario shown in Figure 2 as an example. In this scenario, the crew begins their flight with a standard sea level field pressure altitude and progresses through closing the doors, engine start, taxi out, takeoff, climb to cruise, cruise, descent to approach altitude, executing the approach, landing, engine shut down and opening the doors.

The flight crew initially sets 45,000 feet on the FLIGHT scale of the cabin pressurization selector panel. This results in the adjacent CABIN scale reading of 6,550 feet, the isobaric cabin altitude that corresponds to the maximum differential pressure of 9.41 psid. The cabin RATE dial is set at 500 FPM UP, resulting in the adjacent DOWN scale reading 300 FPM. The average rate of climb to 45,000 feet is approximately 2,700 FPM, with a cabin rate of climb of 500 FPM. The departure runway field elevation altitude is then programmed into the LDG (Landing) dial. Destination runway field elevation altitude (4,000 feet in this example) is set during descent. At this point, the pressurization system is programmed for automatic operation and, assuming the AUTO/MANUAL switch is in AUTO, the system will operate in automatic mode when electrical power is applied

to the aircraft.

With the airplane on the ground, the AUTO/MANUAL switch in AUTO and the FLIGHT/LANDING switch in LANDING, the outflow valve will cycle open as soon as electrical power is applied. This is due to the absence of airflow and the cabin pressurization transducer sensing an on-ground condition from the nutcracker.

With the main entrance door still open at this point, there is no pressure buildup. A negligible pressure increase (approximately 0.05 psid, equalling pressure drop across the outflow valve) occurs after closing the main entrance door, remaining negligible through engine start, APU shutdown and transfer of air source to the engines. During taxi, the pressure remains low until lineup in preparation for takeoff. At this point, the flight crew selects the FLIGHT position on the FLIGHT/LANDING switch on the CABIN PRESSURE CONTROL panel.

With the FLIGHT position selected, the outflow valve immediately begins to close under rate control, "holding" at approximately 0.25 psid of pressure buildup. This "holding", known as ground differential pressure control, serves to minimize the possibility of "pressure bumps" during takeoff.

As soon as the aircraft becomes airborne, the nutcracker system sends an inflight signal to the cabin pressurization transducer. The transducer in turn commands the outflow valve to close, thus pressurizing the cabin at the programmed rate of 500 FPM UP until the maximum differential pressure of 9.55 ± 0.10 psid is reached. The cabin altitude remains stable within ± 25 feet of the final cabin altitude, in this case 6,550 feet at an aircraft altitude of 45,000 feet. Stability is maintained provided the aircraft does not climb above 45,000 feet, the maximum allowable altitude of the aircraft.

In preparation for descent, the flight crew enters the destination runway field elevation altitude (4,000 feet in this example) in the LDG window. A discriminator circuit is incorporated within the cabin pressurization transducer to prevent inadvertent programming of an isobaric cabin altitude (CABIN value) lower than the landing field altitude (LDG value). This feature prevents landing with excessive cabin differential pressure. If the discriminator circuit detects a LDG value higher than the CABIN value, it allows the LDG value to override the CABIN value and control that outflow valve. This is the only instance in which the LDG value can override the FLIGHT position on the FLIGHT/LANDING switch while in the AUTO mode. When ready to descend, the FLIGHT/LANDING switch is positioned to LANDING.

Noting that the cabin rate of climb was preprogrammed to be 300 FPM DOWN prior to takeoff, the flight crew adjusts the BARO CORR (barometric correction), if necessary. This completes the descent programming. As the aircraft descends, the system automatically begins to open the outflow valve until a descent rate of 300 FPM is reached. Cabin pressure is maintained at approximately 400 to 500 feet below the actual LFE, or at approximately 0.25 psid.

Upon touchdown, the nutcracker system signals the cabin pressurization transducer of an on-ground condition, causing the outflow valve to be driven fully open. With the outflow valve fully open, cabin pressure drops to a negligible pressure of approximately 0.05 psid until the air supply is shut off.

B. Manual Operation Mode:

To operate the pressurization system manually, the AUTO/MANUAL switch, located on the CABIN PRESSURE CONTROL panel, is selected to MANUAL. This causes the MANUAL switch legend to illuminate amber, the illumination of an amber light (referred to as the motor power indicator) above the AUTO/MANUAL switch and display of an amber CABIN PRES MANUAL caution message on CAS.

The outflow valve may then be controlled by the flight crew, using its DC motor, by means of a knob on the CABIN PRESSURE CONTROL panel. The knob is spring-loaded to return the vertical position, labeled MAN HOLD, when released. Rotating the knob toward OPEN drives the valve open; rotating the knob toward CLOSE drives the valve closed.

The manual control knob circuit is designed such that the further the knob is moved away from MAN HOLD toward OPEN or CLOSE, the more pulses are applied to the motor, i.e., the faster the valve moves in that direction. The amber motor power indicator above the AUTO/MANUAL switch will blink in proportion to the speed of the pulses applied to the motor.

Valve position is shown by an indicator to the right of the control knob. The indicator displays outflow valve position at all times, whether in AUTO or MANUAL modes of operation. When desired valve position is attained, releasing the knob will return the knob to MAN HOLD and the outflow valve will hold (stop) in that position.

To return system to automatic mode, the AUTO/MANUAL switch is selected to AUTO. The annunciations will be extinguished and the MAN HOLD knob function will become inoperative.

NOTE:

On aircraft having ASC 295 incorporated, loss of AC power will automatically switch the pressurization system to MANUAL control. This causes the MANUAL switch legend to illuminate amber, the illumination of an amber motor power indicator above the AUTO/MANUAL switch and display of an amber CABIN PRES MANUAL caution message on CAS.

C. Cabin Pressure Safety Valve Limiting Mode:

Should the AUTO or MANUAL control mode of the pressurization system malfunction and cabin pressure builds up to approximately 9.7 ± 0.1 psid, the safety valve will open. It then modulates to limit cabin pressure to the safety relief pressure of 9.8 psid.

D. Depressurization Rate Limiting Mode:

Depressurization rate limiting prevents excessive rates of pressure loss, as might occur, for instance, if a malfunction drives the outflow valve to the full open position. Detection of an excessive rate of pressure loss triggers the cabin rate pressure switch, in turn causing the outflow valve to be driven fully closed and automatic control of the system is inhibited. The MANUAL legend of the AUTO/MANUAL switch illuminates amber and an amber CABIN PRES MANUAL caution message is displayed on CAS.

The flight crew can restore the system to automatic operation after

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depressurization rate limiting by first hard-selecting the AUTO/MANUAL switch to MANUAL, enabling normal manual control. Reset is then completed by hard-selecting the AUTO/MANUAL switch to AUTO.

E. Pressurization System Check:

The flight crew normally performs the following pressurization system check in the course of their normal procedures:

- (1) Ensure the main entrance door is open.
- (2) Configure APU BLEED AIR, L ENG BLEED AIR and R ENG BLEED AIR as required.
- (3) Select the FLIGHT/LANDING switch to LANDING (green).
- (4) Select the AUTO/MANUAL switch to AUTO (green).
- (5) Select the ADC #1/ADC #2 switch to ADC #1 (green).
- (6) Verify the outflow valve is OPEN on the position indicator. Perform system check as follows:
- (7) Select the FLIGHT/LANDING switch to FLIGHT (green).
- (8) Verify the outflow valve is driving toward CLOSE. At the midway point:
- (9) Select the ADC #1/ADC #2 switch to ADC #2 (amber).
- (10) Verify the outflow valve drives fully to CLOSE.
- (11) Select the FLIGHT/LANDING switch to LANDING (green).
- (12) Verify the outflow valve is driving toward OPEN. At the midway point:
- (13) Select the ADC #1/ADC #2 switch to ADC #1 (green).
- (14) Verify the outflow valve drives further toward OPEN. Before the valve reaches fully OPEN:
- (15) Select the AUTO/MANUAL switch to MANUAL (amber). Verify amber "cabin pressure manual" light illuminates.
- (16) Verify manual control of outflow valve to OPEN and CLOSE positions using the manual control knob.
- (17) Select the AUTO/MANUAL switch to AUTO (green).
- (18) Verify the outflow valve drives fully OPEN if not already fully OPEN. Set final configuration as follows:
- (19) Select the FLIGHT/LANDING switch to LANDING (green).
- (20) Select the AUTO/MANUAL switch to AUTO (green).
- (21) Select the ADC #1/ADC #2 switch to ADC #1 (green).
- (22) Verify the outflow valve is OPEN on the position indicator.
- (23) Verify amber "cabin pressure manual" light is extinguished.

4. Controls and Indications:

(See Figure 4 and Figure 5.)

A. Circuit Breakers (CBs):

Circuit Breaker Name:	CB Panel:	Location:	Power Source:
CABIN PRESS 115V	PO	D-11	ESS AC Bus, ϕ A

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Circuit Breaker Name:	CB Panel:	Location:	Power Source:
CABIN PRESS 28V	PO	B-11	ESS DC Bus
CABIN PRESS IND	PO	A-12	ESS DC Bus

B. Warning (Red) CAS Messages:

CAS Message:	SWLP Indication	Cause or Meaning:
CABIN DFRN-9.8	None	Cabin differential pressure approaching upper limit (9.8).
CABIN PRESSURE LOW	CAB PRESS LOW	Cabin altitude has climbed above limits (9250 ft $\pm$ 750 ft).

C. Caution (Amber) CAS Messages:

CAS Message:	Cause or Meaning:
CABIN DFRN-9.6	Cabin differential pressure has reached 9.6 psi.
CABIN PRES MANUAL	Cabin pressurization controller has been switched to MANUAL control, either automatically or manually.

D. Other Annunciations:

Indication:	Cause or Meaning:
Amber Cabin Pressure Manual Light	System in MANUAL control mode.
Amber MANUAL Legend On AUTO/ MANUAL Switch	System in MANUAL control mode.
Amber ADC #2 Legend On ADC #1 / ADC #2 Switch	ADC #2 providing static pressure signal to transducer.

5. Limitations:

A. Flight Manual Limitations:

- (1) Cabin Pressurization Control System:
 - (a) Maximum Cabin Pressure Differential Permitted: 9.80 psi
 - (b) Maximum Cabin Pressure Differential Permitted For Taxi, Takeoff Or Landing: 0.3 psi

- (2) Bleed Air System:

Do not operate above 41,000 ft without both engine bleeds ON and each engine being bled by either the air conditioning system or engine cowl anti-ice. See Section 05-01-10, Air Conditioning System Shut Down Or Inoperative.

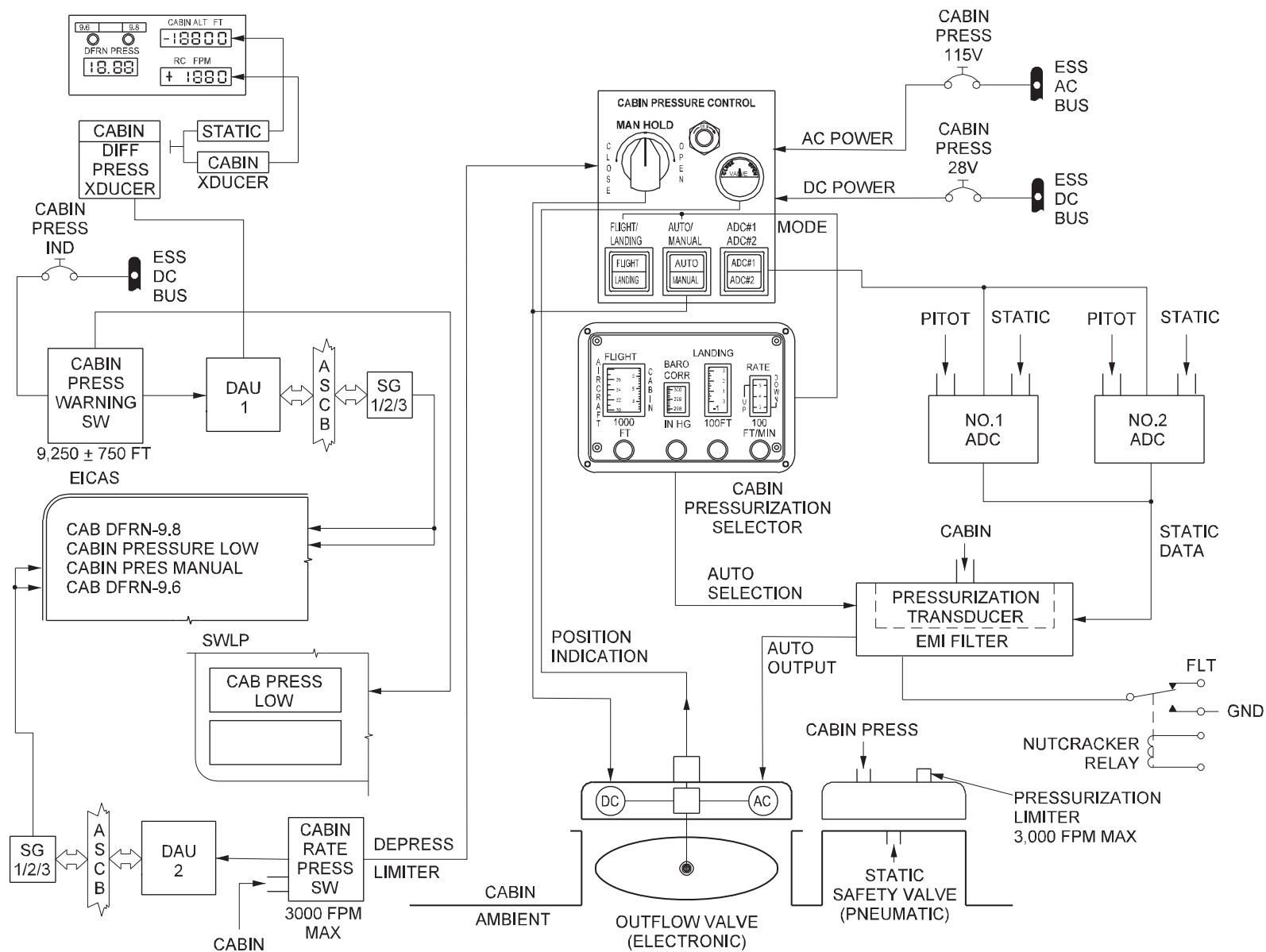
B. Operational Data:

Function:	Value:
Normal Maximum Pressure Differential	9.55 $\pm$ 0.1 psi
Safety Pressure Relief	9.70 $\pm$ 0.1 psi
Maximum Negative Differential	-0.25 psi
Pressurization Rate Limiting	3,000 FPM
Depressurization Rate Limiting	3,000 FPM

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Function:	Value:
Ground Differential Reference Signal	0.5 In Hg
Rate-of-Change Control	±10% of selected value at all cabin altitudes
Barometric Correction Range	28.00 to 31.00 In Hg Absolute Pressure
Cabin Altitude-Isobaric Programming Range	-1000 to 15,000 feet
Landing Altitude Selection Range	-1000 to 15,000 feet
Rate-of-Change Selection Range	Minimum: • 50 FPM UP • 30 FPM DOWN Maximum: • 2000 FPM UP • 2000 FPM DOWN
Rate to Maximum Differential Control Transition	Not to exceed 50 feet with no overshoot beyond the final control value.
Final Absolute Control Pressure	Within 140 feet of selected value at all cabin inflow rates from outflow valve flow of 5 ppm to maximum flow.



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Cabin Pressure Control
System Block Diagram
Figure 1

2A-21-00

TYPICAL FLIGHT PLAN

TAKEOFF FIELD = SEA LEVEL ALTITUDE
29.92 IN. HG PRESSURE

CRUISE ALTITUDE = 45,000 FT

LANDING FIELD = 4,000 FT ALTITUDE

COCKPIT SELECTOR SETTINGS BEFORE TAKEOFF

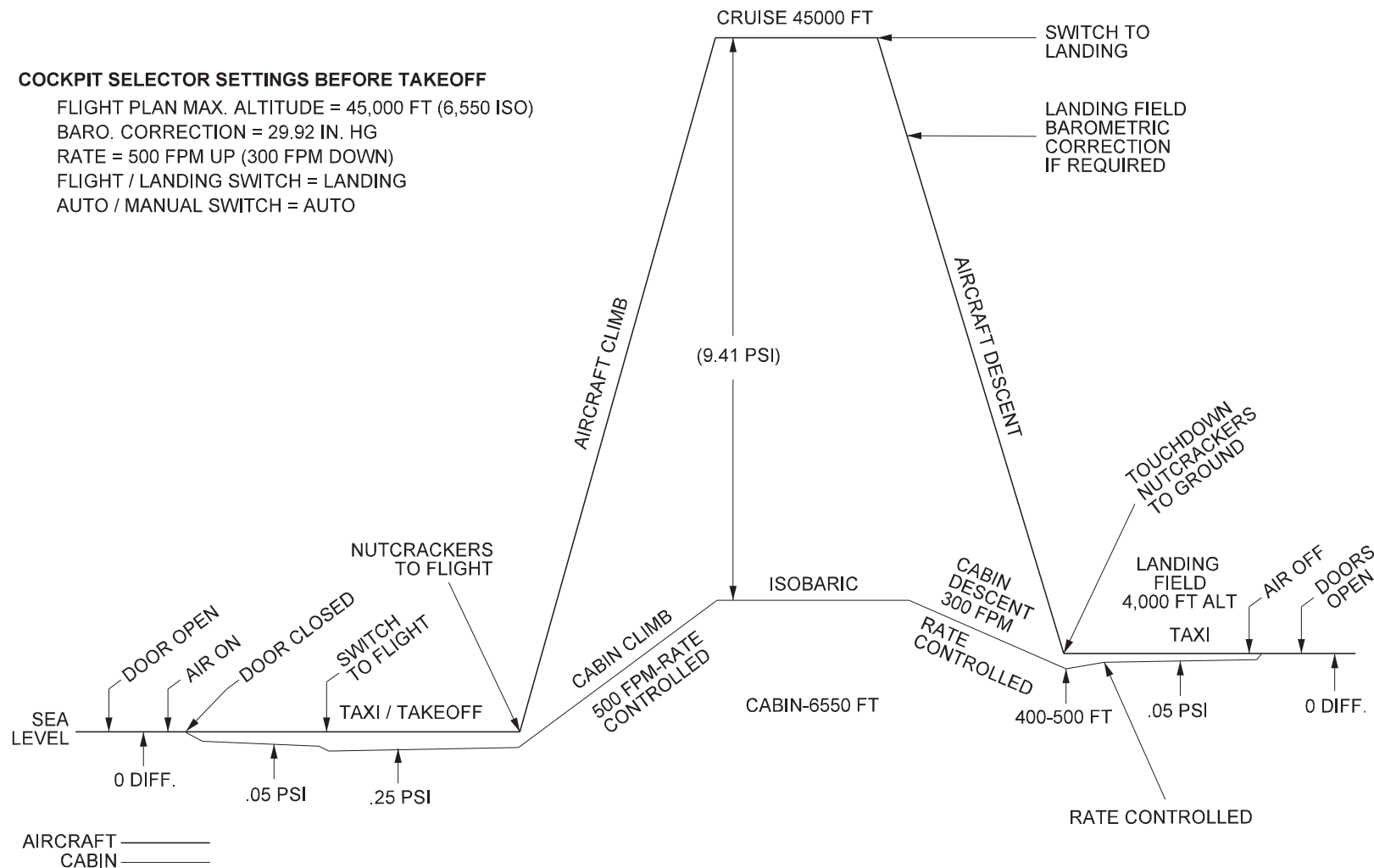
FLIGHT PLAN MAX. ALTITUDE = 45,000 FT (6,550 ISO)

BARO. CORRECTION = 29.92 IN. HG

RATE = 500 FPM UP (300 FPM DOWN)

FLIGHT / LANDING SWITCH = LANDING

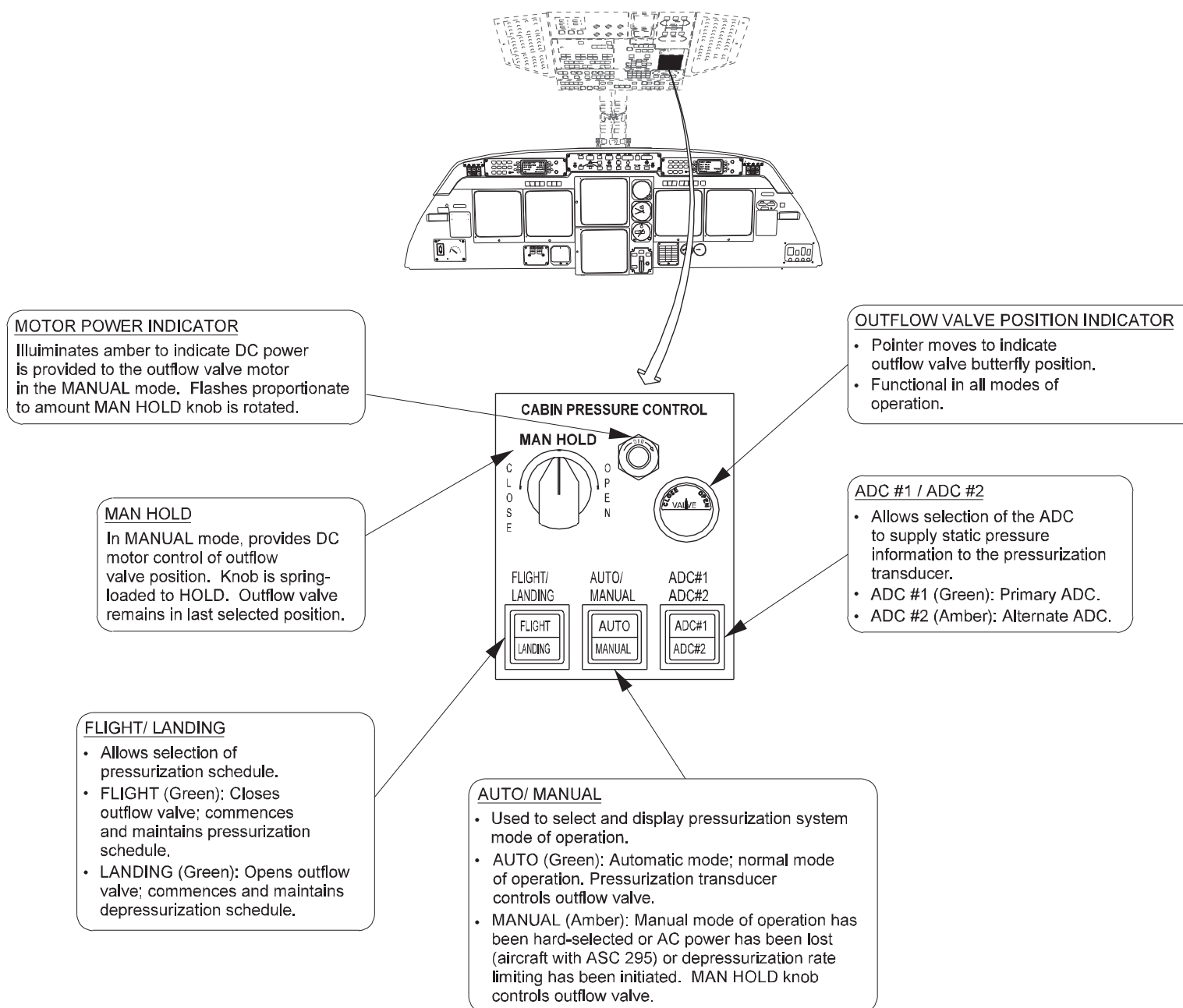
AUTO / MANUAL SWITCH = AUTO



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Typical Flight Profile
Figure 2

2A-21-00

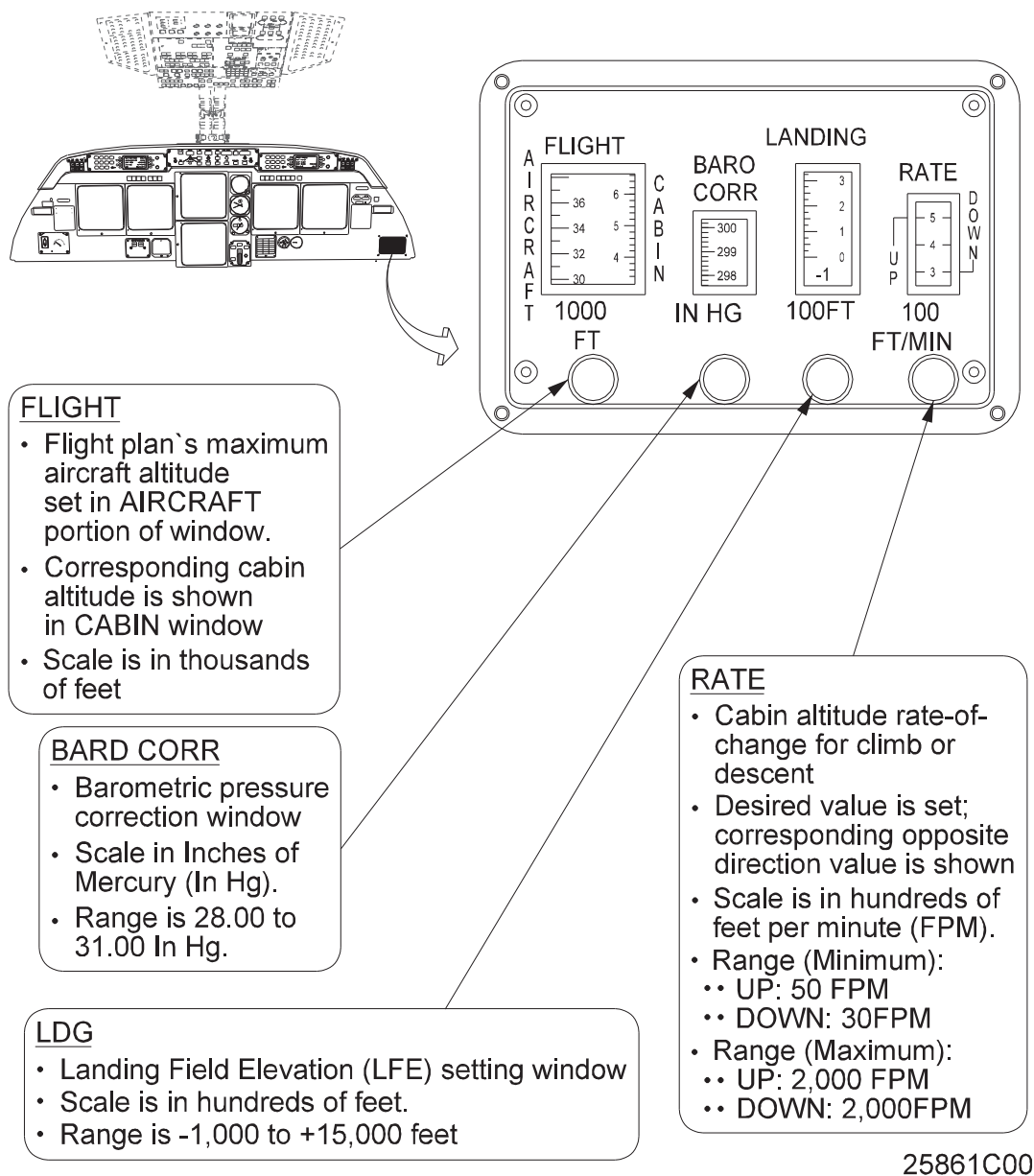


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CABIN PRESSURE
CONTROL Panel
Figure 3

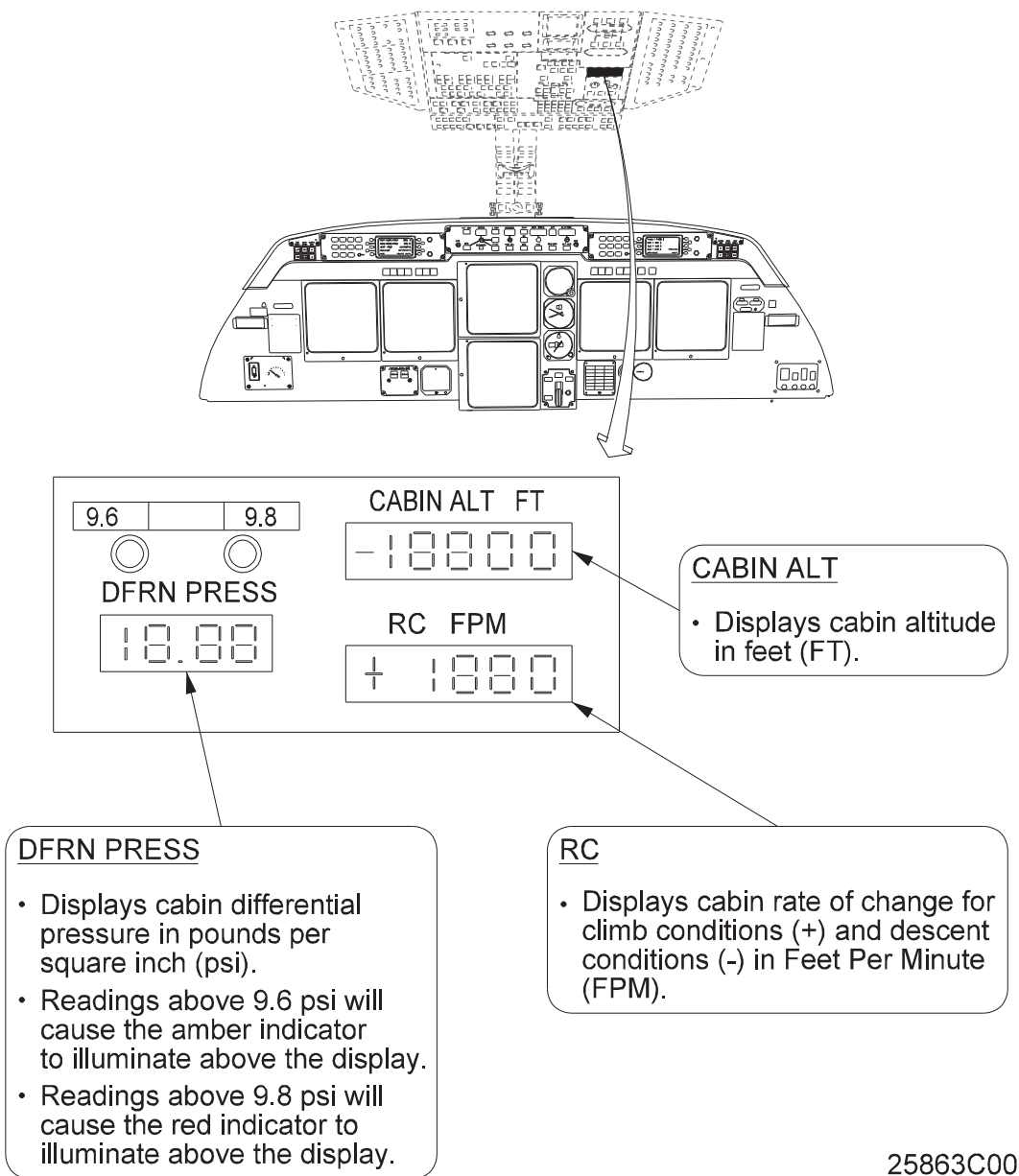
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Cabin Pressurization Selector Panel
Figure 4

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Cabin Differential Pressure / Altimeter / Rate-of-Climb Indicator
Figure 5

2A-21-30: Airflow and Temperature Control System

1. General Description:

The airflow and temperature control system for the Gulfstream IV provides for comfortable cabin and cockpit temperatures throughout the operating envelope of the aircraft by enabling the flight crew to perform the following functions:

- Select and control bleed air entering and exiting two Environmental Control System (ECS) refrigeration pack assemblies, referred to as the Left and Right ECS Packs. This dual pack concept provides redundancy in the event one pack should fail. Source air into the ECS packs is provided to a bleed air manifold by either an approved external air source or APU air (while on the ground), or by High Pressure (HP) turbine bleed air from